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# JOURNAL OF THE SOCIETY OF MOTION PICTURE ENGINEERS

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Vol 43

JULY, 1944

No. 1

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## REPORT OF THE ENGINEERING VICE-PRESIDENT ON STANDARDIZATION\*

D. E. HYNDMAN\*\*

The procedure necessary for the formulation of War Standards for Motion Picture Equipment and Processes was described in an earlier paper which has appeared in the April, 1944, issue of the JOURNAL of the Society of Motion Picture Engineers, pages 211-229. The planning, initiation and prosecution of the major project of the preparation, study and issuance of the corresponding specifications have afforded the Society of Motion Picture Engineers an opportunity to collaborate both with the military forces, the War Production Board and the motion picture industry along lines which, it is believed, have been of constructive assistance to the war effort.

In this report, there will be discussed the nature and course of the work which has been carried on since the activities of the ASA War Standards Committee on Photography and Cinematography-Z52 were initiated.

Prior to such detailed consideration, it is desirable to outline the major elements necessary to the success of a plan for wartime specifications of complex products needed by the Armed Forces. These elements include:

(1) The formulation by the military forces of their needs, usually in the form of a list of the products and methods for which specifications are desired, as well as the scope, degree of detail, method of presentation, and field of application of a corresponding specification. It was fortunate that the U. S. Army Signal Corps, U. S. Army Air Forces, U. S. Army Engineer Corps, Bureau of Aeronautics, U. S. Navy, and U. S. Marine Corps were prepared to present their problems and needs in detail. Particularly active in this

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\* Presented Apr. 19, 1944, at the Technical Conference in New York.

\*\* Engineering Vice-President, Society of Motion Picture Engineers.

regard were all the members of the present Armed Forces Committee.

(2) The availability of committees or groups of highly skilled engineers and technical men active in the field of development and production of the devices needed by the military services, such groups being preferably of long standing and experience and accordingly ready to organize and prepare on short notice to attack and solve problems of a nature generally similar to those which they have been previously considering.

By great good fortune, the SMPE was in an excellent position to make available to the military services, or any other appropriate agency, the long experience and skill of its various committees and subcommittees active in certain fields. The Engineering Vice-President of the Society, in conjunction with the Chairman of the Committee on Standards, Mr. F. T. Bowditch; the Chairman of the ASA Sectional Committee on Motion Pictures-Z22, Dr. Alfred N. Goldsmith; and the future Chairman of the Armed Forces Committee, Capt. Lloyd T. Goldsmith, had arranged for the organization or continuation of the activities of a major group of engineering committees of the Society which, with expanded membership, proved highly effective in the type of specification preparation required by the military services.

The roster of the Society's committees was examined and the following committees and their chairmen were selected as ready and suitable for this work. Accordingly, it is desired at this time to express the thanks of the Society and its officers for the loyal and willing service rendered by the chairmen and membership of the following committees:

Committee	Chairman
Subcommittee <i>A</i> on 16-Mm Cinematography (Z52)	J. B. Contner
Subcommittee <i>B</i> on 16-Mm Sound (Z52)	J. A. Maurer
Subcommittee <i>C</i> on 16-Mm Laboratory Practice (Z52)	M. R. Boyer
Subcommittee <i>D</i> on 16-Mm Projection (Z52)	A. G. Zimmerman

It is certain that but for the immediate availability of these committees, their chairmen and their membership, it would have been difficult indeed to have undertaken the necessary tasks of equipment and method specifications for the military services which were urgently required.

(3) The sponsorship of the entire specification project by a governmental agency in a position to render guidance and financial support

to the project, as well as the existence and availability of a standardizing body of long experience capable of acting as the secretariat of the various specification groups or committees. The task of preparation of specifications involves complexities, need for manpower, and incidental facilities and cost which are usually not fully appreciated by those undertaking a task of such magnitude. The SMPE is thoroughly capable of handling normal standardization projects in peacetime at a reasonable rate of progress which is all that is required under such circumstances. It is unlikely, however, that the Society could have provided the clerical and technical force necessary to act as an effective secretariat for the specification committees under the conditions of greatly accelerated operation and widely expanded scope and detail requisite for specifications needed under wartime conditions by the military services.

However, the American Standards Association had previously been engaged in a War Standards project of somewhat similar nature to that here under consideration. Its expense in these directions was extensive and its staff adequate to handle all secretarial and clerical activities. Furthermore, it had enjoyed the financial backing of the War Production Board in this earlier War Standards project, and had demonstrated its capability of handling such a secretariat within acceptable financial limitations.

Dr. Alfred N. Goldsmith (member, Committee on Standards) had been actively engaged in the earlier project mentioned under this heading and was acquainted with the problems which were involved. He suggested that the Committee on Standards of the SMPE and the Armed Forces enter into corresponding arrangements with the War Production Board, as a financial sponsor, and the American Standards Association, as a secretariat, in order to speed up the project and to insure its successful handling.

(4) Adequate representation of all individuals, groups, engineering societies, as well as interested individuals of specific phases of the motion picture industry are essential as membership on committees to assure unification and agreement on specifications that would receive general acceptance. In the undertaking, the facilities of the Research Council of the Academy of Motion Picture Arts and Sciences, manufacturers of equipment, motion picture film, accessories, and processing plants (motion picture laboratories) were requested to assist in the task as cooperative workers.

These elements have all been coordinated and have been working

together in the unified effort of producing specifications in accord with the requirements of the Armed Forces. Progress has been steadily forward for the past 4 months which will continue as long as the Armed Forces have demands to be satisfied by specification preparation. The following presentations of progress reports of the chairmen of various subcommittees of ASA War Standards Committee on Photography and Cinematography-Z52 will fully show the status of specification work on a number of assignments. The results of the work reported will illustrate the magnitude of the task, the ability of the personnel involved and the cooperative spirit.



## THE ROLE OF THE AMERICAN STANDARDS ASSOCIATION IN WAR STANDARDIZATION\*

J. W. McNAIR\*\*

It may be a surprise to many of today's SMPE members that standardization was probably the most important reason for the founding of the Society. A reading of the early issues of the *Transactions* of the Society, following its founding in 1916, shows a preponderance of articles (now called by the more dignified title of *papers*) on the subject of standardization. To cite just a few instances at random, in the second issue of the *Transactions* there is an article on the importance of precision in the manufacture of cine machinery and film, and another article setting forth suggested standard dimensions for slitting and perforating 35-mm film which are substantially the dimensions in use today.

It is interesting to note that one of the most comprehensive papers which Dr. P. G. Agnew, Secretary of the American Standards Association, has presented to date is one entitled "National Standardization in America," which was presented before the Spring Meeting of the SMPE in 1933 and appears in the October, 1933, *JOURNAL*. Much of the material contained in this article was repeated in a subsequent article by the same author for the *Encyclopaedia Britannica*.

It has been said that the most standard thing in the world is 35-mm film. There is no doubt that a print of a 35-mm film wherever manufactured will, if made in accordance with existing standards and trade practices, project satisfactorily anywhere in the world. Dimensions have been "tied down" and in the case of 35-mm sound film, the Research Council of the Academy of Motion Picture Arts and Sciences has even suggested a recommended sound projection characteristic that has been used for more than 7 years as a reference in theaters. With such standardization and crystallization of trade

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\* Presented Apr. 19, 1944, at the Technical Conference in New York.

\*\* Secretary, ASA War Committee on Photography and Cinematography-Z52.

practices, it is no wonder that both picture and sound from a Hollywood-produced 35-mm film will be satisfactory technically when run in any theater on equipment that has been kept in proper adjustment.

It is obvious that such a desirable state of performance was not achieved merely by promulgating a recommended projection frequency characteristic for the theater equipment used; the *whole process* had to be integrated to make certain that any film would project satisfactorily in any theater. The recommended frequency characteristic was a good starting point for sound in the theater; it was simple and easily applied. The varieties of equipments in use were few; practically all the sound equipment, for example, used high-efficiency, horn-type loud-speakers, the technical characteristics of which were well known. If a film projected on such equipment was unsatisfactory in quality, it was the film that was changed to correct the difficulty. Under these circumstances, attempted correction at the *wrong* point in the system was avoided. Thus, the combination of a good film and good equipment was bound to be productive of a good result.

Unfortunately this happy state of affairs did not prevail when the Armed Forces decided to use 16-mm equipment. The available production capacity for 16-mm films and equipment was relatively small just before the war; the war has accelerated production of these items in pretty much the same manner as it has accelerated radio and other electronic equipment. The standardization job on electronics had to come first; it is used right up in the front line beside weapons. We have had well over 2 years' experience with radio standardization and now it is 16-mm's turn. We hope to be able to benefit in our motion picture standardization from our previous experience in radio standardization and, if possible, use identical component parts with identical stock numbers. In the case of resistors and capacitors, for example, we should be able to do so quite readily as the performance requirements are similar.

And now let me say a few brief words about construction. The beating that military equipment must take if it is to operate successfully at its point of use is widely known. Military equipment is usually transported in carrying cases of the kind indicated in the third (and most recent draft) of the 16-mm projector specification that has just been completed. If you will remember that an enlisted man who picks up a carrying case often does not have the slightest idea as to what is inside, you can well understand why it gets such a

beating. When you put equipment into a carrying case, you can assume that it will be handled no better than a case of "canned willy" (corned beef, to you)—and it may well be that "GI Joe" doesn't like corned willy anyway!

Little things are important. You can obtain an idea of the importance of characteristics of fixed composition resistors when you read over the ASA Specification for Fixed Composition Resistors—C75.7-1943 of which there were 9 drafts; each set of meetings that resulted in a draft required the undivided attention of about 20 to 30 men; all of the men were specialists, and each draft required countless man-hours on the part of the ASA to collect and set up the data in specification form. And yet all this effort was expended (and well-spent, too) for an article that sells at 2 or 3 cents! These specifications are completed and now may be used to describe the composition resistors which are to be used where applicable in the new 16-mm military model projector.

Standardization gets its biggest push during war; the tempo in peacetime is quite slow by comparison. During peacetime standardization is of concern indirectly to all of us, and the procedure of the American Standards Association represents a joint enterprise of the material trade associations, technical societies, and governmental groups together with a cross section of American industry itself. At the present time more than 3000 individuals are enrolled on the committees that are developing new standards or revising standards already in use.

These committees are like miniature technical legislatures set up along industrial lines. The problems to be solved are broken down into parts small enough so that each part can be handled by one of the committees made up of representatives of all groups substantially concerned with the standard. Every effort is made to reach a solution rather than a mere compromise; a consensus of technical opinion rather than a mere majority vote is the objective. It is only in this progressive way that wide acceptance of the standard can be assured with the minimum of delay and the optimum in technical desirability.

American War Standards follow substantially the same plan. As many standardization jobs were needed in a hurry because of the war to aid in the procurement of war material, it was necessary to speed up the process. American War Standards are printed in a special color and format. As these are intended primarily as emer-

gency standards, each will be reviewed after the war to determine whether it shall be:

- (1) reapproved and continued as an American Standard,
- (2) revised, if necessary, or,
- (3) dropped if it has outlived its usefulness.

Before the war, the American Standards Association was supported entirely by industry; during the war, the War Production Board has placed the American Standards Association under contract for the specific standardization projects. The work in connection with 16-mm standardization is being accomplished under this contract. It was begun following a formal request for it from the Armed Forces to the WPB.

The American Standards Association today is generally recognized as the national standardization body for the country. Some of the member bodies are:

Automobile Manufacturers Association

National Electrical Manufacturers Association

American Institute of Electrical Engineers

American Institute of Steel Construction

American Iron and Steel Institute

American Petroleum Institute

American Society of Mechanical Engineers

American Society for Testing Materials

Photographic Mfrs. Group (Anso, Eastman Kodak Co.)

Fire Protection Group (Associated Factory Mutual Fire Insurance Companies, Nat. Bd. of Fire Underwriters, Nat. Fire Protection Assn., Underwriters' Laboratories)

Nine departments or agencies of the Federal Government are also affiliated. The Society of Motion Picture Engineers is an associate member. The officers and a number of members of the Society have cooperated to the fullest possible extent in both the organization and work of the ASA Committee Z52 on Photography and Cinematography. A very large proportion of the members of the committee and its subcommittees are members of the Society. We certainly could not have expected to have had more wholehearted cooperation than we have received on this job. On the work on the 35-mm part of the job the Society is cooperating with the Research Council of the

Academy of Motion Picture Arts and Sciences in setting up the several subcommittees in this field.

For those interested in the methods and accomplishments of industrial standardization, a good over-all view can be obtained from the December, 1943, Silver Anniversary Number of *Industrial Standardization*, the monthly journal published by the ASA.

## SOME FUNDAMENTAL CONSIDERATIONS IN MILITARY AMPLIFIER DESIGN\*

S. L. CHERTOK\*\*

The design of amplifier equipment for military use differs considerably from the design of amplifiers for the commercial market, both in the physical details of construction and in the quality of parts which must be used for trouble-free operation in the field.

The designer of military amplifiers must always keep in mind the extreme conditions of vibration, shock, high humidity, extreme low- and high-ambient storage and operating temperatures, and of salt- and dust-laden atmospheres to which the amplifiers may be exposed. Designing an amplifier which will stand up under these conditions is obviously not the simple job of catalogue assembly which typifies the design of ordinary commercial equipment, which need withstand only relatively "kid-glove" usage, in temperate climates.

Further, the amplifier designer must keep in mind that the using personnel may not always be carefully trained sound men. Consequently, equipment must be as simple and foolproof to operate as possible, so that the most untrained "GI" can use it if necessary. Also, the designer must always remember that eventually the equipment will need repair. He must make provision for quick and easy replacement of parts with other standard parts. There is not a service man around the corner nor is there a parts' jobber 2 miles down the street out in the South Pacific jungles.

One thing the equipment designer can forget is eye appeal. Commercial streamlining and fancy chrome trim need not be allowed to compromise a good electrical design, and functional placement of controls. Plain "o.d." or Navy gray is the height of fashion. Symmetrical placement of controls is frowned upon. Operators will make mistakes under pressure in the dark. Experience has shown that asymmetrically located controls will prevent many *faux pas* in operation. Likewise, controls must be far enough apart and large

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\* Presented Apr. 19, 1944, at the Technical Conference in New York.

\*\* American Standards Association, New York.

enough, so that they can be operated with a gloved hand. It gets a bit chilly showing pictures in the open with the thermometer hovering around freezing.

The mechanical design of typical military amplifiers is much more sturdy than that of their commercial equivalent. Heavier chassis stock and reinforcements to prevent flexing are used. Generous use is made of lock washers, stop nuts, and other means of securing parts to insure their holding together under vibration.



Official U. S. Marine Corps Photo

FIG. 1. Truck-mounted, portable 16-mm sound motion picture projectors, such as this, are used to show training and morale films by the U. S. Marine Corps.

Now, you may question the need for all this, but typical examples of the use to which military motion picture amplifiers may be put are the mounting of a projector and a small gas-driven generator on jeeps or trucks which drive around from area to area showing training and entertainment films as necessary. A typical example of a Marine Corps unit of this type is shown in Fig. 1.

The Air Forces require that portable projectors be capable of continuous transportation for periods as long as 14 hr by air. Unless equipment has been properly designed, one or two such trips will head it for the scrap heap.

Again, in transport by Army truck or other means, equipment is not handled too gently. Consequently, amplifiers may be packed in their carrying cases and may be required to withstand drops from as high as 18 in. on a concrete floor, such as may occur when a man stumbles. A dozen or so drops is plenty tough on an amplifier, or anything else for that matter. There are also gun-shock considerations to be taken into account, such as may be experienced by equipment carried aboard ship. Permanently installed equipment is mounted on shock mounts which help reduce the intensity shock. Portable equipment lying on the floor may be put out of operation unless it is properly designed.

The finishes and materials used in military amplifiers must be capable of withstanding exposure to salt-laden atmospheres, and liberal use is customarily made of stainless steel, plated brass, and other corrosion-resistant materials. Equipment specifications may call for metallic materials to withstand severe salt-spray tests under a 20 per cent salt-spray solution at 130 F for periods ranging from 50 to 200 hr.

Quite often amplifier cases must be drip or splash proof. Where equipment must be capable of operating under these conditions, it means that parts such as volume controls, which protrude through the case, must have special gaskets to keep moisture from entering through the tiny clearance space between the shaft and the bearing. When splash-proof designs are called for, equipments must not leak water when exposed to a 1-in. stream of water under a head of 35 ft played directly on the equipment from a distance of 5 ft for a period of 5 min.

Materials which are susceptible to attack by fungi, or are delectable morsels for tropical beetles, must be avoided. It is customary to spray completely assembled equipments with various fungicidal and insect-proof agents. The eating away of cotton wire insulation by tropical insects can be avoided by replacing with wire that has glass insulation. Fungi will also attack the paper or textile base cones of loud-speakers, and proper impregnants must be used for the speakers if they are to last a reasonable length of time.

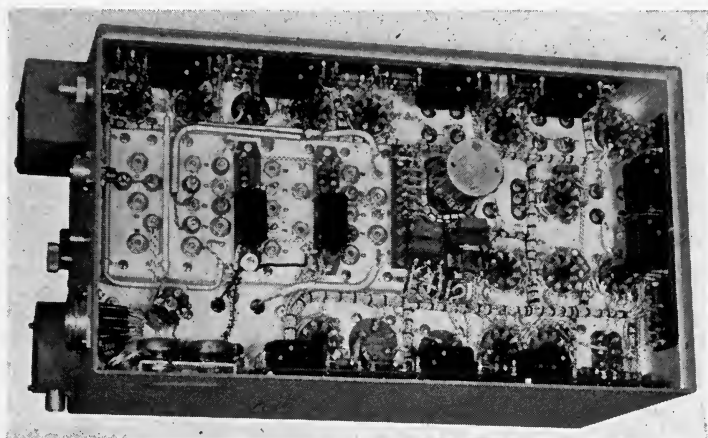
Raw edges of all laminated punchings must be sealed. Otherwise, the layers will soon separate under tropical conditions. So much for the general idea of what faces a military amplifier designer in his general choice of materials.

As far as the design layout of parts is concerned, the layer-built,



point-to-point wiring construction of so many commercial amplifiers is distinctly *passé*. A layer-built amplifier may represent a lower initial investment than an amplifier properly designed for ease of service and replacement, but the final cost of such designs to the military services is prohibitive. It is not considered good design practice in military equipment to save the last  $\frac{1}{8}$  in. of hookup wire and lower the price when servicing of equipment is impaired. Equipment that cannot be serviced easily soon ends on the junk pile.

Fig. 2 shows an underchassis view of a radio receiver which illustrates good design as practiced today for the military and for the de-



Bendix Radio Photo

FIG. 2. Cleancut, easily serviceable design in electronic equipment, such as is shown here, is desired by the Armed Forces.

manding commercial customer. This particular photograph is one of a commercial prototype of an equipment which, relatively unchanged, has been furnished to the military services in large numbers.

Compare this equipment with the ordinary 16-mm projection amplifier, layer built and crammed to save the last possible inch of space. Note how the capacitors and resistors are mounted on terminal boards with very short leads so that they will withstand vibration. Note also how the terminal boards are mounted so that if any resistor or capacitor fails, it may be quickly and easily replaced, since the strips may be quickly unscrewed and turned flat for ease of servicing.

Note how the use of shielding wire has been avoided through use of

copper tubing, allowing quick replacement of leads if necessary and avoiding the insulation leakage troubles which may occur with the use of shielded wire in the field. Note that all the capacitors shown in this particular view are of the molded type. I will have more to say on that later. Note also that most of the wiring has been preassembled as a subassembly and can be soldered in place by a much lower caliber of personnel than is needed to do point-to-point wiring. All in all, I think you will agree that this is a much better type of construction than layer building.

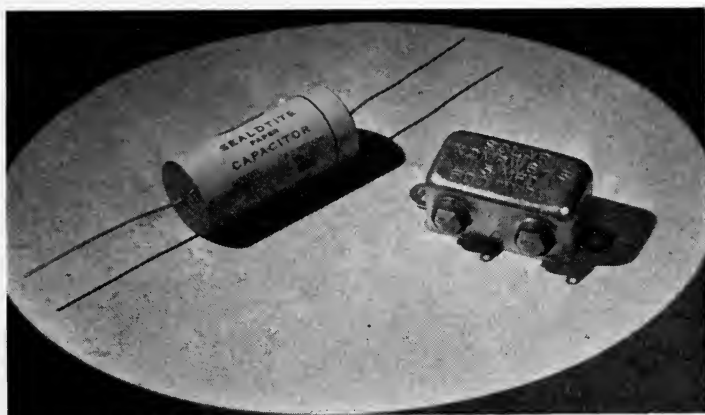
The terminal strips in this equipment have the so-called "turret lug" terminals which have come into favor during this war. This type of terminal solders more quickly than conventional types, and it is possible to remove either of the 2 connections soldered to a terminal without disturbing the other. In addition, connections between various parts on the strips may be run above or below, allowing great facility in wiring.

This type of construction lends itself quite readily to inspection. It is the usual practice to have each inspector place a drop of colored glyptal on each connection as it is checked. Different colors of glyptal may be used on different shifts to help identify strips in case of trouble on the final assembly. The proportion of manufacturer's inspectors to line workers on equipment of this type is much higher than that to which you are probably accustomed. It is quite common to have one inspector check the work of every 3 or 4 assemblers in order to insure a quality product with few rejections on the acceptance line. Of course, these inspectors are supervised again by the government inspectors. Compare this with prewar commercial practice.

Parts in military amplifiers fail most usually because of troubles caused by high humidity. Consequently, components must be of a type which will withstand severe humidity tests either on the part itself or on the assembled equipment. Some parts are capable of being hermetically sealed. Today, the military services are demanding that such parts be furnished if possible. There are various means of accomplishing this, such as gaskets, solder seals to glass or porcelain, or metal-to-glass seals with special alloys.

For example, ordinary paper capacitors furnished in commercial construction are of the tubular cardboard-covered type. Electrolytics may come through in an aluminum can, not hermetically sealed. In the former case, trouble usually occurs when the wax-end seals crack open and moisture enters. In the latter case, not only is there

breathing of moisture, but there is also drying out and consequent loss of capacitance. In modern military construction paper capacitors are either of the oil-impregnated, molded type, not wax impregnated as are their civilian prototypes, or else are of the oil-impregnated, oil-filled, metal-cased type. Fig. 3 shows an ordinary commercial paper tubular capacitor and its metal-cased "bath-tub" equivalent. As a quick check as to whether or not capacitors are properly sealed, samples are placed alternately in baths of warm and cold water. If they are improperly sealed, the capacitors will either short circuit, or there will be a marked decrease in the insulation resistance.



Solar Mfg. Photo

FIG. 3. This photo shows an 0.5  $\mu$ f, 600-v paper capacitor of the type used in ordinary commercial amplifiers, left, and a hermetically sealed, metal-cased capacitor of the same rating designed for military electronic equipment.

As far as the electrolytic capacitors are concerned, they are considered a necessary evil to be avoided whenever possible. In some cases, of course, it is not possible to avoid their use. Then special electrolytics, properly designed to withstand the specified operating ambients, are used. But, as you know, electrolytics designed for low-temperature operation are not the best design for high-temperature applications and vice versa. Since motion picture amplifiers are not ordinarily used at temperatures below freezing you may think high-temperature electrolytics would be all right; but it must be remembered that equipment may be stored in tin shacks on deserts or transported in ships' holds stacked next to steam pipes.

No electrolytic that I know of will withstand a temperature of 185 F (85 C) for more than 100 hr without having to be put back on a forming rack. Forming racks are not found outside capacitor manufacturers' factories.

It has been reported that there has been extensive trouble caused from high-temperature storage conditions in equipments that were not at all affected by storage temperatures as low as 65 below zero. Incidentally, such low storage temperatures mean certain failure for parts sealed with ordinary wax or impregnating compounds. This is another reminder that sealing and impregnation of parts must be intended for military service.

Transformers are usually potted and of late are also hermetically sealed. Where direct current must pass through windings, it is considered good practice today to use acetate winding cores, acetate layer insulation, acetate interlayer insulation, and acetate cross-strip insulation. The reason for the popularity of this insulation is typified by the comparative requirements of one large equipment manufacturer on a certain humidity cycling test. Acetate insulated transformers are required to withstand 80 days of test before failure, while ordinary unpotted paper units of the type used in the cheaper commercial amplifiers are required to withstand only 4 days on this test. Potting the ordinary paper unit brings its life up to 90 days on the same test. When the acetate insulation and potting are combined, you have a tremendous improvement in service life. When equipment is hermetically sealed on top of that, you will agree that there need be no worry about transformer failures from electrolysis or humidity in the field.

Resistors, both composition and wire-wound, used in military equipment must withstand severe thermal shock and salt water immersion cycling tests as a guarantee of a reasonable length of service life. Composition resistors furnished today in military equipment are almost all of the so-called insulated type having a molded insulation over the resistance element. This insulation is never relied upon as a permanent insulation as is done quite often in commercial practice. The military services recognize that because of certain manufacturing conditions, it is quite possible to have a conducting layer of the resistance element extend in about  $\frac{1}{32}$  in. from each end around the resistor circumference.

Insulated resistors using a ceramic outer shell are dropping out of production. Vacuum wax impregnation and filling of the ends will

not keep out moisture as the wax cracks open during sudden shifts in temperature, such as may be experienced in aircraft.

The wire in military equipment is not the push-back or rubber-covered wire used in ordinary commercial construction. The preferred type of wire has an inner insulation of either 2 overlapping tapes of cellulose acetate butyrate, or of a vinyl compound, or has an extruded vinyl insulation. The outer braid is usually a double braid of fiber glass. The wiring is usually made up in harnesses which are preassembled after thorough checking. The forms on which these cables are made quite often have colored lines running between the various pins, so that the most inexperienced operator can assemble the cabling with little trouble.

Laminated switches of the home vacuum-cleaner type found in commercial construction do not stand up in service. Molded housing-type switches are preferred.

Tube sockets of the gang type are also out for military purposes. Not only do they not lend themselves to the use of tube clamps which are a necessity to withstand vibration and shock, but they also form a perfect leakage path between tubes when moisture enters the phenolic strips.

With regard to the choice of tubes, the military amplifier designer does not have at his command the large and almost endless choice with which he can play in civilian design. Equipment designed for the services must have all tubes, including the photo-tubes, chosen from the Joint Army-Navy Preferred List of Radio Electron Tubes. Exceptions to this list are allowed only in very special cases. To design equipment using tubes which must be specially selected is considered an unpardonable sin of the highest order. Equipment must be designed so that any tube with the proper type number will work when plugged into a socket, regardless of whether or not the last 2 db of output is sacrificed.

Incidentally, not only in the choice of tubes, but in the choice of all parts are the services insisting on the use of standard, commercially available parts. The problems of stocking a multiplicity of special parts have been such that it is very easy for a designer to get into the "doghouse" through using special parts.

Regardless of the type of parts that is chosen, manufacturers of equipment for the Armed Forces must have very thorough incoming inspection, checking each individual part as received. Slip-ups and mix-ups do occur in parts manufacturers' factories, as well as in

assembly. If equipment is to be gotten out on time with the least amount of trouble, thorough incoming inspection is necessary.

In order to facilitate servicing equipment, each piece or part must be identified by being marked with a circuit element number or by color coding. In cases where it is not possible to mark circuit element references on parts, they are usually marked on the chassis or mounting strips immediately adjacent. Compare this with ordinary commercial practice, especially when you remember that the repair man of commercial equipment does not have on hand, mounted on the chassis cover, or in some other convenient spot, the clear circuit diagram which the military services insist upon.

The details of design and construction which I have just discussed are, of course, much more thoroughly covered in the procurement specifications of the service or services concerned. All these specifications emphasize the one "must" feature required of military equipment—it must work under all conditions in the field, and that is the most essential feature to be kept in mind by the designer of military amplifiers.

## REPORT OF SUBCOMMITTEE B ON 16-MM SOUND\*

J. A. MAURER\*\*

At the meeting of the War Committee on Photography and Cinematography-Z52 held on December 15, 1943, Subcommittee *B* was assigned the task of preparing specifications for 16-mm motion picture sound-test films.

The first meeting of the Subcommittee was held at Nela Park, Cleveland, Ohio, on Thursday, January 13, 1944. This meeting discussed a set of tentative specifications which had previously been drawn up as part of a program initiated by the Board of Governors of the Society of Motion Picture Engineers, at its meeting in the spring of 1943, for the production of a new set of SMPE 16-mm test films. As the result of discussion by the Subcommittee, a new set of draft specifications was prepared for the following films:

(1) A Test Film for Determining Uniformity of Scanning-Beam Illumination (frequently referred to in the industry as a "snake track").

(2) A Multifrequency Test Film for Field Testing 16-Mm Sound Motion Picture Projectors.

(3) A 3000-Cycle Flutter Test Film.

(4) A Buzz-Track Test Film for Adjusting and Checking Scanning-Beam Location in 16-Mm Sound Projectors.

(5) A Sound-Focusing Test Film.

The second meeting of the Subcommittee was held on March 7, 1944, at the Engineering Societies Building in New York City. The draft specifications resulting from the first meeting were reviewed and, after amendment, were referred by vote of the Subcommittee to the parent Committee, Z52, with a recommendation that they be approved as American War Standard Specifications. This meeting also drafted a specification for a sixth test film, a 400-Cycle Signal Level

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\* Presented Apr. 19, 1944, at the Technical Conference in New York.

\*\* Chairman, Subcommittee *B*, ASA War Committee on Photography and Cinematography-Z52.

Test Film, intended to provide a primary standard of signal level, accurate within approximately  $1/2$  db. This specification was also referred to the parent Committee, Z52, for approval as an American War Standard.

At its meeting in Cleveland on January 11 and 12 Subcommittee *D* on 16-Mm Projection had referred to Subcommittee *B* the problem of standardization of the dimensions of 16-mm sound records and scanning area. The March 7th meeting of Subcommittee *B* reviewed the work on these standards which had been done previously by the Standards Committee of the Society of Motion Picture Engineers, and approved a drawing embodying the result of this work with the addition of a specification for the dimensions of the printed area.

The third meeting of the Subcommittee was held at the Engineering Societies Building in New York City on April 20. At this meeting the Subcommittee discussed the objections to the proposed specifications which had been brought up in the letter ballot by Committee Z52, and recommended a number of changes. The specifications in their resulting, and probably final, form were referred back to Committee Z52 at its meeting on April 22.

Subcommittee *B*, therefore, has completed its initially assigned tasks. However, at the meeting of Subcommittee *C* on 16-Mm Laboratory Practice on April 21, this committee referred the problem of sound-qualification tests to Subcommittee *B*. Your Chairman has appointed a subgroup under the Chairmanship of Mr. Clyde R. Keith to prepare recommendations to meet the needs of Subcommittee *C*. This group will study the problems of cross-modulation, intermodulation, frequency response, and flutter testing for the control of 16-mm sound-track processing, and is expected to draw up specifications for the production and use of a special test leader to be made in both 35-mm and 16-mm. The sound-test material contained in this leader, after reproduction by whatever sequence of processes is used in arriving at the 16-mm release print, should furnish a basis for accurate evaluation of the quality of the sound track on the final print. It is believed that this test leader will prove an extremely useful tool for all laboratories doing 16-mm work, as well as meeting the present need of the armed services.



## REPORT OF SUBCOMMITTEE C ON 16-MM LABORATORY PRACTICE\*

M. R. BOYER\*\*

Subcommittee C on 16-Mm Laboratory Practice has been setting up specifications for 16-mm motion picture release prints. As explained previously, these specifications are intended to be War Standards, but many of them will be applicable to peace-time laboratory practice.

To date the Committee has reached agreement on the following items in 16-mm print specifications:

- (1) Materials—Fine-grain raw stock is recommended.
- (2) Print treatment—Prints shall be treated over the entire width of the emulsion surface to facilitate projection.
- (3) Methods of marking prints—A standard of marking prints has been set up so that the location of titles, type of print, and emulsion position will always be noted in the same location.
- (4) Physical defects—A separation of well-known defects into tolerable and intolerable classification has been made.
- (5) Splices—A standard width has been established, and an allowable number of splices per reel has been decided upon.
- (6) Residual hypo content—A method of measuring residual hypo content of prints has been chosen, and the maximum allowable content decided upon. This will probably be changed when permanent standards are set up, as the consensus of opinion was that the allowable hypo content could be greater for war prints than for library prints.
- (7) Density and gamma variations—Limits of allowable density and gamma variations from print to print have been established.

On the following points decision has not yet been reached:

- (1) Resolution specifications.
- (2) Distortion and signal-to-noise ratio—This will probably be

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\*\* Chairman, Subcommittee C, ASA War Committee on Photography and Cinematography-Z52.

referred to Subcommittee *B* on Sound, as methods of test have not yet been agreed upon.

(3) Measurement of printer slip.

(4) Dimensions of 16-mm printer aperture for picture.

(5) Leaders and trailers—Up to the present time it has been the custom to use the standard Academy 35-mm leader. There is apparently no particular reason for this in 16 mm, and a standard 16-mm leader will be proposed, as well as a standard trailer on which measurements may be made for both sound and picture uniformity and quality.

On completion we hope to have set up standards of sound and picture processing which any purchaser of 16-mm printing may use as a basis for writing laboratory contracts.

## REPORT OF SUBCOMMITTEE D ON 16-MM PROJECTION\*

A. G. ZIMMERMAN\*\*

It had been our intention to report the activities of Subcommittee *D* on 16-Mm Projection of ASA War Standards Committee-Z52 in detail. Although of great interest to the Committee proper, it might be repetitious to some of us; however, to the majority, it should be of great interest and concern to the Society.

With the papers presented by Mr. J. W. McNair,<sup>1</sup> Secretary of the Z52 Committee, and Mr. S. L. Chertok<sup>2</sup> of the American Standards Association, Secretary of Subcommittee *D*, there is little left for us to say regarding our committee activities—they have covered the subject quite thoroughly.

We believe credit is due the Society of Motion Picture Engineers, and particularly the Chairman of the Non-Theatrical Equipment Committee of approximately 4 years ago, Mr. John A. Maurer. Through Mr. Maurer's efforts, the Non-Theatrical group did accomplish some results in arriving at certain specifications for 16-mm projection equipment, which would be a marked improvement over the existing equipments. Unfortunately, the Chairman was not permitted any spare time in which to prepare the material which had been discussed at the meetings of the Non-Theatrical group so that no complete minutes or specifications were issued. Mr. Maurer compiled this material, supplementing it with some additional information, and presented to Z52 *D* a preliminary specification embodying the most desirable changes in features which the Society has fostered as a Non-Theatrical group, abridged with some improvements.

It has been stated that the smaller the committee the more rapidly they move. It has been said that this Committee was the exception that proved the rule, inasmuch as at our Rochester meeting we had 52 individuals present for some of our meetings. In this case the

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\* Presented Apr. 19, 1944, at the Technical Conference in New York.

\*\* Chairman, Subcommittee *D*, ASA War Committee on Photography and Cinematography-Z52.

presence of the specification enabled us to move into the subject very rapidly in the Cleveland meeting; thus enabling the American Standards Association group to prepare Draft No. 2, which, when attacked in Rochester, proved to be such that Draft No. 3 was not too difficult of preparation.

It is my privilege, as Chairman of *Z52 D*, to report at this time, despite the very strenuous requirements as indicated by the speakers immediately preceding me, that upon favorable action of the parent Committee *Z52* on April 22, the specification will be submitted to the Joint Army and Navy Board in Washington for action in a program which will establish the specification as JAN. This will complete our preliminary work in specification preparation on the Class *I* Projector (incandescent lamp).

Class *II* Projector, which is primarily to be the same mechanism except for provision for an arc lamp, will be prepared as soon as sufficient information is available regarding some of the design problems involved, as well as the definite decisions regarding the light source.

The screen problem has been referred to a subgroup, headed by Mr. A. L. Raven, which is to prepare such information as is available; whereupon a meeting of Subcommittee *D* will be called to discuss the situation and compile a specification, in conjunction with the Armed Forces.

The test films for use in either designing or acceptance testing the Class *I* or Class *II* projectors mentioned above were assigned to this Subcommittee. Action taken by the Subcommittee is such that they too can be submitted to *Z52* for their approval; whereupon War Standard Specifications can be issued for procurement for the Armed Forces.

May I, as Chairman of *Z52* Subcommittee *D*, take this opportunity to express my personal gratitude to those who, either as direct representatives on the committee, or as auxiliary aids in other departments of the Society or branches of the armed service, have contributed to the program which enabled us to complete our obligations with dispatch.

#### REFERENCES

<sup>1</sup> McNAIR, J. W.: "The Role of the American Standards Association in War Standardization," *J. Soc. Mot. Pict. Eng.*, **43**, 1 (July, 1944), p. 5.

<sup>2</sup> CHERTOK, S. L.: "Some Fundamental Considerations in Military Amplifier Design," *J. Soc. Mot. Pict. Eng.*, **43**, 1 (July, 1944), p. 10.

## REPORT OF SUBCOMMITTEE G ON EXPOSURE METERS\*

J. M. WHITTENTON\*\*

A proposed American War Standard Specification for Exposure Meters has been drawn up as a part of the standardization activities of the War Committee on Photography and Cinematography-Z52. The Z52 American War Standards Subcommittee G, under the Chairmanship of Mr. F. K. McCune, undertook this work at the request of Capt. Lloyd T. Goldsmith, Signal Corps, who is Chairman of the Armed Forces Committee on Photography and Cinematography.

The Armed Forces in the past have purchased exposure meters which, for the most part, have been of the commercial type, designed essentially for peace-time applications. Reports from the field have indicated that not all of these meters have successfully fulfilled the rigid requirements of the armed services in battle areas in all parts of the world. This fact made it imperative to consider the service requirements for exposure meters and to draw up a specification that would cover a standard type of meter which would be entirely acceptable, from the standpoint of construction and performance, to all branches of the service.

Such a specification has been drawn up by members of industry in cooperation with representatives of the armed services, and it is hoped that this specification will be approved as a joint Army-Navy specification and used first as a development specification, and ultimately as a basis for procurement of production units.

The work of this Subcommittee began by deciding upon a method of light measurement and maximum sensitivity. It was decided that the new exposure meter should be of the general-purpose type designed to operate on the principle of reflected light, in order to be adapted to all types of military use. The maximum sensitivity de-

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\* Presented Apr. 19, 1944, at the Technical Conference in New York.

\*\* Alternate Chairman, Subcommittee G, ASA War Committee on Photography and Cinematography-Z52.

sired for such a general-purpose instrument was defined as "an instrument whose pointer would deflect at least 0.010 in. for an exposure of  $f/11$  with a shutter speed of 1 sec and a film speed number of 100, when used by the reflected light method." This represented less sensitivity than had been previously supplied by most manufacturers, but this change was felt fully justified, since it would enable them to make more sturdy devices which would be necessary to meet the performance specifications which were to follow.

The over-all performance of the device was next considered. An exposure meter is essentially a sensitive microammeter used in combination with a light-sensitive cell of the barrier-layer type, equipped with a suitable light-restricting mechanism over the cell, and a calculator by which exposure can be determined. In view of this, it was felt that the basic mechanism should meet performance specifications similar to those which were set up recently for small panel-type indicating instruments. The American War Standard for Small Panel Instruments, C39.2-1944, was therefore used as a basis for making up this proposed American War Standard for Exposure Meters.

In this proposed standard, careful consideration has been given to the mechanical construction and electrical performance. From the standpoint of mechanical construction, the case design must be dust-tight and moisture-proof, all component parts will be required to be adequately protected against rust and corrosion when subjected to all types of world climatic conditions, moving systems will be balanced within closer limits, and ready means of instrument adjustment will be required. The calculators will be designed to use standardized  $f$ /stops, shutter times, and ASA exposure index speed numbers.

One of the prime purposes of this proposed standard was to set up requirements which would ultimately result in exposure meters made by various manufacturers indicating more nearly the same exposure. To attain this, rigid limits of angle of acceptance, method of calibration, cell spectral sensitivity, and performance were set up.

The angle of acceptance of light energy striking the light-sensitive cell surface was defined, in order to more definitely control the directional characteristics of the device. Essentially this means that some form of hood, barrier, or grid must be placed in front of the cell in such a manner that not less than 60 per cent of the luminous energy actuating the meter from a screen of uniform brightness shall come from an area included within a cone whose half-angle is 25 de-

grees. Definite test conditions have been set up to insure the conformance of meters to this requirement.

The meter and calculator combination on all makes of exposure meters will be designed to conform with the following law:

$$T = \frac{1.25 f^2}{B \times S} \quad (1)$$

where  $f$  =  $f$ /stop;  $B$  = brightness of a uniform brightness surface as described below in candles per sq ft;  $S$  = Exposure Index or ASA Speed Number; and  $T$  = Shutter time in sec.

The specific calibration methods used by the various manufacturers will not be specified; however, a uniform brightness screen for a

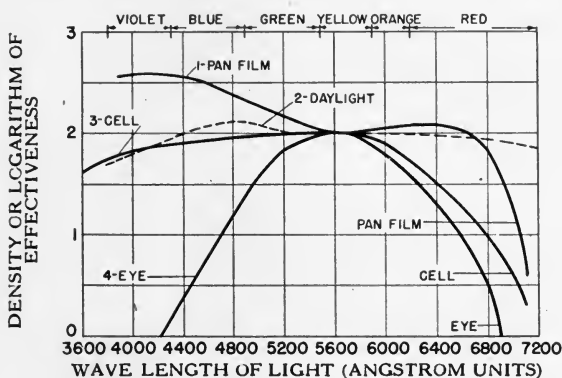


FIG. 1. Color sensitivity of various types of sensitive materials and cell compared with the energy in daylight.

transfer standard has been described in order to insure that all types of meters will conform to the above law for calibration. This uniform brightness screen has been described in general as a good quality pot opal glass illuminated approximately uniformly by a light of equivalent color temperature of between 2680 K to 2820 K at level of 100 to 250 candles per sq ft.

The importance of controlling spectral sensitivity of the light-sensitive cell has been recognized. The response of a typical light cell to light covers a range of wavelengths greater than that of the human eye and less than that of panchromatic film, as may be seen by Fig. 1. After comparing the spectral response of light-sensitive cells available today, an envelope curve was agreed upon which will control this characteristic within adequate working limits. The

curve for cell response, as shown in Fig. 1, falls approximately in the center of the allowable envelope as set up in the new specification.

Performance tests, more rigid and more in detail than previously required, have been made a part of this specification and are listed in Table 1, with allowable limits for each test.

In addition to the requirements of shock and vibration tests indicated above, an abuse test has been added to insure that the exposure meters passing the performance tests will be sturdy enough to

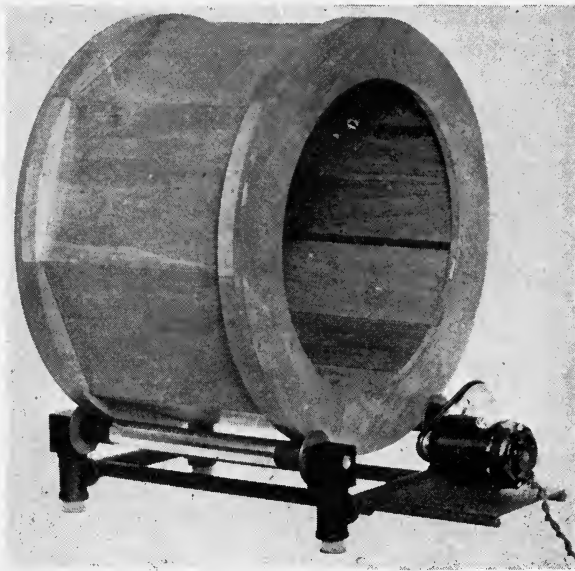


FIG. 2. Abuse-testing mechanism for service-model photographic exposure meters.

withstand the requirements of the services. The tests will be made in an abuse tester which has been standardized for this application. It consists essentially of a tumbling barrel about 15 in. in diameter (see Fig. 2) which will rotate at a speed of 60 rpm. Sample exposure meters will be placed in this barrel and will have to withstand the random shocks of unpredictable acceleration for a period of one minute without becoming inoperative.

Three of the leading exposure meter manufacturers generously contributed their engineering test data and experience on exposure meter design in the making up of this proposed standard. It is felt



TABLE 1

Description of Test	Test Limit (Upper $\frac{1}{3}$ Scale)
Initial accuracy	Within $\frac{1}{3} f$ /stop
Response time	3 sec max
Temperature influence ( $\pm 10$ C change)	$\frac{1}{6} f$ /stop max change
Heat effect at +55 C (131 F), 3 cycles	$\frac{1}{3} f$ /stop max change
Permanent change due to +55 C test	$\frac{1}{3} f$ /stop max change
Cold effect—perm. error due to -35 C (-31 F) expos.	$\frac{1}{3} f$ /stop max change
Humidity test of 6 hr at +55 C (131 F) at 95 per cent RH and 18 hr in reducing temp and 100 per cent RH, 2 cycles	$\frac{1}{2} f$ /stop max change
Effect of vibration at from 500 to 2500 cycles per min at 0.018 in. to 0.020 in. amplitude for 2 hr	$\frac{1}{6} f$ /stop max change
Pivot friction as a result of vibration	$\frac{1}{3} f$ /stop max
Effect of shock—50 G (50 times force of gravity), 10 times, 3 directions	$\frac{1}{6} f$ /stop max change

this work will result in a specification that will cover the requirements for and the performance of exposure meters which will adequately meet the needs of the Armed Forces and also others who use this type of device. This proposed American War Standard should also be of much assistance as a basis for other standards for exposure meters which may be required in the post-war period.

## A FILM FOR MEASURING PROJECTOR STEADINESS\*

M. G. TOWNSLEY\*\*

*Summary.*—A film is described which has circular perforations in each frame which are punched after exposure and processing of the film. The perforations in each frame are located from the normal film perforation and from the edge of the film which is guided during projection. The modification of a standard Bell and Howell perforator for producing this film and a method for checking the accuracy of the finished film are described.

Steadiness in a motion picture projector is the ability of the film moving mechanism to place successive frames of film in the aperture in such a manner as to cause the images in each successive frame to occupy the same position on the screen. Sixteen-mm projectors locate the film frames vertically from a perforation and laterally from the edge opposite the sound track.

A film having an image in each frame located vertically from the same perforation as is used in the projector and laterally from the guided edge may be used to measure the steadiness of a projector, provided that the location of the image is performed with sufficient precision. This could be conveniently accomplished by perforating a pattern in each frame at the same time as the film perforation in the raw stock. There are, however, certain disadvantages in this method. In the first place, it is usual to perforate several frames at the same time when punching raw stock. This introduces possible systematic errors in the film perforation and makes it necessary that the multiple punches required to perforate the steadiness pattern each be accurately located with respect to the corresponding film perforating punch. The possible systematic errors in perforation of the raw stock and possible variations in punch sizes make it desirable to produce the steadiness test pattern one frame at a time, locating always from the same side of the perforation as will be used in projection and from the guided edge.

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\* Presented Apr. 19, 1944, at the Technical Conference in New York.

\*\* Bell and Howell Company, Chicago, Ill.

Complete elimination of the systematic errors requires that each steadiness test pattern be located in the projector from the same side of the same perforation as was used in perforating.

It has been found that a suitable pattern for steadiness testing consists of a film of medium density in which are punched two  $1/16$ -in. diameter holes in each frame of film. One of these holes is on the frame line and the other is located approximately in the center of the frame as shown in Fig. 1.

To be certain that the steadiness test pattern is located from the same side of the same perforation as was used to locate it when it was punched, it is necessary that the film be threaded in the projector in the proper relation. This is accomplished by printing a suitable title to identify the proper threading position of the film. The title is printed in a slightly lighter density on a background of density approximately 0.3 so that the title itself is only a threading guide and is not present in sufficient contrast to interfere with steadiness test measurements.

After printing and processing of the title, the perforation of the steadiness pattern is performed on a modified Bell and Howell perforator (Fig. 2). The perforator is modified to feed one frame at a time, and a "die set" having pilot, punches, film guide, guide pins, and stripper plate is attached to the perforator ram. As the ram descends, the pilot enters the perforation first. The pilot fills the hole vertically, but not laterally. Spring edge guides locate the film against a fixed rail. The shuttle is set to feed the film approximately 0.002 in. short of its proper location so that the tapered end of the pilot makes the final location always from the same side of the perforation. Figs. 3 and 4 show close-ups of the die set.

As the descent of the ram continues, the stripper plate closes to hold the film firmly while the punch completes its stroke and perforates the film.



FIG. 1. Holes punched in film for testing projector steadiness.

Various projectors locate the film differently in the gate. This makes the film of maximum value only for the projector which locates from the same perforation as is used to locate in perforating the steadiness pattern. In the Bell and Howell projector, the film is located from the perforation at the upper corner of the aperture. The present film is made to locate from this same perforation. If the film is used in any other projector, the inherent steadiness of the film

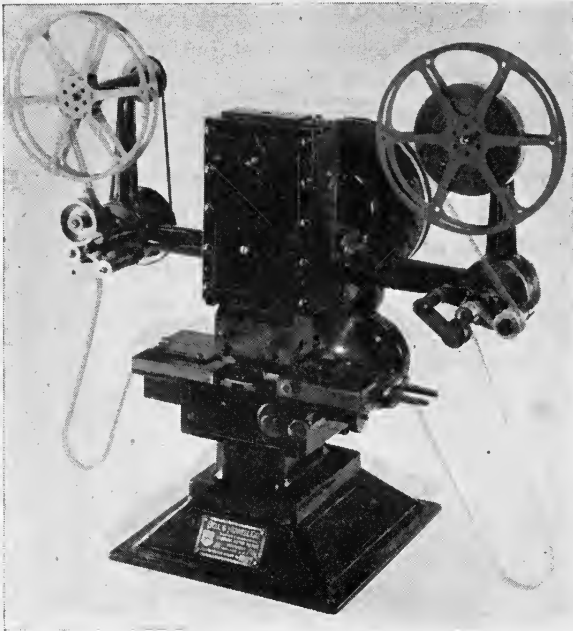


FIG. 2. Bell and Howell film perforator modified to feed one frame at a time.

will be no better than the combination of the errors of original perforation and steadiness perforation will permit.

As a part of the title which appears in each frame are lines which tie together the two perforations in each frame which were punched at the same time and the film perforation from which they were located. As seen on the screen, these are the center and lower steadiness perforations and the lower left corner film perforation.

Current projector specifications call for steadiness tolerances of from 0.2 to 0.3 per cent of the picture width. Careful workmanship

in preparation of the film results in film with an inherent unsteadiness of approximately 0.05 per cent of the picture width.

Two different procedures have been used to measure the inherent unsteadiness of the film. During the original experimental work which led to the present film, a projector was fitted with a cut-away aperture plate which permitted the perforation which located the film in the aperture to be projected on the screen. The relative unsteadiness between this perforation and the steadiness perforation was measured to give a direct measurement of the unsteadiness.

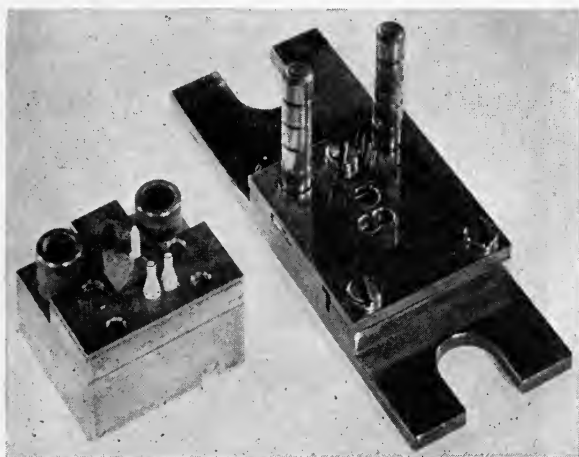


FIG. 3. Close-up of "die set" used to perforate steadiness test film.

The current procedure is to measure the relative unsteadiness between successive frames. This is done by making use of the perforation on the frame line. The perforation on the lower frame line was located from a different film perforation one frame behind the film perforation which located the steadiness perforation in the center of the frame. A pair of mirrors on a standard is set up approximately 18 in. in front of the projection lens as shown in Fig. 5. The mirrors are adjusted in the projection beam so that the center hole is reflected to the screen by one mirror and the lower hole is reflected to the screen by the other mirror. Tilting screws on the mirror mounts make it possible to shift the images so that they are immediately adjacent to each other. The relative movement of the two images

during projection is measured directly as the inherent unsteadiness of the film. All film now produced is completely inspected in this manner.

It is obvious that the second method also checks the film for uneven spacing of the film perforations so that film which meets the unsteadiness requirements when inspected in this manner may be used in any projector.

It has been suggested that a printed spot be used instead of the perforated hole. This would have the obvious advantage that the tendency of the present holes to collect dust would be overcome. It

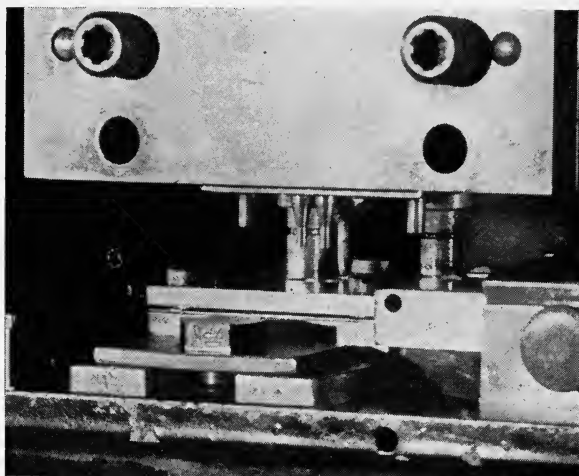


FIG. 4. Die set mounted in Bell and Howell perforator.

has been found that the possibility of emulsion shift during processing imposes such rigid processing conditions as to make the production of film of sufficient accuracy seem unprofitable.

The film is used to measure projector unsteadiness by threading in the projector so as to project the guide title correctly and projecting the steadiness perforation to a suitable size. If the steadiness perforation is projected to a diameter of  $15\frac{5}{8}$  in., the unsteadiness may be scaled directly with a scale graduated in tenths of an inch,  $\frac{1}{10}$  in. being equal to an unsteadiness of 0.1 per cent of the picture width. The unsteadiness is measured as the maximum excursion of the test pattern during the specified unsteadiness period.

It is obviously necessary that the projector be rigidly supported

during the test. This may be checked by projecting the edge of the aperture with no film in the gate, and examining the image for movement.



FIG. 5. Adjustable mirror setup to measure the relative unsteadiness between successive frames.

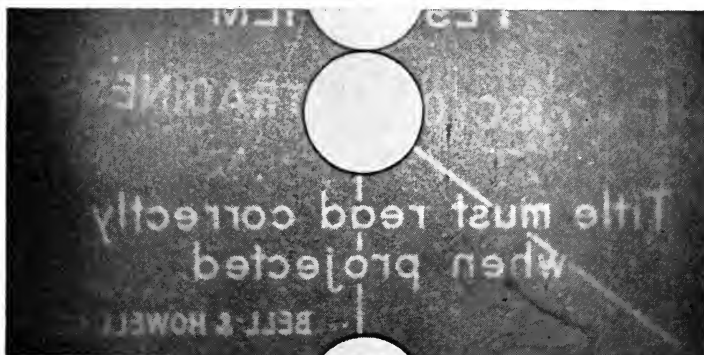


FIG. 6.

The author is indebted to Mr. L. T. Sachtleben for the suggestion that lines be added to the guide-title to identify the steadiness pattern punched from a common film perforation and the film perforation from which they were punched.

Several years' experience with this steadiness test has shown it to be accurate, simple, and readily performed by comparatively unskilled personnel. The test film is simply and easily prepared, accurate when produced by skillful personnel, and readily inspected for inherent accuracy.

Use of the film in a short loop tends to cause excessive perforation wear and the unavoidable jump from the splice tends to confuse the measurement. For these reasons, it is not recommended that the film be used in lengths shorter than necessary to perform the complete test. A length of 25 ft may be made part of a multiple purpose test film, but at least 50 ft should be used when no other test is incorporated in the same film.



## THE EFFECT OF LAMP FILAMENT POSITION ON PROJECTION SCREEN BRIGHTNESS UNIFORMITY\*

M. G. TOWNSLEY\*\*

*Summary.*—Data are given on the effect of filament shift and filament rotation on the screen brightness and brightness uniformity in a high-efficiency 16-mm projection optical system. The data show that the filament location and orientation are critical for maximum brightness and best uniformity. The precision illumination-testing projection equipment used in making these tests is described.

In 16-mm projection it is desirable that the screen brightness be as uniform as possible, and that the total screen illumination be as high as possible. Important among the many factors which contribute to the screen brightness and the brightness uniformity are the condenser design, the projection lens design, and the location and size of the lamp filament.

Mili and Cook<sup>1</sup> have shown that properly designed aspheric condensers contribute materially to the screen brightness and screen uniformity. The commercial difficulty of fabricating aspheric condensers has prevented their wide commercial use although some commercial 16-mm projectors are equipped with aspheric condensers.

Comparatively few data are available on the effect of the filament position on the screen brightness and brightness uniformity. It is the purpose of this paper to present the results of studies made in the laboratories of the Bell and Howell Company on the effect of the filament location.

The filament alignment in a projection lamp is not under the control of the user so that the conclusions drawn from the present investigations will be an indication of the allowable filament location tolerance in the lamp base and lamp socket construction.

The condenser system in a 16-mm projector images the filament at a point usually within the projection lens and passes substantially all of the light which emanates from the condenser through a rather sharply defined circle at the position of the aperture plate. The maxi-

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\*\* Bell and Howell Company, Chicago, Ill.

imum condenser efficiency is obtained when the filament image approximately fills the projection lens aperture, and the aperture illumination circle is as small as is possible with complete coverage of the aperture. It is also necessary that the maximum possible solid angle be subtended by the entrance pupil of the condenser.

Lateral shifting of the filament shifts the image of the filament within the projection lens so that it no longer properly fills the projection lens, resulting in loss of light and uneven illumination in the projector aperture.

All 16-mm projectors are equipped with a spherical reflector behind the projector lamp which forms an image of the lamp filament in the plane of the filament itself. This image returns a considerable quantity of energy to the filament plane and results in additional heating of the filament and higher filament efficiency. Lateral shifting of the filament causes this reflected image to shift in the opposite direction, decreasing the overlap of the filament and image, and lowering the filament efficiency.

The first set of tests was conducted to determine the effect of shifting the filament laterally. A 750-w, 100-v, 25-hr lamp was used with a high-efficiency condenser and a 2-in.  $f/1.6$  projection lens. The condenser used is equivalent to the most efficient condenser used by Bell and Howell in a commercial projector. The lamp was operated at its rated voltage throughout the testing procedure.

The equipment used in performing these tests is the projection optical testing bench which was developed for the purpose of testing projection optical and illumination systems in this laboratory. The entire unit is mounted on a large optical bench and consists of a lamp house, which is equipped with a precision socket adapted to take a large lamp mounting flange, a movable condenser holder, which will accept any condenser diameter and may be moved longitudinally to position the condenser at the proper relation to the lamp, and a movable aperture plate and lens holder, which may be moved longitudinally with relation to the condenser mount and lamp housing. This complete unit forms a flexible projection optical system which may be set up to simulate the optical system used in any desired projector.

The optical bench is equipped with a saturated iron constant voltage transformer which maintains the voltage output constant within 0.1 v for a line voltage fluctuation of several volts. This effectively maintains the constant voltage on the lamp which is essen-

tial to proper testing. Various voltages for testing with lamps of differing design voltages may be obtained by feeding the output of the constant voltage transformer into a tapped auto-transformer from which any output voltage from 15 v to 130 v may be selected in steps of one volt.

Voltmeter connections are made directly at the lamp socket so that the voltage supplied to the lamps may be read without the inclusion of any line drop. Large flanged brass rings are provided into

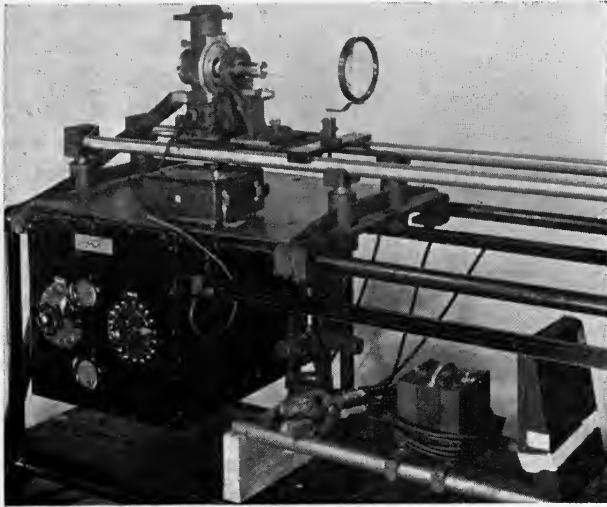


FIG. 1. Construction and arrangement of lamp testing equipment.

which the lamp is soldered in a special positioning fixture which projects both face and edge views of the filament on a graduated screen so that the filament may be properly located with respect to the base laterally, vertically, rotationally, and longitudinally along the optical axis. When the lamp is thus positioned, it is soldered into the brass flange and the entire lamp and flange assembly is then ready for transfer to the projector lamp house. The flange diameter is maintained to fit the lamp socket. The flange is provided with a pin which engages a slot in the lamp socket to hold the lamp in rotational alignment. With this arrangement, it is possible to position the lamp filament with respect to the projector optical axis

within a tolerance of  $\pm 0.005$  in. and a rotational tolerance of approximately one degree.

For the purpose of this test, a special lamp socket was constructed having a lateral slide so that the lamp could be shifted laterally, the amount of shift being measured by a depth micrometer. The rotational adjustment of the lamp filament position was made by attaching a protractor to the lamp, unsoldering the lamp in the ring, and rotating the lamp through the desired angle.

Fig. 1 shows the general arrangement and construction of the lamp testing equipment described, and Fig. 2 shows the lamp base which was used for these tests.



FIG. 2. Lamp base used for testing projection optical and illumination systems.

A standard 16-mm aperture was projected to a screen width of 18 in. Screen illumination readings were made with a Weston Model 603 photometer at 9 positions on the screen: 4 corners, the center of each edge, and the center of the screen. The reference position was the position in which the lamp filament planes were parallel to the film gate and the center of the filament was on a line perpendicular to the film gate and passing through the center of the aperture.

Table 1a gives the illumination readings at the 9 chosen positions for the lamp on center, 0.020 off center, 0.040 off center, 0.060 off center, and 0.076 off center. Table 1b gives corresponding readings converted to per cent of the maximum reading on the screen. It will be observed that there is a progressive decrease in screen uniformity as the lamp is moved laterally. This is most clearly seen in Table 1b where the lowest corner reading decreases from 74.07 per cent for the center position to 55 per cent for the 0.060 off center position. There is an apparent gain in screen uniformity for the position where the filament is 0.076 off center, but this is offset by the fact that the maximum brightness on the screen has decreased from 270 ft-c to 230 ft-c. It is not considered desirable that the screen illumination at

TABLE 1

(750-w, 100-v, Westinghouse 25-hr Lamp, 8C-1A Condenser. Operated at 100 v, 2-in. *f*/1.6 Projection Lens, 18-in. Screen Image)

	1a			1b		
	Illumination in Foot Candles			Per cent of Maximum Illumination		
	L	C	R			
Lamp Centered	220	260	210	81.48	96.29	77.77
	225	270	225	83.33	100.00	83.33
	200	250	207	74.07	92.59	76.66
0.020 Off Center	190	235	220	71.69	88.67	83.01
	185	265	235	69.81	100.00	88.67
	175	235	210	66.03	88.67	79.24
0.040 Off Center	168	233	212	67.20	93.20	84.80
	178	250	220	71.20	100.00	88.00
	157	220	200	62.80	88.00	80.00
0.060 Off Center	145	220	220	60.41	91.66	91.66
	148	240	235	61.66	100.00	97.91
	132	210	210	55.00	87.50	87.50
0.076 Off Center	145	200	204	63.04	86.95	88.69
	155	225	230	67.39	97.82	100.00
	148	210	210	64.34	91.30	91.30

any corner drops below approximately 70 per cent of the illumination at the center of the screen. On this basis, it appears that a lateral shift of 0.020 is more than can be tolerated with this condenser design.

Photographs were made of the filament image at the various settings to show the filling of the projection lens by the filament image. Fig. 3 shows the progressive stages of lateral shift. At 0.040 the lateral shift has become sufficient so that the reflected image has shifted noticeably from behind the filament. At 0.060 the shift has become sufficient so that more than  $\frac{1}{3}$  of the filament image is outside of the lens covering circle, while at a lateral shift of 0.076 only about  $\frac{1}{2}$  of the filament is being utilized.

The second set of tests was made to determine the effect of rotary motion of the filament about a vertical axis on the uniformity of screen illumination. The tests were made in the same way as the tests for lateral shift except that a 115-v lamp was used. The lamp was rotated about its vertical axis passing through the center of the filament. Measurements were made at the reference position with the filament plane parallel to the aperture plate and the filament rotated 10, 15, and 20 degrees. Table 2a shows the effect of the rota-

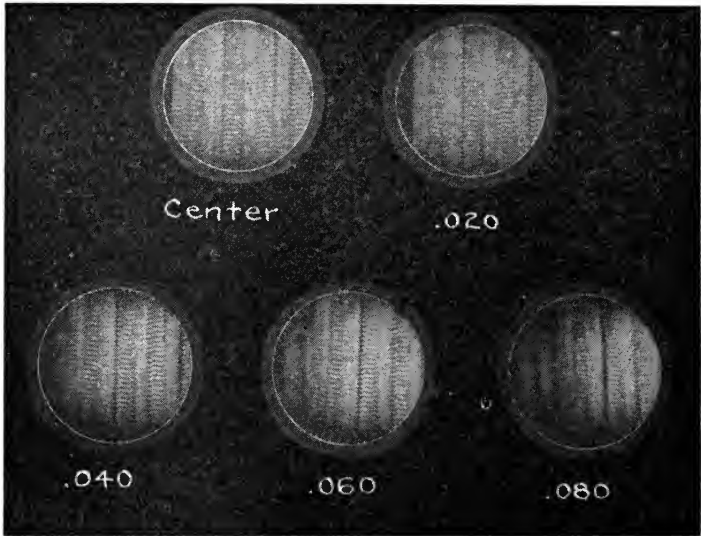


FIG. 3. Progressive stages of lateral shift of filament image.

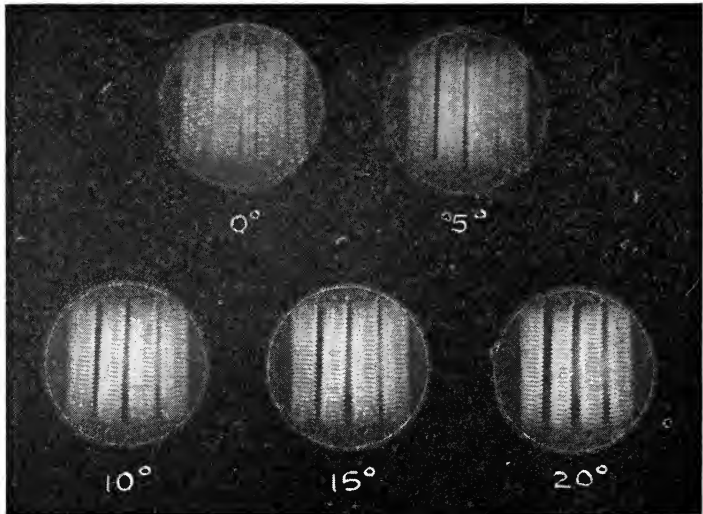


FIG. 4. Filament appearance when rotated from the reference position by successive steps.

TABLE 2

(750-w, 115-v, Westinghouse 25-hr Lamp, 8C-1A Condenser. Operated at 115 v, 2-in. f/1.6 Projection Lens, 18-in. Screen Image)

Position of Lamp	2a			2b		
	Illumination in Foot Candles			Per cent of Maximum Illumination		
	L	C	R			
Lamp Centered	231	290	256	75.4	94.7	83.6
	257	306	260	83.9	100.0	84.9
	226	272	231	73.8	88.8	75.4
5 Deg Rotation	200	279	265	66.4	92.6	88.0
	220	301	274	73.0	100.0	89.5
	200	270	245	66.4	89.7	91.0
10 Deg Rotation	190	258	270	65.5	88.9	93.10
	201	290	282	69.3	100.0	97.2
	184	250	253	63.4	87.2	87.24
15 Deg Rotation	178	242	260	61.37	83.44	89.65
	192	265	290	66.20	91.37	100.00
	170	230	253	58.6	79.31	87.24
20 Deg Rotation	186	220	256	65.72	77.73	90.45
	200	241	283	70.67	85.15	100.00
	170	210	243	60.07	74.20	85.86

tion on the screen illumination readings. Two effects are apparent from this table and Table 2b which shows the same values converted to percentage readings. The maximum screen brightness decreases as the filament is rotated from the reference position, and the screen uniformity becomes progressively poorer as the rotation increases.

At the reference setting, the lowest corner brightness was 73.8 per cent of the center brightness, and the center brightness was 306 ft-c. Five degrees rotation causes a 2 per cent decrease in center brightness and a decrease from 73.8 per cent to 66.4 per cent in corner-to-center ratio. This effect becomes worse as the rotation is increased and it appears that approximately 5 degrees is the maximum allowable rotation of the filament plane from the best or reference position. The photographs of Fig. 4 show the filament appearance as it is rotated from the reference position by successive steps. These photographs show graphically the reason for the decrease in screen illumination due to masking of the filament coils as the filament is rotated. The photographs do not clearly show the reason for the decrease in brightness at the center as compared to the brightness at one edge of the

screen. This is partially explained by the closer approach of one edge of the filament to the condenser and by the rotation of the reflected image in a direction opposite from the rotation of the filament, so that the filament image is formed in a progressively differing relation to the filament itself, thus resulting in a change in the efficiency of the reheating process. At no time does the maximum screen brightness reach the brightness of the center of the screen with the filament in the reference position.

Although the data given here represent the results of tests on one lamp and condenser combination, they confirm and represent a great mass of similar tests made on other condenser and lamp combinations. The present lamp and condenser combinations were selected as being representative of excellent commercial practice.

From the data given, it is possible to make a tentative selection of lamp position tolerance for any given criterion of the screen brightness ratio and acceptable decrease from maximum possible screen brightness. It is apparent from the data that for an efficient condensing system, the lamp filament position tolerance will be small.

#### REFERENCE

- <sup>1</sup> MILL, G., AND COOK, A. A.: "Condensers for 16-Mm Optical Systems," *J. Soc. Mot. Pict. Eng.*, **XXVI**, 6 (June, 1936), p. 603.



## A METHOD FOR MEASURING THE STEADINESS OF MOTION PICTURE CAMERAS \*

M. G. TOWNSLEY\*\*

*Summary.*—The unsteadiness of the film motion in a motion picture camera may be directly measured in terms of the maximum failure to return frames to identical register on successive passages of the film through the camera by photographing a ruled target during each of the successive passes, and inclining the target before the second passage of the film through the camera. The amount of tilt and the line width depend on the focal length of the lens being used and the resolving power of the film.

Unsteadiness in a motion picture camera is the failure of the film moving mechanism to register every frame in identical relation to the locating perforation and the guided edge of the film. The present test depends on the high order of probability that, if the same film is run through the camera twice, there will be one frame where the maximum out-of-register condition in one direction on one run will coincide with the maximum in the other direction on the other run. For the frame on which this condition occurs, the displacement of the two superimposed images is equal to the maximum unsteadiness of the film moving mechanism.

The measurement is facilitated by the use of a special target consisting of a series of parallel horizontal lines crossed by a series of vertical lines. Tilting of the target slightly about an axis normal to its plane between the first and second exposures causes the two images to cross each other at an acute angle. Rings are drawn on the target at convenient radii from the center, and the line width and degree of tilt are chosen so that the two images will normally cross in such a manner as to bring the dark line of one exposure to just fill the light space between the lines of the other exposure, at one of the rings. The magnification is so chosen that the ring spacing on the target subtends a known distance on the film.

Fig. 1 shows the target pattern as developed in this laboratory. The width of the black lines is equal to the width of the white spaces

\* Presented Apr. 19, 1944, at the Technical Conference in New York.

\*\* Bell and Howell Company, Chicago, Ill.

between lines. When the target is tilted  $2^\circ 40'$ , the crossing point, where the line from one exposure just fills the space from the second exposure, is at a radius of  $1\frac{3}{8}$  in.

With a line width  $\omega$  and a rotation  $\theta$  between exposures, the line just fills the space at a radius  $R_1 = \frac{\omega}{\tan \theta}$  and again at  $R_2 = \frac{3\omega}{\tan \theta}$ .

If the target is placed at the focus of a collimator having a focal length  $L$ , and photographed with a lens having a focal length  $l$ , the line image will have a width  $\omega' = \frac{\omega l}{L}$ .

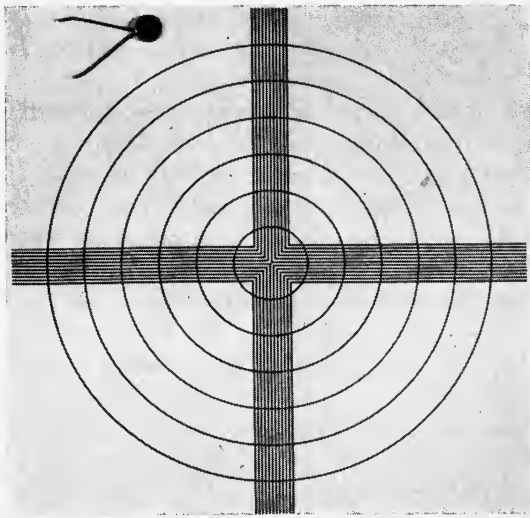


FIG. 1.

A vertical displacement of one of the inclined exposures by a distance  $s'$  will result in a lateral shift of the crossover point  $\Delta' = \frac{s'}{\tan \theta}$ .

This corresponds to an apparent shift at the target  $\Delta = \frac{s'}{\tan \theta} \left( \frac{L}{l} \right)$ . The most convenient target design contains a series of concentric rings separated by a distance  $\Delta_1 = \frac{s'_1 L}{l \tan \theta}$ , where  $\Delta_1$  corresponds to a unit displacement  $s'_1$  of the images at the film. For maximum

sensitivity,  $\Delta_1$  should be as large compared to  $s'_1$  as convenient. With  $s'_1$ ,  $\Delta$ , and  $L$  fixed,  $l \tan \theta$  may be maintained constant by changing  $\tan \theta$  to correspond to the focal length  $l$  of the lens used to make the test. In the actual instrument as used in this laboratory, the following parameters were chosen arbitrarily:

$$\Delta_1 = 1.375$$

$$s_1 = 0.001$$

$$L = 32$$

whence

$$l \tan \theta = 0.023273$$

We proceed now to the design of the target for a specific application. Certain primary data may be selected for convenience. In the case of a 16-mm camera, the usual lens is of 1-in. focal length. The maximum unsteadiness expected is approximately 0.004. A collimator objective of 32-in. focal length is to be employed. The target is to be calibrated with rings separated by a distance corresponding to an unsteadiness of 0.001 per ring. We have

$$\Delta = \frac{s'_1 L}{l \tan \theta}$$

$$\Delta = \frac{0.001 \times 32}{l \tan \theta}$$

We may obviously choose  $\tan \theta$  to give any  $\Delta$  desired. This gives values of  $\theta$ :

$$2^\circ 40' \text{ for } 1/2\text{-in. lens, } \tan \theta = 0.04658$$

$$1^\circ 20' \text{ for } 1\text{-in. lens, } \tan \theta = 0.02328$$

$$40' \text{ for } 2\text{-in. lens, } \tan \theta = 0.01164$$

In the equipment as used, stops are provided to limit the tilt, and feeler gages for setting the stops for each lens focal length.

The line width  $\omega$  is chosen to give good resolution on the film and to have a simple relation to  $\theta$  and  $\Delta$ , let

$$R_2 - R_1 = 2\Delta$$

$$2\Delta = \frac{2\omega}{\tan \theta}$$

$$\omega = \Delta \tan \theta$$

Fig. 2 shows the appearance of the target when double exposed by running the film through the camera twice with the target tilted through  $2^\circ 40'$  between the first and second exposures. The cross-over point at which the 2 target images merge into a continuous band is seen to be quite sharply defined and in line with the fourth ring of the target. Vertical displacement of the 2 targets with respect to each other will obviously cause this crossover point to move laterally

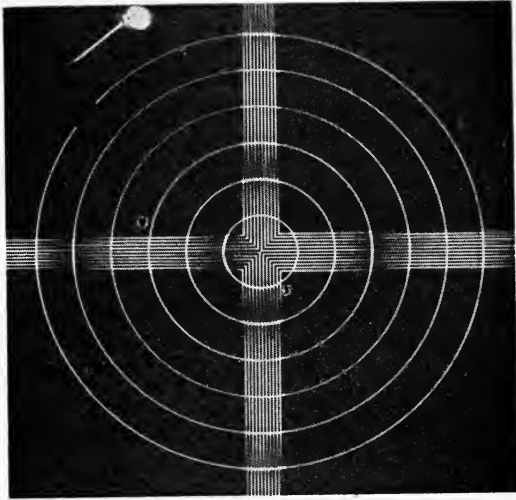


FIG. 2.

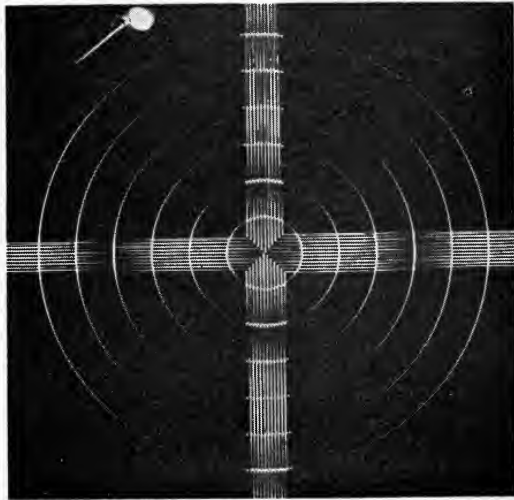


FIG. 3.

in the double-exposed pattern. Several rings are provided so that a displacement of the crossover from one ring to the next corresponds to 0.001 unsteadiness.

The effect of a displacement equal to the width of a line is shown in Fig. 3. The crossover point is now seen to be at the center of the pattern.

Use of a lens of longer focal length than 1 in. decreases the sensitivity of the test by decreasing the magnification. When it is necessary to use a longer focus lens, the shortest feasible lens is used and

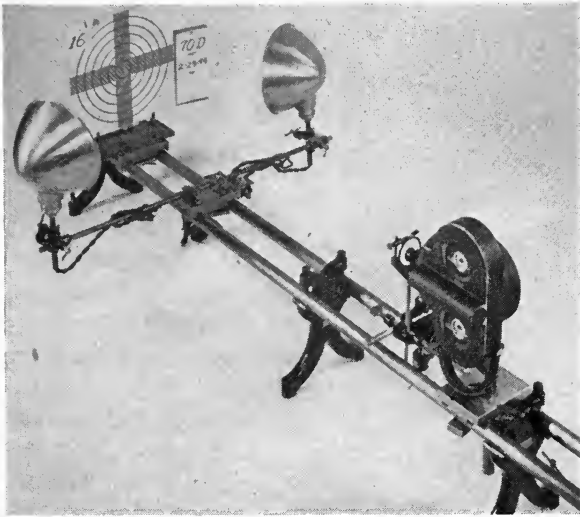


FIG. 4. Equipment used to make tests for motion picture camera unsteadiness.

the calibration scale is multiplied by the ratio of the focal length of the lens used to 1 in., or the angle of tilt is decreased to increase the sensitivity.

Complete equipment for making the unsteadiness test is shown in Fig. 4. The target is mounted on the tiltable plate at the left of the figure. This plate is equipped with stops and an overcenter spring and lever to control the tilt. The camera is mounted on the adjustable support at the right. Film is loaded into the camera and exposed with the target tilted clockwise. Without moving the camera, the film is rewound, rethreaded, and run through the camera again

with the target tilted counterclockwise. When large numbers of cameras are to be tested, each is fitted with an auxiliary base plate which enables it to be removed from the supporting bench and replaced in identical alignment.

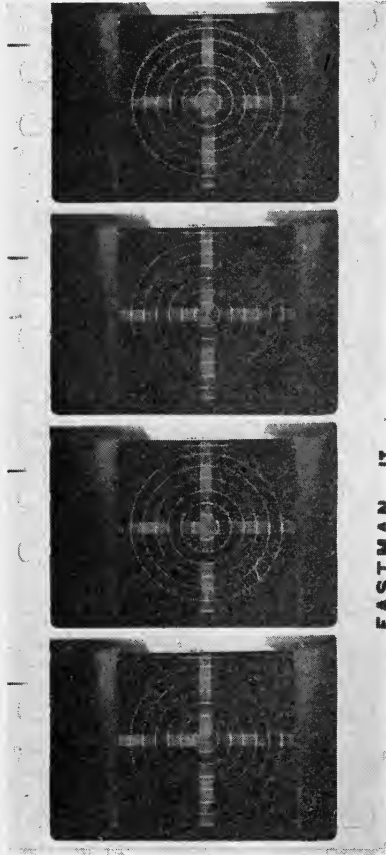


FIG. 5.

Dr. E. K. Carver during a discussion on perforation standards, and the specific embodiment as presented here has been in use in this laboratory for several years. Publication is made desirable at this time because of the demand from many government agencies for steadiness tests on cameras being purchased and the incorporation of steadiness requirements in many government specifications.

If the camera being tested uses 35-mm film, it is necessary in rethreading to be certain that the identical perforation is used as was used for framing the first time. Failure to do this will result in the 2 exposures being one or more perforations out of frame and the test useless.

The film is projected at slow speed in a standard projector, or is examined a frame at a time in a still projector. The difference between the extreme positions of the crossover in any 2 separate frames is the maximum unsteadiness of the camera film moving mechanism under test. Fig. 5 shows a typical series of frames which show an unsteadiness of 0.0013.

Horizontal unsteadiness is measured in the same way, from the same film, by measuring the excursion of the crossover point in the vertical lines of the pattern.

The basic method was suggested several years ago by

## A NEW MOBILE RECORDING UNIT FOR STUDIO AND LOCATION WORK\*

JAMES L. FIELDS\*\*

*Summary.*—The planning and construction of a new-type mobile film recording unit in use in Hollywood and by two branches of the Armed Forces are described.

When the latest-type mobile recording unit built by the RCA Victor Division of the Radio Corporation of America was in the design stage, the following thoughts were kept in mind:

- (1) The unit must provide comfortable working conditions.
- (2) The unit must be completely self-contained for studio or location work.
- (3) The equipment must be arranged for easy operation.
- (4) All equipment in the unit must be readily accessible for servicing and maintenance.
- (5) The unit must have a minimum of waste space.

It was decided that the recording compartment of the unit would be of aisle-type construction—that is, the unit was to be free from any bulkheads thus permitting the operator to move to any point in the unit without having to go out the front door and walk around to the back door. This feature was considered to have several advantages, some of which are:

- (1) It would permit greater flexibility in the arrangement of equipment and storage compartments.
- (2) It would simplify the maintenance problem.
- (3) It would make easier the handling of equipment normally stored in the truck but used on the set.
- (4) It would allow better ventilation of the unit.

In order to reduce the amount of waste space and to keep the overall length of the unit as short as possible, the driver's compartment was incorporated into the recording compartment. This made the entire unit into a single room. Fig. 1 shows the layout of the unit. It will be noted that the additional length usually required because of

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\* Presented Oct. 20, 1943, at the Technical Conference in Hollywood.

\*\* RCA Victor Division of Radio Corporation of America, Hollywood.

the radiator, engine, hood, and dashboard has been entirely eliminated.

The body of the unit was built on an open-faced, cowl-type Stude-

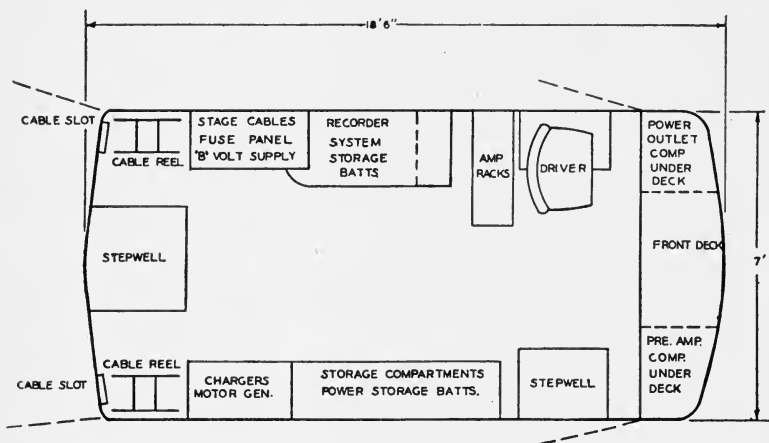


FIG. 1. Layout of mobile recording unit.



FIG. 2. RCA sound recording truck.

baker truck chassis having a wheel base of 152 in. Dual tires are used on the rear wheels and a 2-speed rear axle provides extra power for tough locations.

The hangover of the body past the rear axle was reduced 18 in. by





FIG. 3. Interior of mobile sound recording unit.



FIG. 4. Access to storage battery compartment is through 2 outside doors as well as from inside.



FIG. 5. Power batteries are serviced through compartment doors at left. Motor generator set is shown at right.

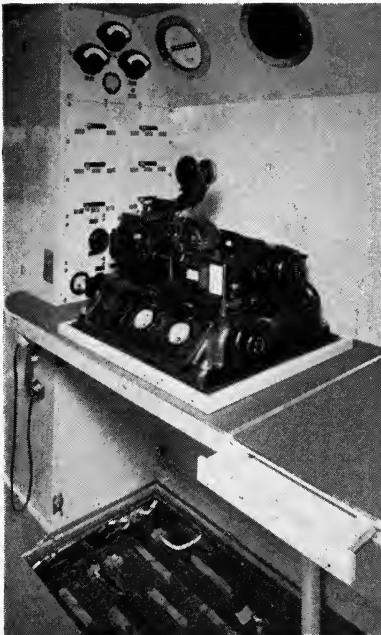


FIG. 6. Recording machine and removable flooring for servicing recorder and filament batteries.

moving all of the foot control pedals and the steering mechanism forward 18 in. The angle of the steering column to the floor was also increased, which effectively reduced the hangover an additional 6 in.

The over-all height of the recording unit was not limited to the height of baggage car doors because the trend in recent years has indicated that motion picture studios prefer to use a trunk-type channel for distant location work. The minimum headroom clearance of the unit is 6 ft. A 4-in. space between the ceiling and the roof is packed with insulating material. The interior of the unit is finished with grain filled, enameled plywood.

In order to make the unit easy to get into and out of, step wells were provided at the front and rear doors. An over-all view of the unit is shown in Fig. 2. An interior view of the unit is shown in Fig. 3. Note how the rear doors open the full width of the body.

The center of gravity was lowered by building the storage battery compartments below floor level. To facilitate the changing of batteries, all storage battery compartments are accessible from the outside of the truck. The operation of these outside doors is shown in Fig. 4. All compartments are also accessible from the inside of the unit.

The power batteries for operating the motor generator set and the *B*-voltage dynamotor are on the right side of the truck, and the filament and recorder batteries are on the left side of the truck. The power batteries are serviced through doors which open on the inside of the unit, as shown in Fig. 5. A section of the floor under the recording machine table is readily removable for servicing the recorder and filament batteries, as shown in Fig. 6. All battery compartments have a minimum clearance of 18 in. over the top of the batteries, and are equipped with electric lights. In order to prevent bat-



FIG. 7. Equipment storage compartments, and film loading compartment over spare tube drawer.

tery fumes from getting into the recording compartment, all inside doors are provided with seals. The battery compartments are ventilated through louvers which open to the outside.

Equipment storage compartments are above the power battery compartments along the right side of the truck. Fig. 7 shows these compartments open. A film loading compartment is shown directly above the spare tube drawer. Additional storage space is provided in the front crown of the roof section.

The motor generator and the *B*-voltage supply unit are mounted in readily accessible soundproof cabinets directly over the rear wheels.

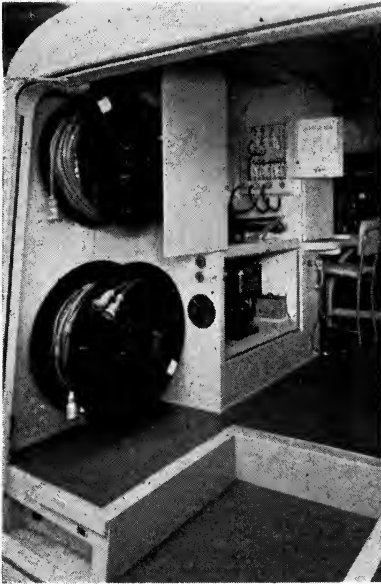


FIG. 8. *B*-voltage supply unit and cable reels.



FIG. 9. Mixing panel in location setup position.

These compartments, with the doors removed, are shown in Figs. 5 and 8.

The cable reels shown in Fig. 8 are located at the rear of the unit. The cable reels are provided with brakes to prevent the cable from unreeling too rapidly when it is being pulled out. Cables which are used on the set are stored in the compartment directly over the *B*-voltage supply unit, also shown in Fig. 8. Speech and power cable connections may be made at the rear or at the front of the truck.

The amplifier equipment, the recording machine, and the power control panel are mounted on the left side of the unit, with the recording machine between the power control panel and the amplifier equipment. All amplifier and power controls may be readily reached by the recordist from a sitting position in front of the recording machine.

A linoleum covered deck even with the bottom of the front windshield has been built across the front of the body. A section at the right end of the deck has been angled downward and may be used as a desk for the mixing panel when the unit is on location. Hood clamps are provided for holding the mixing panel in place. A bar-type stool fits into a floor socket immediately in front of the sloping

portion of the deck, thus, for location work, the mixer has an unobstructed view. This location setup is shown in Fig. 9.

Two compartments, which open from the front of the body, are built at each side of the truck under the deck. The left-hand compartment has an outlet through which power is supplied to the camera. The right-hand compartment is used for holding microphone preamplifiers. Short jumper cables from the preamplifiers to the mixing panel pass through a small trap door in the deck immediately in back



FIG. 10. Power outlet shown at right, compartment for microphone preamplifiers at left.

of the mixing panel. Such an arrangement makes it necessary to run only 2 cables from the recording unit to the set when on location, one power cable for the camera and one cable from the preamplifier to the microphone. Fig. 10 shows the unit set up for location.

The audio circuit used is a conventional bridging "bus" type using electronic mixing, therefore, no further description of it will be given. The power circuit is also of the conventional manually operated type and requires no further description.

Recording units of this type have been used in the production of motion pictures for the past 18 months and have given satisfactory

service in all respects. Also, 2 units of this type have been supplied to the United States Navy, and a third unit is now under construction for the United States Army Air Force.

The author wishes to acknowledge the work done by Mr. James W. Bayless, who supervised the construction of the units, and wishes also to thank the many others for the good suggestions that were used in the planning of these units.

## NOTE ON THE EVALUATION OF PHOTOGRAPHIC SPEED FROM SENSITOMETRIC DATA\*†

C. TUTTLE\*\*

*Summary.*—A method of ascertaining the gradient speed of a photographic material without the use of special gradient measuring instruments is pointed out. The derived formula shows the relation which must exist between density and log exposure at the value of exposure which is the reciprocal of the speed.

It has been demonstrated by Jones<sup>1</sup> that a reliable determination of the effective camera speed of a photographic negative material may be made by the following sensitometric procedure. The characteristic curve of the material is produced in the conventional manner (Fig. 1). Upon this curve is located a point, *A*, at which the slope of the tangent has a value that is a fractional part of a second gradient. This second gradient is the average gradient of that portion of the *D*-log *E* curve which is used in making the negative. In terms of the figure, the range employed is designated by *A* to *C*. The position of *A* is determined by the condition that the tangent of the angle *a* shall bear a certain relation to that of the angle *b*. The abscissa of *A* in log *E* units is the basis upon which the speed rating is made.

It has recently been proposed as an American Standard<sup>2</sup> that the reciprocal of the exposure at *A*, in meter-candle-seconds, shall be the speed. Specific conditions as set up are that the log *E* distance from *A* to *C* shall be 1.5 and that the tangent of angle *a* shall be 0.3 times that of angle *b*.

It is obvious that the direct method of evaluating photographic speed according to this criterion involves the measurement of 2 gradient values—a procedure that is perhaps not commonly practiced in laboratories doing sensitometric work. The author<sup>3</sup> at one time suggested designs for various instruments with which the desired

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\* Communication No. 818 from the Kodak Research Laboratories; received Sept. 5, 1941.

† Reprinted from *J. Opt. Soc. Am.*, **31**, 11 (Nov., 1941), pp. 709-12.

\*\* Kodak Research Laboratories, Eastman Kodak Company, Rochester, N. Y.

data could be readily obtained. In that paper it was also pointed out how the whole complicated operation of analyzing a sensitometric strip and computing relative gradients can be performed automatically with a photoelectric densitometer.

The author realizes that the instruments suggested are special tools requiring some expenditure of time and money to produce. For this reason the comparatively simple suggestion of an accurate and not laborious mathematical method of analyzing conventional sensitometric data may prove useful.

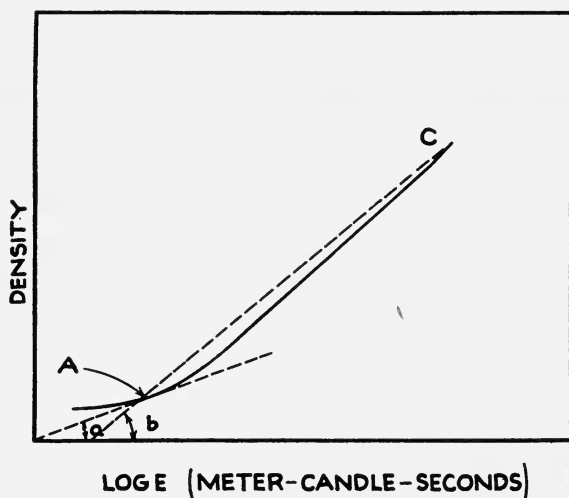


FIG. 1. Method of determination of gradient speed point.

The condition for the establishment of the speed value stated algebraically is

$$G_{\text{limit}} = 0.3 G_{\text{average}} \quad (1)$$

in which  $G_{\text{limit}}$  is theoretically the first derivative of the density-log  $E$  function and  $G_{\text{average}}$  is by the specified condition the density difference between  $A$  and  $C$  in Fig. 1 divided by 1.5.

Actually, with typical negative emulsions, it is not necessary to find  $G_{\text{limit}}$ , as the theoretical  $dD/d \log E$  for this first derivative value is very closely approximated by the ratio of a finite density increment to a finite log  $E$  increment, even if the log  $E$  increment is as large as 0.3. Thus, in place of  $G_{\text{limit}}$  we can write  $(D_2 - D_1/0.3)$ , where  $D_1$



and  $D_2$  are densities on the toe of the curve produced by 2 log exposures separated by 0.3.

The gradient value so found would apply to a point on the characteristic curve midway between  $D_1$  and  $D_2$ . The density at this midpoint would be the average of  $D_1$  and  $D_2$ —again an approximation, but a very close one, for the photographic characteristic curve.

For the value of  $G_{\text{average}}$ , may be written the equation

$$D_3 - 1/2(D_1 + D_2) \div 1.5$$

in which  $D_3$  is a density produced by a log exposure 1.5 greater than that which produced the density midway between  $D_1$  and  $D_2$ .

With these substitutions, Eq (1) may be rewritten:

$$\frac{D_2 - D_1}{0.3} = 0.3 \left[ D_3 - \frac{D_1 + D_2}{2} \right] / 1.5 \quad (2)$$

This simplifies to

$$17.18D_2 - 16.18D_1 = D_3 \quad (3)$$

One further approximation is allowable. Since  $D_1$  and  $D_2$  are always on the toe of the curve, and therefore both numerically small, the decimal part (0.18) of the coefficient on  $D_1$  and  $D_2$  may be dropped, so that an algebraic relation presenting no arithmetic difficulties is the result:

$$17D_2 - 16D_1 = D_3 \quad (4)$$

By the use of this equation sensitometric data, as usually obtained for the plotting of characteristic curves, may be used conveniently to establish the gradient speed value precisely and without recourse to any special gradient-measuring device. Take as an example the typical data for a negative material sensitometric strip shown in Table 1. Column 1 shows the step numbers, column 2, the actual log  $E$  values in meter-candle-seconds, and column 3, the step densities. Now, the values in column 3 obviously may be used to form a series of  $D_1$  and  $D_2$  values. For example, let step 21 be the first  $D_1$  value; the corresponding  $D_2$  value will be two 0.15 steps farther along in the table, which is step 19. Now, the steps 19 and 21 really determine the gradient at step 20; hence, the first  $D_1$  and  $D_2$  values are entered opposite step 20. Columns 6, 7, and 8 are self-explanatory. The last column,  $D_3$ , is taken from column 3, starting at the 11th step, thus advancing  $D_3$ , to a position ten 0.15 log  $E$  steps from the points midway between  $D_1$  and  $D_2$ .

A cursory examination of the last 2 columns reveals that they are approximately equal at step 19, and the log  $E$  value from which the speed is to be determined should be about  $\bar{3}.75$ . To accept this as the true value, or even to interpolate in the table to ascertain the value, would be placing more than necessary reliance upon the densitometric accuracy for two  $D_1$  and  $D_2$  values. It is better to follow the procedure shown in Fig. 2 and to plot the points in column 8 against those in column 9. It will be

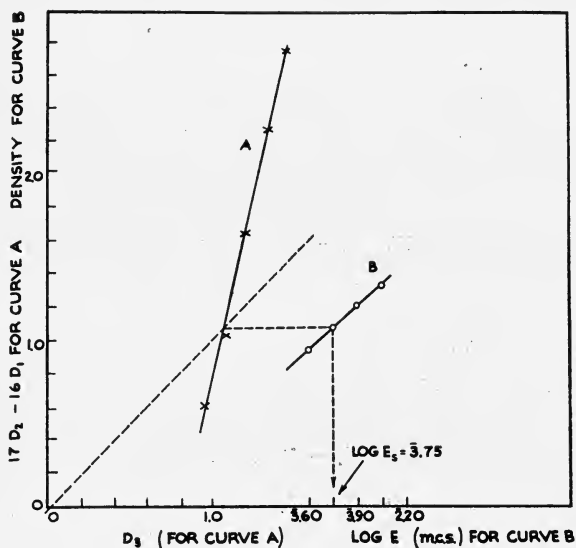


FIG. 2. Gradient speed determination by plotting data derived from density reading.

noted that these points rather definitely establish the position and slope of a straight line (A). A dotted line at 45 degrees is drawn to establish the location of the point at which  $17D_2 - 16D_1$  is equal to  $D_3$ . In this particular case, the value happens to be exactly 1.08—identical with the  $D_3$  value for step 19. The log exposure for the gradient speed determination is  $\bar{3}.75$ , as previously estimated. In general to find the value of log  $E$  which applies to a particular value of  $D_3$ , it is desirable to construct a short section of a second curve by plotting a few values of column 2 against values in column 9. This has been done in B of Fig. 2. This short segment of a curve may always be considered a straight line. By interpolation on this curve the log  $E$  value may be readily found.

To check the results of the formula, the gradient speed value of this particular sample was compared with that given by other methods of gradient speed determination. The numerical results of all the most precise methods proved to be in excellent agreement with that found here.

The particular set of data given in Table 1 was the product of very careful sensitometric and densitometric technique. Moreover, the data apply to a normal kind of negative emulsion curve with a typical toe shape and a long straight-line portion. Such perfect correlation of speed values and such easily drawn curves as those of Fig. 2 are hardly to be expected in routine work. If the sensitometric and densitometric work is less refined or if emulsions of less conventional characteristic shapes are encountered, disagreement will probably result.

TABLE 1

*Sensitometric Data and Computed Values*

Step	Log E	D	D <sub>1</sub>	D <sub>2</sub>	16D <sub>1</sub>	17D <sub>2</sub>	17D <sub>2</sub> -16D <sub>1</sub>	D <sub>3</sub>
21	3.45	0.10						0.83
20	3.60	0.11	0.10	0.13	1.60	2.21	0.61	0.95
19	3.75	0.13	0.11	0.165	1.76	2.80	1.04	1.08
18	3.90	0.165	0.13	0.22	2.08	3.74	1.66	1.21
17	2.05	0.22	0.165	0.29	2.64	4.93	2.29	1.34
16	2.20	0.29	0.22	0.37	3.52	6.29	2.77	1.46
15	2.35	0.37						
14	2.50	0.47						
13	2.65	0.59						
12	2.80	0.70						
11	2.95	0.83						
10	1.10	0.95						
9	1.25	1.08						
8	1.40	1.21						
7	1.55	1.34						
6	1.70	1.46						

To test the general usefulness of the formula, samples of negative emulsions covering the gamut of present commercial emulsion curve shapes were obtained. Sensitometric data were then collected for these samples by the group of these Laboratories that deals with routine testing. The data were then subjected to the formula for the determination of the log  $E_s$  values. They were also treated by an older, thoroughly tested method involving the use of a transparent scale known and distributed as the "fractional gradient speed meter."

This meter measures directly on a characteristic curve plotted from the data and gives, in the hands of experienced users, entirely consistent results. For a description of the method see the paper previously cited.<sup>3</sup>

A comparison of  $\log E_s$  values found by the formula and by the gradient scale meter is given in Table 2, along with a general description of the character of each curve and the value of gamma for each sample. The greatest error is 0.03 in  $\log E$  which is about 7 per cent in speed—approximately a quarter-camera-lens stop.

TABLE 2  
*Log  $E_s$  Determined by Different Methods*

Sample	Description	$\gamma$	Log $E_s$ (Formula)	Log $E_s$ (Scale)
A	Long toe	0.45	$\bar{3}.41$	$\bar{3}.38$
B	Same material as A	1.15	$\bar{3}.25$	$\bar{3}.28$
C	Normal shape	0.8	$\bar{3}.75$	$\bar{3}.75$
D	Normal shape	0.5	$\bar{3}.43$	$\bar{3}.43$
E	Short toe	1.3	$\bar{3}.23$	$\bar{3}.26$

The sole advantage claimed for the use of the formula has been that the speed value may be determined from conventional sensitometric data without resort to any auxiliary equipment. It might be mentioned, however, that the arithmetic involved would be materially shortened if the densitometer were calibrated to read  $16D$  and  $17D$  directly. If it is desired to elaborate further on an instrument for use with the formula it would be possible to incorporate a simple computer to subtract  $16D_1$  from  $17D_2$ .

The accuracy and reliability of any method of speed evaluation are influenced by the following uncertainties:

- (1) The photometric inaccuracies of densitometry.
- (2) The unevenness of emulsion coating, particularly in that portion of the sensitometric strip which bears the low-density image.
- (3) The inequalities of sensitometric strip processing.
- (4) The uncertainty that a representative sample is taken from the emulsion batch.
- (5) The errors in sensitometric exposure caused by fluctuating lamp intensity.

All of these uncertainties are decreased by taking multiple samples and by averaging the results.

In cases where the importance of the results justifies multiple

sampling, there are some interesting possibilities in the application of the formula to obtaining the gradient speed value directly. This formula may be written:

$$D_3 + 16D_1 = 17D_2$$

Suppose that a sensitometer such as the Eastman *Iib* instrument is altered slightly so that one-half of the strip, divided lengthwise, receives the normal exposure, while the other half is given twice as much exposure. Each step of the processed strip will then consist of 2 areas, the lighter of which represents  $D_1$ , while the darker represents  $D_2$ . If 16 such strips are stacked in a pile with all steps in register, the densities will be additive, so that densitometer readings of the stack would give directly  $16D_1$  and  $16D_2$ .<sup>\*</sup> Now, if a seventeenth sample is exposed on the sensitometer to give one side a twice-normal exposure and the other side a 45 times normal exposure, the 2 halves of the strip will represent  $D_2$  and  $D_3$ , respectively. If this last strip is superimposed upon the stack of 16, the conditions required by the formula will be fulfilled. The reading of a stack of densities, as was pointed out by the author,<sup>3</sup> will very much diminish the probable error of the densitometry in the toe region and at the same time will minimize the other sources of error.

It is of interest to mention that with such a stack of samples it is possible to assign the speed value approximately without the aid of even a densitometer. If the stack of strips is illuminated by a strong light, the lowest steps of the  $D_2$  group are definitely more transparent than the adjacent area of the other group, but the gradient of this side of the strip is materially greater than the gradient of the other side, so that within a few steps it becomes definitely the darker side. There probably would never be a case in which the  $D_2$  side, as judged by the unaided eye, would not change from the darker to the lighter in the increment of one step, so that it is safe to say that speed can be *estimated* to within 0.15 in log  $E$ , by this method.

The more accurate method of comparison is, of course, to read a few steps of each half with a densitometer, and then, after plotting each set of densities against log  $E$  to determine the speed value from

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\* The validity of the addition of densities by superposition has been questioned on the grounds that interreflections between layers would affect the numerical result. The procedure is justified in this case because one is interested only in the comparison of an equal number of layers at an equal density value. The surfaces concerned have nearly equal reflectances so the error if any is cancelled.

the point of intersection of the 2 curves. Some modification of the conventional densitometer to enable it to read higher densities than usual would be found necessary.

#### REFERENCES

<sup>1</sup> JONES, L. A.: "The Evaluation of Negative Film Speeds in Terms of Print Quality," *J. Frank. Inst.*, **227** (1939), p. 297; **227** (1939), p. 497.

<sup>2</sup> American Standards Association, Committee on Standardization in the Field of Photography, Subcommittee on Sensitivity to Radiant Energy. "Proposed American Standard: Specifications for determining photographic speeds of roll films, film packs, and miniature camera films," *J. Opt. Soc. Am.*, **31** (1941), p. 87.

<sup>3</sup> TUTTLE, C.: "Methods and Instruments for the Determination of Photographic Speeds by Measurement of Relative Characteristic Gradients," *J. Opt. Soc. Am.*, **29** (1939), p. 267.

## TECHNICAL NEWS

There appears in this issue of the JOURNAL a distinct innovation in the policies which have governed the Society's publications in the past.

In accordance with an authorization passed by the Board of Governors on April 16, 1944, a section devoted to more or less current "Technical News" will appear in the JOURNAL about every 3 months. It is hoped that the various items of Technical News will not only be of interest in themselves to the members of the Society, but will also result in more detailed articles describing applications of the ideas to various phases of the production, distribution and presentation of motion pictures, and in allied fields.

Technical advancements in the motion picture industry are often delayed in their publication to the point where their news value is lost. There are also occasions when technical advancements are made which are never published. It is the intent of this Committee, therefore, to be on the alert and obtain as much technical news as possible for publication in the JOURNAL as news items. In many instances it will be necessary that permission for publication be obtained. However, since these items will not contain more than basic facts, it is felt that the Committee can serve a useful purpose to the Society membership in keeping them abreast of the times technically.

The items\* appearing in this section have been contributed by the members of the following Technical News Committee:

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\* Submitted May 19, 1944.

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EMERY HUSE

Eastman Kodak Co.

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Hollywood, Calif.

*Television*

H. R. LUBCKE

Don Lee Studios

3800 Mount Lee Dr.

Hollywood, Calif.

The Committee will welcome and consider items of current technical interest from any member of the Society.

## COLOR

**Technicolor Motion Picture Corporation.**—The following was taken from Technicolor's Annual Report:

*"Improvements in monopack procedure:* Among the feature pictures produced in Technicolor was *Lassie Comes Home* distributed during 1943 by Metro-Goldwyn-Mayer. The photography of this picture was largely exterior and from the Technicolor point of view was an experiment in monopack. The great beauty of the picture and its favorable reception at the box office speaks for the success of the experiment. But it only went part way because the monopack procedure will have to be improved so as to be satisfactory for the photography of interior studio scenes illuminated by artificial light as well as exterior scenes illuminated by daylight. Research work to this end has been undertaken by your company's research laboratory in cooperation with Eastman Kodak Company so that the Technicolor monopack process may gradually supersede the present Technicolor 3-strip process and thus eliminate the necessity of special Technicolor cameras."

In addition to the foregoing, *Thunderhead* was produced in monopack and another major feature, *Son of Lassie*, is reported to be scheduled for early production.

**Producers Releasing Corporation.**—Plans are under way for the production of a feature-length picture by PRC making use of 16-mm Kodachrome for photography and the Cinecolor 35-mm 3-color process for release prints. Production on the picture is scheduled to start in June. Utilizing the above-mentioned material and process, several short subjects and a feature-length picture are already in production in Mexico City.

## LABORATORY PRACTICE

**Eastman Kodak Company.**—During May, 1944, the Eastman Kodak Company submitted to the motion picture industry in Hollywood a new fine-grain variable-density sound recording film having the code No. 1373. This film is suitable only for variable-density



work and has excellent characteristics for this type of sound recording. The chief feature of this film is that it was made for development in a normal borax picture negative developer.

Most variable-density sound films are of the positive-film type, that is, of high basic contrast. In order that they might be used successfully at low values of gamma, it is necessary to use dilute borax-type solutions, which are often difficult to maintain. It is believed that a film of low basic contrast designed for development in a normal negative solution is a step in the direction of better sound negative control.

**Walt Disney Productions, Inc.**—A method recently developed at the Walt Disney Studios for edge numbering 16-mm Kodachrome is now in use, and further improvements in it are under way. Among other things, it contains several unique features which probably will be disclosed in a paper to be presented to the Society.

**Cinecolor, Inc.**—In order to speed up work and facilitate production to accommodate increasing demands for 35-mm 3-color prints from 16-mm Kodachrome, Cinecolor, Inc., has plans under way for the expansion of its contract and optical printing facilities. Toward this end construction of a new Acme Dunn Optical Printer is nearing completion at the Acme Tool and Manufacturing Company of Burbank, California. This printer will be installed shortly in the Cinecolor laboratory in Burbank.

#### SOUND

**Warner Bros. Pictures, Inc.**—The latest production technique, which requires that motion picture sets simulate the structures that they are to represent with greater realism, has forced the Sound Department to construct a special microphone boom for small sets. The new boom is a little over 6 ft high, which is about half the usual size, and the boom arm may be extended to 14 ft. Its small size and relatively light weight, which is about 140 lb, save considerable production time when working in constricted spaces.

Work is nearing completion on a new reverberation chamber which is 25 ft sq and 10 ft high, and will have a reverberation time of 7 sec. The novel feature of this chamber lies in the arrangement of directional microphones to control the amount of reverberation required.

**RKO Radio Pictures, Inc.**—In order to effect film saving and get recorded material back from the film laboratory more rapidly, direct-positive Class B recording is used on certain sound effects,

and where taps are recorded to be later added to dance routines. A further advantage is that clipping is avoided since no noise reduction is necessary. When it is considered that as much as 10,000 ft are often shot for one solo dance routine, the amount of film saved by not having prints can be appreciated. The direct positive is reproduced on an ordinary re-recording machine.

The use of various kinds of microphones in the studio has made it necessary to have a universal microphone hanger, which in this case is a kind of fixture with 2 rapid-acting thumbscrews so that one type of microphone may be substituted for another quickly.

In order that the film recordist may not leave a 3-position key in a nonrecord position during a take, a second pair of contacts has been added for the nonrecord positions which are energized by the starting system and cause a buzzer to operate continuously until the key is restored to its proper position.

**Walt Disney Productions, Inc.**—In recording of foreign versions of cartoons, a humming track is made of all choral groups so that this material may be used in certain foreign versions where singers for that particular language cannot be obtained.

To create the effect of music or dialogue in underwater scenes, such as appeared in the picture *Pinocchio*, the sound track was reproduced on a machine from which the flywheel had been removed. The resultant speed variations created a warbling effect. This effect can also be greatly intensified by leaving the film gate open so that, in addition to the speed variation, the sound track tends to go in and out of focus.

**Republic Pictures Corporation.**—The automatic marker system at Republic Studios utilizes the existing camera power cables as a carrier system for the current supplied to the marker lamps at the camera and sound heads. A 2000-cycle signal generated by an oscillator in the sound truck energizes the marker lamps and a series resonant filter system is used to obtain minimum insertion loss at 2000 cycles and maximum loss at 60 cycles.

**Paramount Pictures, Inc.**—Paramount has instituted a practice of vacuum cleaning all sound negative after it has been recorded, and before it goes to the laboratory. This practice has resulted in an appreciable decrease in negative film noise. The vacuum cleaning equipment was developed at Paramount.

A system has been developed wherein phase No. 2 of the stator between the distributor and the load is metered to indicate to the

recorder the number of cameras, *etc.*, that are on the line. The meter is calibrated in terms of the machines on the line, and it operates so effectively that the recorder can even tell when there is no film in the camera.

#### STUDIO LIGHTING

Recognizing the part motion pictures are playing in the war effort, the WPB has issued priorities which are making possible the production of additional lighting equipment for motion picture studio use.

There is a growing tendency in the use of light meters by Chief Set Electricians. The Chief Set Electrician, under the direction of the Director of Photography, is responsible for the placement and operation of all lighting equipment, and the light meter is proving a valuable means of control.

*(Ed. Note: Additional information concerning the items above, or the equipment and processes discussed, may be obtained by communicating with the general office of the Society, Hotel Pennsylvania, New York 1, N. Y.)*

## SOCIETY ANNOUNCEMENTS

### ATLANTIC COAST SECTION

The last monthly meeting of the Atlantic Coast Section until fall was planned to commemorate the anniversary of the first public showing of motion pictures. The program was divided into 3 parts briefly covering the past, present, and future of motion pictures.

The *past* was represented by the exhibition of a 16-mm sound film produced several years ago by March of Time and supplied through the courtesy of the Museum of Modern Art. The film described some of the historical points of the industry with views from a number of well-known silent and sound pictures.

The past was also represented by an exhibition of historical projector mechanisms arranged through the courtesy of the International Projector Corporation.

To represent the *present* state of the motion picture industry talks were given by 2 representatives of the Army Pictorial Service on their experiences in motion picture photography on the African and Italian fronts.

Major W. H. Rivers talked particularly about the supply problem and experiences in Africa dating from the first landing until the invasion of Italy. Major Arthur Ransom discussed his experiences landing on an Italian beachhead and photographing with the American Army at the front near Salerno. Major Ransom stressed the necessity for motion picture equipment capable of withstanding the rough treatment which is unavoidable in Army use. Two 16-mm films entitled *Combat Bulletins* were shown.

To represent a phase for *future* development, a film supplied by General Electric was shown entitled *Sight-Seeing at Home*, describing the production and transmission of a television picture.

Approximately 250 members and guests attended the meeting held in the Roof Garden of the Hotel Pennsylvania, May 24th.

### PACIFIC COAST SECTION

R. B. Hood, special agent in charge of the Los Angeles office of the Federal Bureau of Investigation, addressed the Pacific Coast Section at its meeting held on June 6th. Mr. Hood told members and guests of the special problems which the Bureau faces during wartime, and described how motion pictures are used in the detection of crime.

Following his remarks, Mr. Hood exhibited in the Paramount Studio Theater a selection of motion picture films taken from the Bureau library. These films were shown publicly for the first time.

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*We regret to announce the death of Dr. Milo A. Durand, Active member of the Society, on May 15, 1944, in New York.*

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*(The Society is not responsible for statements of authors.)*

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*Industrial Arts Index* available in public libraries.

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# JOURNAL OF THE SOCIETY OF MOTION PICTURE ENGINEERS

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## FILM IN TELEVISION

*Summary.*—The 2 following papers and subsequent discussion took place at a meeting of the Atlantic Coast Section of the Society in New York on March 22, 1944. The subject was limited to the use of film in television programs broadcast for reception in homes, as an alternative to the production of programs of this type directly from live talent. Discussion was directed along 3 lines, i. e., the effect on technical phases of picture quality such as definition and focus, possibilities in artistic effects, and economic aspects. It was emphasized that the views expressed were personal opinions and did not necessarily represent the policies of any company or organization. Discussion section follows the second paper—page 85.

### TELEVISION PRODUCTION AS VIEWED BY A MOTION PICTURE PRODUCER

WYLLIS COOPER\*

I first want to qualify myself. I do not want to appear as a television expert. I have had a good deal of experience in radio, some experience in television, and considerable experience in motion pictures. I am going to talk to you for a few moments about the possible or probable use of motion picture film in television broadcasting. I want to emphasize again that what I am going to talk about are my own ideas and may not be shared by the people I work for.

There is not any argument at all on the merits of motion picture film in television. The live type of television broadcasting may have its place and will have its place, and certainly there will be an enormous place for the use of film. The *Wall Street Journal* recently said, quoting some unknown Hollywood producer, that "Television is nothing more than a talking picture and talking pictures are our business." I have a slight quarrel with that statement. Certainly motion pictures are Hollywood's business, but the other half of the

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\* National Broadcasting Company, New York.

statement, that television is nothing more than a talking picture, is not adequate. Television is considerably more than a talking picture for a number of reasons, and we will try to go into those as we go along.

In the development of any art medium, we must take into consideration the things that have gone before. Every development in any of the art mediums has been influenced by the work of the people who went before. Michael Angelo painted pictures. They were still pictures. They were fine in color and so forth. Somebody else discovered photography—Niepce, Daguerre and Fox-Talbot, and the rest of them—but each of the mediums as it was developed, had a considerable influence upon the development of the medium that followed. That is what is going to happen to television. Motion pictures came ahead of television. Motion pictures will definitely have some influence, great or small, upon the development of television, and television will undoubtedly have a great effect on whatever follows it.

In my opinion, the important point in the consideration of motion pictures in television is this: Television, to be acceptable apart from its novelty feature, must conform to certain standards of quality, the establishment of which the television industry had nothing at all to do with. The people who began radio had a great deal to do with the establishment of conventions and of standards. Although the radio industry will probably do the major portion of television broadcasting, they must conform to standards that have previously been set.

Let us consider the standards of present-day theater films. The use of dissolves, fades, close-ups, and other cinematic devices is universally understood. The technical quality of film is taken for granted by the audience. No matter how poor the story quality, or how bad the acting in a Hollywood film, the technical quality of the film is almost always above reproach. If there are deviations from the standard high quality of Hollywood films, lighting, photography, and so forth, they stick out pretty badly, and they are very obvious to everyone who sees them. It is equally obvious, then, if television is going to compete in the home with the motion picture—and it is quite likely that to a limited degree it will—it is necessary to accept the standards of present-day film production and to measure up to them.

As another example of the conventions, those of editing entertain-



ment motion pictures are thoroughly understood by the audience probably because they are based on very sound psychological concepts. Any deviation, any use of makeshifts in editing, or in other phases of cinematics, becomes immediately apparent, and the audience does not like it. For example, I mentioned the use of lighting. When you come in for a close-up from a medium shot, the lighting is always changed, of course, so that the 2 scenes will match. It is sometimes impractical to do that in television which is transmitted from a live pickup, because it is not always possible to use the same camera for a close-up and a wider angle shot. Usually there is not time to change the lighting, and an immediate change in the character of the scene being photographed results. It takes attention away from the story and does something to the psychological reactions of the persons viewing it.

Pudovkin, who is generally considered one of the best authorities on cinematics, says "the essence of the film is editing. Editing in time and space is vital to the production of a good entertainment picture, or, for that matter, of almost any other kind of picture." The use of film obviously gives you the opportunity to use all the technique of editing in time and space that you have in film for theater projection. Inserts, the use of stock shots of all types, matching close-ups, the general cinematic flow of the picture, are all functions of the film, and I use the term "film" in its generic sense and not an actual strip of celluloid with a silver emulsion. It is not always possible to make the best use of the various cinematic devices when one must depend upon instantaneous decisions in a studio to overcome the limitations of space, sets, characters, and so forth.

There are many faults in present-day television. Many of them, of course, are due to equipment limitations and the war situation, but it goes without saying that these things will be licked within a few years following the end of the war. There are many other faults due to production. We hope that they, too, will be remedied. A film can be used for most television programs in the future. Understand, I say it *can* be used. Whether it *will* be used or not, I do not know. I do not think anybody knows at present.

There are certain objections to the use of film. These can be broken down into 2 main objections: first, the cost of film production. A great many people think that to use film for television implies the use of film in the Hollywood manner, which certainly costs a lot of money. The equipment necessary for producing film

for television is another element that must be taken into consideration.

The second principal objection is the question of time—the time required for processing the film, and the lack of what some television people call immediacy, which is the quality of knowing that what you see is happening at the time you see it.

In present-day television there is a great deal of talk about this immediacy. I, for one, feel that that concept is considerably overrated. Some people in television have gone so far as to use the word instantaneity. That is a philological handspring the like of which I have never seen or heard before. The fact that the singer is opening his mouth at the precise moment you see him on your home television set, is something I am afraid will not keep you awake nights. However, if you want to have him open his mouth and sing, and know that he is doing so at the exact moment you see him grimace as he reaches for a high one, it is all right with me. The flexibility that can be had by prescoring, and then having the singer mouth his lines with a pleasant smile, I think more than compensates for the stop-watch attitude you may have if you know he is doing it *now*.

I want to talk for a moment about how to use film for television. As I said before, it is perfectly obvious that we cannot use the Hollywood style, because the cost would be completely out of line. It would be impossible to spend the amount of money for television broadcasts—which are fairly shortlived, like radio broadcasts—as is spent in Hollywood. There must be a considerable change and some more economical way in approaching the subject of using film.

We have to observe the analogy of television with radio. Television is coming into the home just as radio does. The programs will have to be of approximately the same length as radio programs, although nobody knows for certain what they will be. And in each case, whether we are using television for education, for entertainment or for news, we have these arbitrary standards already in existence. We cannot in any way foist inferior standards on a public that is conditioned by standards which have been a part of its life for many years.

In radio, we do not find it necessary to set up a physical theater with a stage and sets and curtains and so forth in order to do a play. By a number of clever devices and by the use of conventions, we avoid expense and time. By now, in radio's second or third decade, people have become pretty well conditioned to the conventions of radio,

and they understand it as well as they do the conventions of the theatrical motion picture. We can do the same thing in television by the use of motion pictures. I mean, we can use shortcuts, and we can use a number of devices, but these must always be devices with which the audience is familiar and which they understand.

Of course, we will have to borrow from Hollywood what we need. A great many things will have to be simplified, and owing to the technical limitations of the medium, we will have to do a number of things that are not necessary in theater films. The point I am trying to make, somewhat laboriously, is that the perfection of a theatrical film is not a vital part of a film made for television. Just as we have shortcuts in radio when we do a play, there will also be the same shortcuts in a television film when we are making that film specifically for television. We will be able to use the over-all general technique of the cinema, but we will synthesize a new technique with the production of television films, and it will be definitely television technique.

In the actual production of films for television, I want to point out what I think is a simple way. Starting with the script, it will have to be more carefully written than the average entertainment film script. We will borrow, as I said, from Hollywood, but we will have to keep in mind the fact that we are not making a picture which will be shown on an enormous screen to a large number of people at once. We will have to tell the story rather simply. For one reason, the television film will very likely be much shorter than even the average motion picture short. On the breakdown for production, it probably will be necessary to arrange the breakdown so that, as far as possible, the film can be shot in sequence. We cannot always do that, of course, but with some care and some insistence upon this as a vital part of television production, we can arrive at a situation in which much of each film will be shot in sequence.

The actual production of the film presents some other difficulties. We will have to do a lot of cutting in the camera. We will have to keep down the number of takes as far as possible, because we will not have time to make numerous takes and, again, we are not seeking the perfection that we would have to have for large screen projection.

The rushes should be made available as you continue shooting. You can make a rough cut as you go along. That may sound hard to do in view of present-day production methods in Hollywood and elsewhere, but I have a suggestion about that. If these pictures are made on 16-mm reversal film, it is quite possible to have on the set.

with the camera crew and the director—the director, incidentally, should be a combination cutter and director—a portable processing unit that can keep right along with the camera crew. As soon as the scene is shot, the magazine is handed to the man at the processing unit, and in a comparatively short length of time you have a positive print ready for projection.

At the present time I am under the impression that it takes about 15 min from the time you thread a developing machine until the film comes out at the other end, polished and ready to project. That time can be cut down appreciably, possibly not under existing conditions, but there are ways of speeding up the development of the reversal process. In that way, you have a rough cut of the film going right along with you.

So far as the sound is concerned, you make that with a double system sound, process it at the same time, but the sound track is never printed on the picture print. It is cut along with the picture, rough cut as you are shooting, and by the end of your shooting schedule, you have a rough cut. With one or 2 hr more for the final cut, both of the sound track and the picture, you are ready for the actual broadcast. It is perfectly simple to set up the projection arrangements so that you project from separate sound and picture films. It is going to be possible; it has been done and is perfectly simple to do.

Special effects, if you want them, can be added. You can do prescoring to add sound effects or music at the same time you are shooting the main part of the picture. It is a definitely specialized technique with which no one has had much experience, of course, but it is perfectly simple to use and can be used.

There is a great need, of course, for experimenting with this technique. Nobody is going to be able to produce that kind of film day after tomorrow. The equipment for the most part is available, or could be “haywired” together so that people could experiment with it as soon as they want to. The same technique can be applied to almost any kind of broadcasting. I am talking particularly about dramatic broadcasts, but musical programs can be done the same way. You prescore exactly the same as for Hollywood pictures, and then you avoid the appearance of tonsils and false teeth, and the pained expression when the singer tries to hit a high note.

The stock shots, almost anything you want, can be intercut as long as your sound track runs straight through the way you want it to. You then have a film that looks as professional as a Hollywood enter-

tainment film, and is certainly up to the previously established standards.

You can see that the cost of making a picture for television, if we use the method I have just proposed, need not be measured in Hollywood figures. The equipment, of course, is expensive, but most television broadcasters have lights and cameras and other equipment already, and the total over-all cost to establish a modest film production setup for television of this type—well, some equipment people might like to figure that one out.

There is one other advantage of film for the picture that goes on the tube and that is, when it is photographed you have a record which you can keep and refer to, and cry over your failures.

In network broadcasting, of course, the problem of supplying television broadcasts to distant stations is not of such importance, but certainly independent television broadcasters will make a great deal of use of film for this purpose. Any station with any transmitting equipment at all can use film, whether they can use the other type of pickup or not.

I have tried to give you a rough outline of how film can be used in television. Experience and experiment will give the final answer, and the final answer will be the kind of picture you get on your home television receiver.

### TELEVISION PRODUCTION AS VIEWED BY A RADIO BROADCASTER

WORTHINGTON C. MINER\*

I have been assured by your Chairman that this is strictly an off-the-record gathering in which honesty is to be the keynote. That seems to put it up to me to clarify one point right away. Your advance publicity indicated that I was to discuss—and presumably with some authority—the problem of “Film in Television, as Viewed by a Radio Broadcaster.”

Just so that you may know how much credence to give to whatever I say from here on, I want to state my qualifications as an

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\* Columbia Broadcasting System, New York.

authority on this subject. My background is the theater. I have never been a radio broadcaster; I have had only the most cursory contact with pictures; and, like everyone else I have ever met, I know nothing whatever about television. So now I shall go right ahead and make an authoritative analysis of the entire problem for you.

It has always seemed to me that in a discussion of this sort it is just as well for everyone to know as clearly as possible what we are all talking about. I therefore want to read a definition I wrote in preparing a report for television over 4 years ago:

"Television is a new and inclusive art. It embraces many attributes of stage, screen, radio, and news reporting; yet it is none of these. It is not merely a derivative art, but an individual one, owing no more than a respectful gratitude to its ancestry. It possesses too many vital and unique characteristics of its own for it to adopt a servile allegiance to any paternal standard. Rather, it should allocate to itself the dignity of an independent standard, established in terms of its own peculiar, generic pattern.

"It is the business of television to report the transient experience vividly and immediately, constantly alert to those unpredictable fragments of action and reaction that give life to the elusive moment. Television is the immediate truth presented in a pattern of deliberate selection."

In other words, television is potentially the greatest reporting medium in existence. This is its supremely individual characteristic. It should be clear, however, that naming the characteristic of a medium is not defining *what* it shall do, but *how* it shall do it. Temporarily, television must exploit its most provocative characteristic. Both pictures and radio went through the same phase.

So much for the definition of television. The next point which needs clarification is whether television can or should be limited to the production of entertainment. To the extent that pictures are produced for an audience to be assessed an admission fee, they must think in terms of show business, and that means entertainment. To the extent that radio, and likewise television, is produced for free distribution to the public, it must think in terms of public service. And within the scope of that concept entertainment takes a comparatively secondary place.

It may even be justifiable to question whether "entertainment" is not a biased limitation upon any discussion of television's potential. Consequently I am going to shift focus and analyze this problem as an answer to 2 basic questions:

First, should the backbone of a future television schedule for the home be produced on motion picture film?

And second, if it should, can it be done?

I must confess that the answer to the first of these 2 questions is in the nature of a warning, rather than of a dictum. Just consider for a moment the basic problem of the psychological effect that a motion picture via television may have on the audience. Will it feel it is seeing something "canned," rather than the original? I do not profess to know the public's response, but I can guess. And my guess is that temporarily, while the momentum of conditioning to motion pictures persists, the public will accept films of good quality without any great resentment. I will hazard a second guess, however, that there will be a growing uneasiness as the technical performance of live television pickup improves and live programs appear on any schedule bracketing film. I believe it will be a little like the difference between seeing a football game and seeing a newsreel clip version of that game one week later.

But the basic difficulty that faces the picture companies is the enormous breadth of scope in entertainment forms which they will suddenly be asked to cover. If it were possible to say that an entire television schedule of 10 hr a day could be made up of *A* productions from the top motion picture lots in Hollywood, it is possible that films might do a more excellent and polished job of production than television could ever do. But it is sheer folly to imagine that either 10 hr a day, or 5 hr a day, or even 2 hr a day can be solely devoted to this type of entertainment. Television, simply because it must maintain a standard of public service, has an obligation to produce in widely varied categories to a hungry public. It must produce fully as widely as radio.

Let us take a specific problem, the "Quiz." When Columbia was first considering the transmission of a regular television schedule, it debated seriously the advisability of attempting a quiz on television. A single fact, occurring at almost precisely the same moment, very nearly defeated the effort. (Remember that, because I am coming back to it.) Eventually a method of considerable flexibility was developed. It turned out to be a pretty good program, but something very nearly stopped us from going ahead at all. That something was the dismal and altogether dreary effort made by motion pictures to recreate the mood and quality of *Information Please*. I have not the foggiest notion whether or not a deal of intelligence

and imagination might evolve a satisfactory form of quiz on film, but I do know that it was most horribly mangled in that initial effort. All the years of experience behind motion pictures were not worth 5 cents to the producers of that particular film. It was, in fact, a new form, and in meeting it they floundered like porpoises. It is unnecessary to analyze all the reasons for this. The fact remains that this is a glaring example of motion pictures falling down once they stepped outside the strict confines of show business, of entertainment for theater release.

I do not know what a motion picture would do with *Wings Over Jordan*. I do not know what they would do with *An Invitation to Learning*. I do not know what they would do with *The People's Platform*. I only know one thing: They would have to throw away the book and start from scratch, and there is not one atom of proof that when the horses broke from the post, live pickup might not be half way round the track. But this type of argument can go on endlessly without being conclusive, for the simple reason that the best anyone can offer is an inspired guess, and a guess is a guess, no matter what adjective you put in front of it.

So let us assume for a moment that pictures should by the best standards make a full 10 to 20 hr of television every day in the week. That brings us right down to cases with the simple question, "Can it be done?" Can one hour of television, whether it be entertainment or news, whether it be documentary or informal, whether it be religious or social, can one hour of television be put on film cheaply enough to compete with the type of production which can be given with live pickup cameras?

The first obligation is simply to take the established costs for the average *A* or *B* picture in Hollywood. Let us say that a good working price for an *A* production is \$600,000, for a *B* production, \$300,000.

The *A* productions run approximately an hour and a half. That is at a rate of \$100,000 a quarter hour. Very obviously, so long as television is to be transmitted to the home free of charge, there is no advertising rate in the world that can stand such an assessment.

Now, let us assume that you are going out and make an hour's entertainment for something within reason for television distribution. What is reason? I have heard that *Voice in the Wind* cost \$40,000 to shoot and cost nearly that much again to add a new sound track. Forty thousand dollars is almost unreasonably low for a motion picture production, but it still is out of line with any reason-



able hourly rate for television. I have heard costs quoted on training films made by independent documentary producers of somewhere around \$10,000 for 20 min. Nobody makes a great deal out of that, except in bulk. Yet \$10,000 for 20 min is still \$30,000 an hour, and that is still out of line with anything that television could afford. What, therefore, pictures must face is the fact that, because of a cold, hard economic equation, they will either have to lower the standard of film which they distribute to television, or make films for television at a staggering loss. Neither would appear particularly attractive.

Let us look at it from another angle. A figure which I had given me the other day was that during the year 1943 Hollywood produced 452 feature length pictures. Being overgenerous and assuming that these pictures ran an average of an hour and a half apiece, the total would be 678 hr. Presume that one network were to maintain a television schedule of 10 hr a day for one year—I use 10 hr with no hidden implication, but merely because it is easy mathematics—it would be putting out 3,650 hr of television, and if all of that were to be on film, Hollywood would have to multiply its plant 6 times before it could even take care of one television network.

Now I have heard this problem bandied about and heard hundreds of different methods of cutting this pie so that it looks tastier for all concerned. The arguments are too long-winded to go into. So I am going to try, if possible, to tie this down to something so basic that this economic equation will suddenly become a vivid reality for you. I am going to talk about nothing but the cost of film itself.

It takes 5400 ft of 35-mm film to make up one hour at present projection speeds. Assume that a studio were to organize itself to shoot television entertainment at a ratio of 2 to one. This would mean that there would be 10,800 ft of negative used. At a cost of 6 cents per ft, that is \$648. Suppose that sample prints were made up at a ratio of 1 $\frac{1}{4}$  to one, and printed at 3 cents; the cost would be \$202. The final print, 5400 ft, at 1.4 cents per ft, would be \$75, a total of \$925. For the air time to show this film on television, it would be necessary to employ 8 men at, let us say generously, \$2 per hr; a total of \$941 per hr. Now just remember this excludes any production cost—talent, lights, scenery, promotion, distribution, anything else; it is nothing but the cost of the film itself.

Making the same eliminations for television, you would have to use, for the same hour on the air, possibly 20 men at the same \$2

per hr, or a total of \$40. That is a difference of approximately \$900 per hr. Now, quite disregarding any other factor involved in the production, this would mean on a yearly basis at 10 hr per day you would be spending \$3,285,000 merely for the luxury of using film. If you use 16-mm reversal, you can cut that cost by about 3, and say that it will cost you \$1,000,000. It is these equations, and there are hundreds of them, which make many of us like myself seriously doubt that it is in any way realistic to consider film as the basic form for the backbone of a television schedule.

I have taken up to this point an attitude that films cannot be used as the backbone of a television schedule. Now just in closing, I would like to mention some of the places where I think film can and will in all probability be used. For a number of years after the war, television stations are likely to grow up in scattered parts of the country, remote from the centers of talent, and temporarily linked to no major network stations. I think it is conceivable, therefore, that films may be used in this fashion: A show will be produced on television. There will be a receiver equipped with a 16-mm camera designed to make a visual and aural record of that program. As the program goes on the air, the camera will grind, and that film will be printed and distributed to these outlying stations at a rate which will make it feasible for them to contemplate a full television service without the staggering cost of producing the total number of hours within the confines of their own studios.

I think there will be another important use for film, perhaps the most important and the most permanent. Both the broadcaster and the theater operator will eventually be receiving spot news—a fire in Joplin, or a riot in Pittsburgh, or a parade in Butte, Montana. Many of these things will be unpredictable in time; many more will not be of sufficient importance to warrant allocation of full time for their showing. It would be ridiculous, for instance, to expect a New York exhibitor of a Betty Grable picture to stop the projectors 20 min before the end and announce, "We now bring you a baby contest from Galveston." It would not even be feasible to do it if the television cameras happened to have caught the Hindenburg fire. What can happen is that a film recording of the remote and immediate event can be picked up, rapidly developed, and held for release either a minute, or an hour, or 10 hr later.

I also believe that film may be used to enrich and give scope and change of locale internally to many television productions. Nobody

has yet measured how much pictorial effect can be gained from the limitations of a television studio. It is possible that television will develop a technique of many fewer setups and greater concentration than are normally practiced at the present time in pictures. Inevitably, however, there will be certain programs which will demand a sense of flexibility in time and space. When that is needed, I can see no reason why films should not be used for the purpose as parts of an otherwise live program.

And finally, there will be a certain portion of every schedule almost certainly devoted to the release of film per se. I do not know the percentage, but I believe that it will be extremely selective; it will not be the backbone of a television schedule.

In closing, I think there is one question which may have been growing in your minds as I have spoken. Granted that the arguments as I have presented them are valid, why should any motion picture person or company be interested in television? As an answer, I would like to recall the brief statement I made at the opening: "Television is a new and *inclusive* art. It embraces many attributes of stage, screen, radio, and news reporting."

There is, in addition, one simple fact which must not be forgotten. Television is a motion picture. It is adaptable not alone to home release, but can be used for theater release. There is no precedent to make me believe that the growth of television will supplant any previous medium such as pictures, radio, or newspapers. But I do know that television is all of these, and will intimately affect the conduct and the future in each of these fields. Every owner of a radio station, every owner of a picture theater, every owner of a daily paper, every publisher of a weekly pictorial is going to feel the effect of television. It cannot be ignored, and it cannot be held back. It is coming. And consequently it would appear to me that you motion picture people, looking at television, would be more realistic were you to ignore the problem of how to produce the best film version of a television program, and to ponder more and deeply on what a television program itself may be. Your future may depend on it.

#### DISCUSSION

##### *Effect on Picture Quality*

MR. PALMER: I think it is quite obvious to anyone who has ever spent any length of time in a motion picture studio that the picture, as you see it on the

stage of the studio, is as far removed from what you see on the screen in the theater as it possibly can be. It seems to me that the only thing that the television broadcaster can put on the *vido* screen is a picture of what is happening in the studio and the way it looks.

There are many things which happen to that picture in the processing which add immensely to its quality and to its perfection of detail, which you never saw at all in the studio. In the first place, the lighting in a studio has to be adapted to the limitations of the medium itself, the photographic emulsion, or the television camera, and the lighting in a studio is extremely "contrasty," in many cases, and very different from the way the film records it. What you see in the studio would not look at all good if you were to reproduce that same thing on the screen. In the processing of the film, however, many changes occur which add to its beauty and, you might say, to its audience acceptance.

MR. MINER: I think there is not very much question about the validity of that statement, if people are judging television by its present performance. Certainly all of us have been suffering from a reasonably inferior performance up to now. We have reason to be extremely optimistic about what it will be in the future. But I think there will be perhaps some misapprehension about the quantity of things which television can presumably do, in order to achieve many of the effects which are now achieved on film in the laboratory and in developing processes.

In the first place, it is possible to exercise electronic control that can change the quality of high light and shadow. It is possible with proper lighting—and I have checked this and tested it—it is possible even under present conditions to get a picture on television which can compare extremely well with the average type of light quality that you get on the average 16-mm film at the present time. I am not saying that I have seen anything on television up to the best of 35-mm, but there is an infinite opportunity to go much further than has been demonstrated at the moment, simply because there have been to date no absolutely efficient lights designed or built for television purposes, and the result is that a great many studios have had to operate with faulty equipment. However, having made one experiment under fairly limited conditions but with rather good equipment, I can assure you that you would be quite surprised at the number of gradations in the gray scale, and the quality of depth that appeared on the end of that television screen.

It can be done, and furthermore, it can be electronically controlled by the control room engineer, who will become as adept in his profession as the average laboratory engineer is in the development of film.

MR. COOPER: My experience has been that the quality of a picture on the television screen from even 16-mm is probably a little better than the average television shot. I say "average television shot" and I am also quite conscious, as Mr. Miner is, of the fact that not all the television shots you see are the best possible shots that can be made.

MR. HYNDMAN: I think this problem resolves itself into one fundamental principle in current circumstances. Judgment can be based only by the currently available material in motion pictures and in the television field, whether it be equipment, processes, or film.

Unless the television system is greatly improved, to the best of my knowledge

the problem is one of latitude and definition of the television system which is not now capable of giving high-quality tone reproduction or photographic quality. In motion picture production it is possible to have a latitude of 1 to 100 or, in exceptional cases, of 1 to 200 when photographing outdoor shots. This latitude can be recorded on the film because the film is capable of accepting it in terms of tone value and it is also possible to secure a high definition. The print from this negative does not have a latitude of the above-mentioned magnitude, but it is not necessary that it should because the screen upon which it is projected is not capable of accepting such a great latitude. A very high-quality motion picture screen when properly illuminated will give latitudes of from 1 to 30 to perhaps as high as 1 to 35. Most of us have become accustomed to this range of latitude and find it fully acceptable in a motion picture theater.

From all the information that I have been able to gather, the television screen (the kinescope or receiving tube) is supposed to have a latitude of 1 to 20 at its very best, and yet, most engineers who have made an attempt to measure the latitude doubt that it is over 1 to 15.

In these circumstances, it is impossible, therefore, to obtain a tone reproduction on current television equipment that approaches what may be obtained from 35-mm motion picture film during projection, or even 16-mm motion picture film during projection.

If we consider amateur motion picture film (the reversal type of 16-mm motion picture film), then the latitude is less than that of the films comprising the classic negative-positive process. It should be appreciated that 16-mm motion picture films obtained by reduction from 35-mm motion picture film have a latitude that is equivalent to the original 35-mm films so there should be practically no difference in comparing them. There may be a slight loss in definition in the 16-mm reduction print, but at least from the standpoint of the picture, this is not noticeable to the average viewer. Furthermore, the latitude of the 16-mm screen and projection system can be conditioned to equal that of the 35-mm system provided sufficient illumination is available. An additional point is that the depth of focus obtainable on either 35-mm or 16-mm motion picture film is far beyond that obtainable with the current television system, especially when the images of all three are compared at equivalent magnification.

The combination electrical and electronic optical system in television is not capable of giving the depth of focus comparable to that obtainable in motion pictures. This is due to the fact that the high sensitivity of the motion picture negative film permits photography with the lens working at low apertures, whereas the low sensitivity of the mosaic of the iconoscope will not permit working the lens at a low aperture to provide equivalent depth of focus.

It is my belief that these factors definitely indicate that the motion picture equipment and the motion picture film do give an image of better definition and higher photographic qualities than is obtainable on the television system. The general public will eventually expect a photographic quality and definition in television comparable to that which is now available in motion pictures.

MR. MINER: I think that there is a slight misconception. There are 2 factors involved in television. One is contrast range, and the other is a sensitivity within various gradations of the gray scale. It is certainly correct that the average performance in television at the moment has a contrast range of approximately

15 to 1. There have been laboratory experiments even before the war began which raised that to 30 to 1. There is every reason to believe—and I cannot even quote you an exact figure—that that will be considerably higher. I will not say how much higher, but it will be raised considerably.

You have mentioned again the question of the depth of focus. That is without question a temporary problem in television. It is a factor involved in the size of the mosaic and the distance of the mosaic from the lens. As the smaller tubes are developed and a smaller mosaic is used which can be placed closer to the lens, there is no reason why the same depth of field cannot be achieved in television that can be achieved in any motion picture camera. The laws of optics apply identically, and it is only a question of the development of equipment which will supply approximately a duplicate of the size of, say, a 35-mm frame and place it as the mosaic within the camera tube itself.

Naturally, it is true that we are talking here in terms of the future, but I am not discussing anything which is not a very eminently foreseeable future.

MR. HYNDMAN: To avoid any misunderstanding, it should be emphasized that the fundamental problem is that a much greater sensitivity of the mosaic is desirable. This becomes very obvious if we will consider the mosaic as replacing the negative motion picture film in a camera. When the mosaic has a sensitivity that is comparable to current normal speed motion picture negative film, then it will be possible to operate the television camera lens at a much lower aperture opening which will increase the depth of focus and also allow the television cameraman leeway in the adjustment of focus for definition.

Unfortunately in some cases, it is general practice in the motion picture industry to purposely expose motion picture negative film of high sensitivity at a wide aperture opening so as to have in focus only the object of interest but, if it were desirable, the whole scene could be shot in needle-sharp focus by simply increasing the illumination of the scene and exposing at a much lower aperture, say,  $f5.6$ , or even  $f16$ . None of us doubt that with research and development progressing at its normal rate, the definition, depth of focus, and latitude of the television system will eventually be greatly improved over the present equipment and, when it is, it will open for itself numerous new fields to conquer.

MR. MINER: Yes. The problem there of sensitivity is again in the future, but there is considerable reason to believe that there will be a tube in the market for television, at not too distant a date, which will equal or even surpass the sensitivity of any motion picture film on the market. I will not say there will not be motion picture film to compete with it eventually, but it is not outside of the knowledge of engineers at the moment.

MR. OFFENHAUSER: I would like to supplement Mr. Hyndman's statement and say that all 16-mm film need not be considered amateur. I admit my prejudice.

MR. WAXMAN: From the viewpoint of a man who has a television set at home and sees these programs, I have always noticed that when we sit down to a play, the lighting, the definition, and everything else seem to be far superior than when they show films.

The question also comes up about using 16-mm film. We all know that 16-mm sound is limited to about 6000 cycles, and here we are trying to get high fidelity by adding FM to the sound which is supposed to go up to about 15,000

cycles. If we use 16-mm film with that 6000-cycle sound, we are not going to get very high fidelity.

MR. OFFENHAUSER: What you get on it depends on how well you work it in.

MR. WAXMAN: The best engineers in the motion picture industry say that it is 7000. They have admitted they cannot go much over 7000.

MR. OFFENHAUSER: I can sell him all the film he wants with 15,000 cycles recorded on it at 1½ cents a ft, provided he gives us a triple A priority or a directive.

#### *Possibilities in Artistic Effects*

MR. PALMER: It is very interesting to me to hear the blissful confidence that has been expressed here tonight, that you can produce in a television studio anything which will compare at all with a motion picture in entertainment value. I assume that people are going to still want to hear Fibber McGee and Molly and see them at the same time. Anybody who can produce in a television studio the sequence of events that happens in a Fibber McGee and Molly half-hour program has to have more movable equipment than I ever saw put together in one place.

MR. MINER: I just happened to listen to Fibber McGee and Molly last night, and they never got out of the living room. I think we can get all around the living room.

I do not know; I think it is perfectly all right that *Casablanca* was a success, but so was *Oklahoma*, and there is nothing to say necessarily that television is going to have to use a vast amount of scope and freedom in time and space in order to create good entertainment. There is no rule to say that because you keep within rigid formalities necessarily you cannot create good entertainment.

There is also nothing to say that you cannot use entirely informalized scenery which may be sheerly indicative of location and create audience respect for that type of thing. It may make you put up a sign that says, "We are in the Sahara," and make them believe it. Just because pictures make them believe that they have to establish a set all over Burbank does not mean we have to do the same thing.

MR. PALMER: Well, I cannot agree with that. In the very early days of motion pictures they used to paint the window curtains on the wall, and they got away with it then, but you will never get away with that sort of thing now, when people are used to seeing *real* window curtains.

MR. COOPER: I agree with Mr. Miner that it is quite possible that a new technique may be developed in television whereby we may be able to indicate locations rather than actually show them. As a matter of fact, that technique has been used in motion pictures before, can be used again, and will be used again.

I do not believe that you can do Fibber McGee and Molly in their present type of show merely by putting any kind of camera on them and having them walk around, going through their stuff, alternating between medium shots and close-ups. It is quite likely that a very different photographic technique will have to be evolved for entertainment programs. For example, one of the things that everyone must be thinking about is the daytime serial. That introduces a considerable problem, because every daytime serial has a definite setting. It is quite possible that in the production of that type of television broadcast there

will be a considerable use of rear-projection process shots, with a great deal of the action in close-ups. It is also possible that a great deal of the action to be taken will take place with off-stage voices and possibly stock shots of some kind to indicate the action.

There is a good deal to be thought about in the development of a technique for television, either live or by motion pictures. We cannot arbitrarily photograph people going through a series of gag routines and expect to get a highly entertaining program. It is quite certain that for a television version of Bob Hope, or McGee, or what-have-you, we will have to evolve a completely new technique of our own which will partake partly of radio and partly of motion pictures.

### *Economic Factors*

MR. SCHLANGER: With regard to the economics of the production of a picture, to make it economically possible to show a picture on television, I recall a question that I put to an exhibitor of motion pictures, a very successful single-run house, where the use of good short subjects would be a very welcome addition to the single feature. I said to him, "Why don't they make more good single features—that is, short subjects—that are condensed down to 8 to 10 min or 12 min, and which are produced very economically because of the clever ideas in them—the shortcuts that might be used by the art of motion picture production?"

The answer was that if they got these good ideas, they would stretch them into a 5-reel feature, they need them so badly.

Getting back to television, if you could produce a clever short by virtue of the art of the motion picture that has been developed and clever directing, you would not need stars, expensive stars, from Hollywood. Here is a chance to develop stars. So in the cost of your live talent, you could use all the shortcuts known to the motion picture art, and you could produce shorts for television which I believe would be economically in the right category.

MR. PALMER: I think there is one thing that television might learn from the motion picture industry, and that is that they could use a lot of repeat action. When Walt Disney makes a duck waddle across the screen, he only has to make one waddle, and he can use that all the way across the screen.

MR. FRANK: In Mr. Miner's talk, discussing the economic factors of television, he stated a lot of figures and quickly dismissed them by simply saying that it was too expensive. As I see it, in television there are 3 different types of programs that might be considered: One might be a sponsored program for pure entertainment purposes. One might be a sustaining program, and one might be an advertising program. Those of us who were privileged to hear the speech that Mr. Joyce of RCA made last week on the use of television as a selling tool were impressed about the possibilities of using it for advertising purposes.

Were you, Mr. Miner, dismissing these figures as being too expensive on the basis of any one of these 3 uses of television, or were you doing it simply on the basis of sustaining programs for entertaining purposes?

MR. MINER: No, I dismissed them on the basis of any type of television, because when you have taken the cost of any film that I have ever heard of, and



you add line charges and other expenses involved in distribution to a network, the rental of the film is but a drop in the bucket compared to what some of the other costs are going to be. Consequently, it is not the total cost; I know no rate charges that will stand the cost of a good Hollywood *A* production, which is \$100,000 a quarter hour. I do not think there is any advertiser who can possibly foot that bill—it does not make much difference who he is.

MR. PALMER: When Chesterfield cigarettes puts on a program in a Broadway theater, they fill it with people. Perhaps a production on film, after it is shown in television, could be distributed and exhibited in theaters throughout this country or the world, thus making it economically possible to spend larger amounts on the original production.

MR. KEITH: I think perhaps another thing which might be added there is that the cost of the film is going to be divided up among a number of projections, assuming that you did not have to have instantaneous projection. Would that not be the case?

MR. MINER: That certainly is the case, unless you are dealing with a network show which is presumably covering its major audience in one showing. Possibly you could get away with two. Nobody has really studied or experimented with that problem. There are those in England who made some checks which showed that audiences would not mind a repeat showing within a fairly reasonable length of time. But I think that when you have had 2 showings within a month, you have probably exhausted the network audience for any practical purposes commensurate with the cost which is involved.

MR. COOPER: As far as this question of cost is concerned, I think we should pay particular attention to this: Television motion pictures do not need to be of the Hollywood variety. They do not have to be produced at Hollywood costs. They do not even have to be produced at the costs of ordinary commercial motion pictures—that is, advertising pictures.

One of the things that makes Hollywood films cost an awful lot of money is lack of adequate preparation. With a tight organization of television film production, and with enough attention paid at the beginning to the preparation for making the film, a lot of lost motion is going to be eliminated.

Also, there are not going to be any of the tremendous write-offs that sometimes occur in Hollywood productions, because, as some of us may know, somewhere in the budget of \$300,000 or \$400,000 for an *A* picture is occasionally a \$20,000, or \$30,000, or \$50,000, or \$100,000 charge that belongs to the working title of the picture which was purchased a long time ago and is written off in the total cost of the production.

I think that by careful attention to all the details of preliminary work in producing films for television, the over-all budget can be cut way down. It is also possible that in our conception of what advertisers will pay for television broadcasts, we may be a little wrong in comparisons. It is quite possible that when we get around to commercial television broadcasting we may find that the average cost of television broadcasting will be much more than the cost of the regular radio broadcast. However, by careful attention to details and holding things down to the minimum, I do not think it will be too far out of line to make them possible commercially.

MR. SCHLANGER: One idea that may be of help is the narration idea, the splic-

ing in of narration to cut down the amount of pictorial stuff. During the narration period a stock geometric pattern of harmless and pleasing type could be used, and the cut-in of the narration could reduce the production costs considerably.

## DUPLICATION OF KODACHROME TRANSPARENCIES FOR BACKGROUND PROJECTION\*

EARLE K. MORGAN\*\*

*Summary.*—A process for duplicating Kodachrome transparencies for use in background projection is described.

The use of still Kodachrome transparencies for background projection is becoming an established process in making colored motion pictures.

Natural color values and color correction are first in importance in making slides for projected backgrounds. The lack of control of these important factors in other methods led to the development of a duplicating process whereby color value, color correction, density, enlargement, and reduction are controllable.

The following description outlines the method used to make the duplicate transparencies:

The original color transparency is placed over one end of a light-proof tunnel (in this case the front bellows of a copy camera) with the copy lens at the other end. Two large daylight blue flash bulbs (approximately 60,000 lumens) in white reflectors are used. These are placed on either side of the copy camera and directed at a curved diffusing white surface 2 ft directly in front of the transparency to be copied. The film used is Daylight-Type Kodachrome and is exposed by open flash at stops as required by the size of duplicates and density of the original.

Color distortions in the original transparencies, or those introduced by the stereopticon projector, are corrected by the use of tinted filters. The use of these filters requires no change in exposure.

In cases where lower contrast is desired, a neutral gray mask (a low gamma, black-and-white negative of the original transparency) is placed in contact with the original and the exposure made through both.

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\* Presented Oct. 19, 1943, at the Technical Conference in Hollywood.

\*\* Still Processing Dept., Paramount Pictures, Inc., Hollywood.

Here is an example of density control: By decreasing the exposure at the time the duplicate is made it is possible to convert a daylight transparency into a night scene.

The advantages of enlarging or reducing certain sections of a transparency are obvious.

The duplicate transparencies are on an acetate base and are transferred to glass before use in the projector.

The original transparency is in no way altered and can be filed as a stock shot to be used for future pictures.

## KODACHROME TRANSFER\*

BARTON H. THOMPSON\*\*

*Summary.*—This paper describes the method whereby a color image-carrying emulsion may be transferred from a plastic film base onto another medium without distortion of the image or bleeding of the color values.

With the adoption of the high-intensity arc system used in stereopticon machines in the motion picture industry for background projection purposes, the use of straight Kodachrome was rendered impossible. It was also impractical to use Kodachrome cemented to a single piece of lantern-slide glass. As the demand for natural color still background transparency plates increased, an early solution to the problem was urgently needed. After an inspection of the plates exposed to the heat of the light system in the stereopticon, it was found that the principal difficulty was being encountered not in the breakdown of the Kodachrome emulsion, but in the disintegration of the acetate butyrate film base. The elimination of this plastic therefore was imperative. After lengthy research, including tests and varying processes, the following procedure was adopted as a standard.

Place a clean lantern-slide plate into position on a special plate holder. Next, place the Kodachrome previously cut to size, emulsion side down, upon the lantern slide and affix one edge of the Kodachrome to the plate holder with the use of transparent Scotch tape. Then fold the Kodachrome back, using the Scotch tape as a hinge and with the use of a medicine dropper place a bead of previously prepared 5 per cent water solution gelatin on the lantern slide at the edge where the Kodachrome has been attached to the plate holder. Starting where cement has been applied, and with the use of either a squeegee or a roller, press the Kodachrome down upon the glass, maintaining a bead of cement at all times as the lamination is completed over the entire plate area. No great pressure is required in this procedure, but a steady drag of the squeegee or the roller is necessary. Remove

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\* Presented Oct. 19, 1943, at the Technical Conference in Hollywood.

\*\* Research Engineer, Paramount Pictures, Inc., Hollywood.

the lantern-slide glass from the plate holder and proceed to the second step of the transfer.

With the use of a weak solution of ammonia and water, dampen the gelatin backing of the Kodachrome and allow to stand for several minutes. Then with the use of a razor blade scrape all the gelatin backing from the plastic base. During this stage the film—that is, the acetate butyrate film base—may be damaged, but as this will be removed later it will not affect the finished article. After all gelatin has been removed, place the lantern slide in a petri dish partially filled with menthol cellusolve acetate, allow to stand for approximately 4 min, remove, shake off the excess, and allow to stand for another 30 min.

With the aid of a razor blade under one corner, lift off the swollen plastic. It will be found that the plastic has sufficient strength and will separate from the emulsion readily. If the plastic film is too tender, allow it to stand until strength has returned. This will range from 5 to 20 min. After the base has been removed, take a small piece of cotton, well saturated with menthol cellusolve acetate, and swab the surface of the Kodachrome emulsion to remove all excess plastic. This might require 5 or 6 clean applications, or until the surface is perfectly smooth and glossy. The plate is then ready for use in the stereopticon.

Another way to remove the acetate butyrate film base which was standard before the adoption of the menthol cellusolve acetate solvent, is by the use of acetone. The procedure up to the time of the immersion of the plate in menthol cellusolve acetate was the same, but at that point the plate was placed in a desiccator and allowed to stand for approximately 24 hr, or until the Kodachrome emulsion layer was dry. The plate was then removed from the desiccator and placed in a petri dish containing acetone, and with the use of a camel's hair brush the film base was dissolved by gentle agitation. Several applications of clean acetone were used to insure the complete removal of the acetate butyrate plastic. No further treatment to the plate was required for its use.

Appreciation is hereby expressed to the Eastman Kodak Company and to Dr. Norwood L. Simmons of the Eastman Kodak Company for their assistance.

## HIGH-EFFICIENCY STEREOPTICON PROJECTOR FOR COLOR BACKGROUND SHOTS\*

FARCIOT EDOUART\*\*

*Summary.*—The use of hand-colored slides in connection with transparency process production has long been practiced, but at best such slides are far from satisfactory. A solution to their limitations was to project and rephotograph natural color. Paramount Studios has designed and developed a stereopticon which projects natural color slides, and which incorporates such modern devices as a special relay-optical system, heat-absorbing shutter, and the latest-type projection light source. These features and other details of the transparency stereopticon are described in the following paper.

Years prior to the advent of Motion Photography, when Edison invented his Kinetoscope, back in 1892, the old "Magic Lantern," with its oil lamp light source, was just the thing for an exciting evening's entertainment. And how well most of us can recall the various stages of development and advancement made through the more recent years, from the kind of lantern-slide pictures we enjoyed as kids, to the type of screen entertainment and artistry we now enjoy and demand.

In keeping with the color motion picture production demands of today, Paramount has designed what we believe to be a most modern and up-to-date type of "magic lantern" or stereopticon projection equipment, incorporating a specially designed relay-optical system, with synchronizing heat-absorbing shutter, and powered with the latest type Mole-Richardson projection light source (Fig. 1).

This stereopticon was developed to project natural color slides, in connection with the transparency process on color production, and constitutes a long step forward over the first stereopticon developed at Paramount along the middle part of 1932 for black-and-white transparencies.

The use of hand-colored slides in connection with transparency

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\* Presented Oct. 19, 1943, at the Technical Conference in Hollywood.

\*\* Director of Transparency Div., Special Photographic Dept., Paramount Pictures, Inc., Hollywood.

process production has long been used, but at best this medium has been far from satisfactory for a number of reasons. First, the basic monochromatic values and density of the plates seldom permit the correct reproduction and richness of true color. There is the ever-present problem of coloring the slides correctly and evenly for enlargement to a screen picture of any size, a job requiring the most

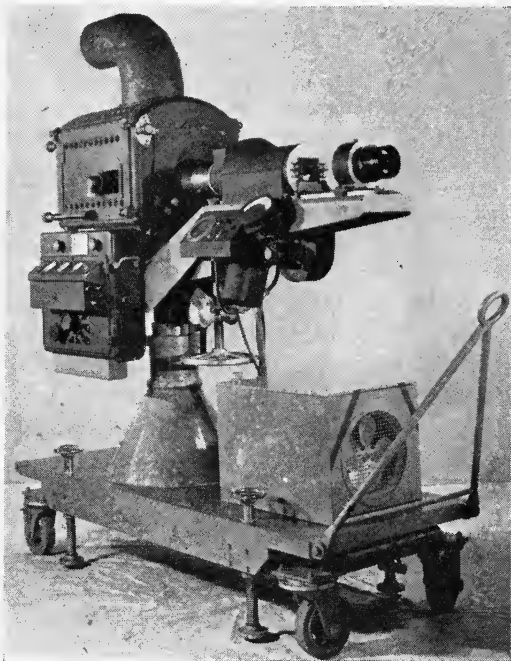


FIG. 1. Paramount transparency stereopticon, operating side showing adjustable plate holder and lens mount.

meticulous skill, care and patience. Then there is the difficulty of securing stable nonfading color pigments and dyes that will stand the heat and intensity of the Super-Hi arc light. Added to these, there is the troublesome problem of securing heat-resisting, nonbreakable glass plates that will stand the terrific heat necessary for sufficient light to rephotograph in color. These are just some of the problems of using artificially colored plates.



Obviously the best solution to the problem was to project and rephotograph natural color. To do this required 3 major steps, each in itself a major necessary link in the accomplishment of the whole:

(1) The duplication in quantity of correctly distorted, non-fading natural color prints  $3\frac{1}{4} \times 4$  in. in size. In this connection, it must be realized that the light source, condensers and optical system, slide glass, and the translucent projection screen used all act as a cumulative filter on the projected image. There-



FIG. 2. Paramount transparency stereopticon cooling unit consisting of radiation units for water-cell and lamp water circulation.

fore, the slide reproduction must be distorted in color to allow for this, so when finally projected the image should appear in the correct color balance to the camera as originally intended.

(2) The transferring of these duplications to a heat-resisting glass, water clear and free from bubbles or striae, and cemented in a manner to resist the most intense heat without peeling or separating from the glass support and causing Newton-Ring effects during projection.

(3) The designing of a unit to project the  $3\frac{1}{4} \times 4$ -in. image with sufficient light intensity to adequately rephotograph in color.

This required a light source and optical system producing the maximum efficiency, and required all the heat reducing and cooling elements we could employ, at the same time sacrificing a minimum amount of light and causing a minimum of color distortion.

The light source provided for operation of the stereopticon consists of a Mole-Richardson lamp house designed to the Academy Research Council Process Projection specifications, and has specially designed condenser elements composed of a primary system consisting of a quartz plano-convex condenser exposed to the arc, and a pyrex double-convex condenser. These in turn are focused on a circulating water-cell system consisting of 2 plano-convex condensers of optical crown glass, which in turn are focused onto a field condenser system large enough to fill the  $3\frac{1}{4} \times 4$ -in. slide.

The combination condenser water-cell is equipped for the introduction of filters such as heat absorbing, color distortion, or neutral density, mounted in a slide that drops into a set position covering the full light ray. They may be added or removed as desired, depending upon the amperage used, whether the slide being used is of nonbreaking glass, or whether the color ratio is required to be altered. The cell uses circulating deaerated distilled water to eliminate air bubbles from forming on the inside glass surfaces during operation, and is circulated by pump through a fan-cooled radiator (Fig. 2). The capacity of the cell circulation system is approximately 2 gal per min with enclosed liquid volume totaling approximately  $\frac{1}{2}$  gal.

The circulation part of the equipment is a dual system, mounted in a case on the base of the stereopticon and connected by flexible transparent plastic tubing. This mounting, in addition to the cell circulating and cooling system, also contains the circulating water and cooling system for the lamp house, as the positive carbon-mounting unit in the Mole-Richardson lamp house is always kept down to hand-touch temperature, even while operating at 220 amp.

The heat-absorbing glass used in the water-cell when occasion demands is the unusually effective glass developed by Dr. Tillyer, designated as "Phosphate Heat-Absorbing Glass."

Owing to the physical characteristics of this glass, it is most essential that it be utilized in such a manner that the entire area of the screen be subjected to heat of a relatively uniform level. Because of the comparatively high coefficient of thermal expansion, coupled with a

low degree of elasticity, lack of uniformity in heat absorption over the area of a piece of this glass is most likely to result in fracturing.

Immediately adjacent to the outside of the water-cell, in the path of light between the cell and field condenser unit, is mounted a heat-absorbing shutter operating in the same manner as that found in 35-mm background projection equipment, interrupting the light path, the shutter being operated in synchronism with the camera. Experimental work has been done using a shutter made of Aklo No. 2 heat-absorbing glass, which absorbs approximately 30 per cent of the



FIG. 3. Paramount transparency stereopticon, looking down on optical system showing water-cell, heat-resisting experimental glass shutter, and field condensing system for plates.

heat, and which is transparent enough not to have the disturbing flicker effect of a solid shutter (Fig. 3).

It might be said that one psychological advantage in using a glass shutter in stereopticon shots is that the average director is not disturbed by shutter flicker on the screen which is always existent with the conventional type used in motion picture projection.

The following figures will indicate the conditions found without a shutter, with an opaque shutter, or with a shutter of heat-absorbing glass:

	No Shutter <i>Per Cent</i>	Metal Shutter <i>Per Cent</i>	Glass Shutter <i>Per Cent</i>
Photographic value of illumination	100	100	100
Light incident upon eye	100	63	91
Heat incident upon slide	100	63	70

It is evident from the above that the introduction of the metal shutter reduced the heat flux upon the plate by 37 per cent, and at the same time introduced the flicker characteristic typical of 35-mm

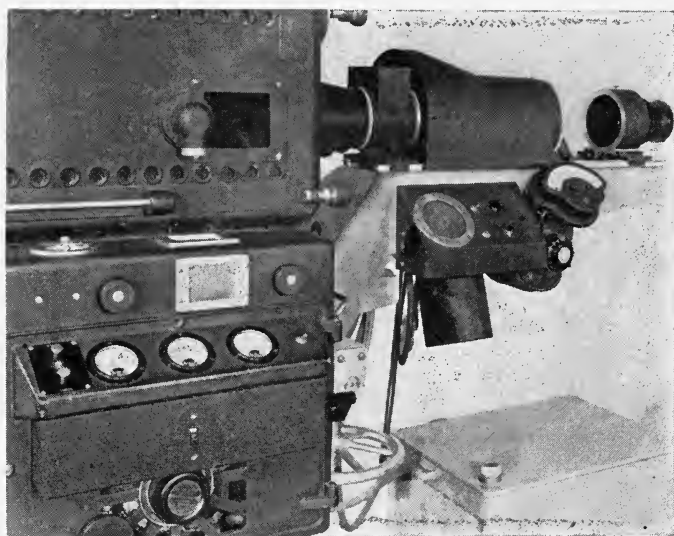


FIG. 4. Paramount transparency stereopticon, operating side showing control panel on Mole-Richardson lamp, speaker system, and tachometer.

background projection, whereas the heat-absorbing glass reduced the heat flux upon the plate by 30 per cent and caused a negligible flicker. With an increase of only 7 per cent in total heat on the plate, the shutter flicker was changed from a condition of 100 per cent illumination dropping to zero with the solid shutter, to a condition of 100 per cent dropping to approximately 80 per cent, under which circumstances the presence of the glass shutter could hardly be noticed. Obviously this freedom from flicker is of considerable value in exposure determination.

The sole purpose of the shutter, whether glass or metal, is the protection it affords the glass stereopticon plate from heat. The shutter motor is equipped with a magneto-type tachometer for determination of shutter speed when operating wild during tests and line-up operations. When shooting, the shutter motor is interlocked with the camera motor by means of a standard interlocking distributor.

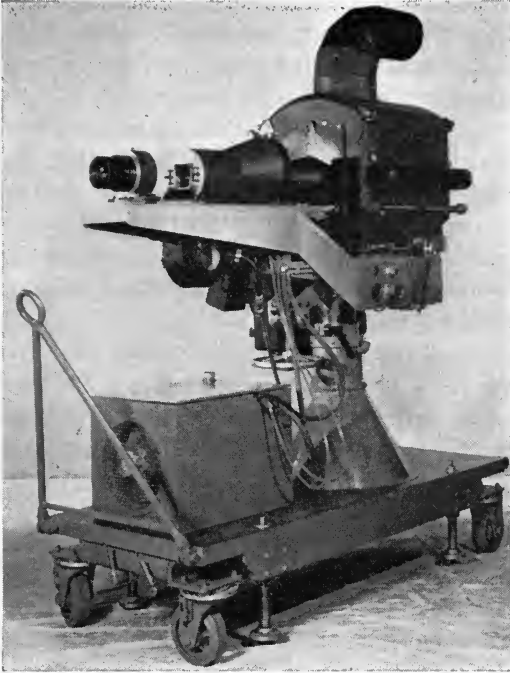


FIG. 5. Paramount transparency stereopticon, showing right side and electrical hookup.

The preference for a heat-absorbing glass shutter blade over metal may be realized if the increase of heat transmission amounting to approximately 7 per cent will not result in damage to the slide, emulsion or breakage of the plate it is mounted upon.

The light path between the water-cell and field condenser unit is completely enclosed with a tight-fitting hood so that no appreciable leak-light is present. It has a convenient piano hinge cover for easy access to the shutter assembly (Fig. 4).

The field lens unit consists of 2 condensers, mounted with the convex spherical curves face to face with the input and output plano surfaces to the outside. The colored slide is mounted on the output side, and the unit revolves around the optical axis through 180 degrees so the slide may be leveled up for horizon line or angled either way at will.

The slide is held away from the face of the field condenser by a specially designed 4-point holder, constructed to allow for the smallest point of surface plate contact, and to allow a cooling air stream to pass between the condenser and plate, preventing heat transmission and resulting in a minimum of plate breakage.

A squirrel-cage type blower is mounted directly below the field condenser and plate holder assembly, capable of delivering 200 cu ft of air per min, the speed of which is controlled by a switch and rheostat from the main control panel. A Venturi-tube principle of adjustment with directional air baffles located directly over the blower and under the slide, provides the best possible directional adjustment for both sides of the slide simultaneously.

The objectives used are anastigmatic coated and consist of a 12-in. Astro  $f3.1$  and 16-in.  $f4.5$  Bausch and Lomb, which are quickly interchangeable in an adjustable focusing mount. When operating at approximately 225 amp using 16-mm positive carbons, the output of this equipment is in excess of 60,000 lumens.

The main operating panel is located on the right and operating side at convenient height on which are mounted all necessary operating switches and a 2-way "talk-back" speaker connected with the camera operating table ahead of the projection screen.

The whole unit is very portable; the base is all metal, built on the dolly principle and mounted on rubber tire castors. It weighs 1800 lb, and is equipped with convenient pan and tilt mechanisms and adjustments which lock tightly. The base has 4 screw jacks which lock the unit solidly to the floor after being placed in correct stationary shooting position (Fig. 5).

It is silent in operation for sound and is equally adaptable for both color or black-and-white stereopticon projection plates.

This whole problem of natural color stereopticons with respect to transparency process work is new and has required the most ingenious and cooperative efforts of various departments. While we do not claim perfection, we know we have achieved a reasonably satisfactory result so far, which will improve with use.

The first step of accomplishment—that of color print duplication—was taken over by Earle Morgan and Roy Peck, heading up Paramount's Still Processing Department and they have, after many difficulties, ably surmounted most of the problems of copying, contrast control and color correction. The paper entitled "Duplication of Kodachrome Transparencies for Background Projection" was presented by Mr. Morgan.<sup>1</sup>

The second step and problem of transferring the duplicates has been very successfully accomplished by Barton H. Thompson of our Engineering Department, who has developed a rapid special control technique. The paper entitled "Kodachrome Transfer" was presented by Mr. Thompson, research engineer.<sup>2</sup>

The number three step—that of engineering and constructing the unit—has been ably mastered by A. C. Zoulis, Chief Engineer of Paramount Engineering Department; Wilbur Silvertooth; Larry Brunswick; and the personnel of the Transparency Department.

Were it not for the intelligent effort and perseverance of all these technicians, our stereopticons would have remained a difficult problem.

We have two of these units and have already utilized them in single- and dual-color projection. With the constantly increasing production of color motion pictures we feel we are on the right track to accomplish better results in color stereopticon transparencies.

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<sup>2</sup> THOMPSON, B. H.: "Kodachrome Transfer," *J. Soc. Mot. Pict. Eng.*, **43**, 2 (Aug., 1944), p. 95.

## PRESENT AND PROPOSED USES OF PLASTICS IN THE MOTION PICTURE INDUSTRY\*

BARTON H. THOMPSON\*\*

*Summary.*—A general survey of plastics as they apply to the motion picture industry, outlining molding and fabricating problems, basic material make-up, outstanding physical properties, and a general description of some of the actual usages of thermoplastic and thermosetting resins are given. The future of the many plastics is also briefly discussed.

The adoption of plastics within the motion picture industry has been held up to a great degree by the war effort. Prior to the war many applications were made by using a plastic alone or in conjunction with other materials. Although the plastic field is in its infancy, with the development of new resins and processes due solely to the war effort, in the future we may expect to accomplish with plastics what has heretofore been considered impossible.

The word "plastic" is too new to have a clear definition. It is understood by many to be an animal or plant resin, or a synthetic organic material composed mainly of a resinous or cellulose derivative binder. Actually, the majority of plastics are made from one or more of the following basic materials: Air, water, coal, petroleum, natural gas, limestone, salt, cellulose from wood or cotton, or sulfur.

Plastics are classified as thermoplastic, thermosetting, and element reactive. The element reactive will not be discussed at length in this paper, but it is composed of resins which react to the elements, such as oxidation, and is used in coatings and surface finishes.

**Thermoplastics.**—These are synthetics except for a few natural resins, such as polyterpene and shellac, the cellulosics and the synthetic organic materials, which can be heated and molded into shape, and can be reheated and remolded from time to time.

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\*\* Research Engineer, Paramount Pictures, Inc., Hollywood.



**Thermosetting.**—These are plastics which set up or become rigid under heat and pressure or by heat alone. Unlike the thermoplastics, they may not be reheated to reform. In the motion picture industry we use all types of thermoplastics and thermosettings in some way, shape or form, and in many instances we are unaware that the material used contains a plastic.

In this discussion of plastics I will present some of the present plastic applications, taking into consideration the type of plastics, why they are used, and how they are fabricated. In closing I will deal with the future of plastics as they pertain to the motion picture industry. We will start with the thermoplastic field, and follow with the thermosetting.

#### THERMOPLASTICS

In the thermoplastic field we find the celluloses, vinyls, acrylics, shellac, polyterpene, styrenes, and synthetic fibers such as nylon and rayon. In our studio we do not have injection molding machines, extruders, or large capacity presses, all of which entail expensive hardened steel molds. Our one- or 2-piece production schedule would not permit such an expenditure; therefore we must rely on fabricating our needs from stock sheets, rods, and tubes furnished us by manufacturers or other sources of supply.

Cellulose nitrate, the oldest of the cellulosics, is made from carefully purified cotton having a high alpha cellulose content, and is treated with a mixture of nitric and sulfuric acids. This resin was developed to a commercial status in the middle of the 19th century by the incorporation of solid camphor. From that time on it has grown in proportion to the point where it is now used in many applications such as the replacement of tortoise shell, ivory, and other materials found in nature.

The majority of work on motion picture film has been based on cellulose nitrate. As a matter of fact, approximately 95 per cent of all film used in Hollywood today is cellulose nitrate. Its outstanding properties are toughness, ease of fabrication, water resistance and moldability, but it has one great drawback, and that is its inflammability. This problem has been worked on by many concerns and it is found that with the use of certain plasticizers the inflammability has been reduced. Some handles of ladies' purses are made of ni-

trate; the desired rod size is obtained, cut and bent to shape with the assistance of heat. The question immediately rises: why is nitrate chosen for the handle of a bag? The answer is because of its resistance to water, perspiration from the hand, toughness, and ease of fabrication. It is also used in the fabrication of eye shades, blotters, printed calendars, clock dials and crystals.

Next in line is the cellulose acetate which is a resin made up similarly to nitrate, except that the treatment of cotton linters is with acetic acid and acetic anhydride in the presence of a catalyst such as sulfuric acid, instead of a mixture of nitric and sulfuric acid. It was commercially available about 1906 and was used in small quantities for the manufacture of nonflammable photographic film. During World War I it was used in the manufacture of airplanes as "dope" coatings. It is also used today in the motion picture industry in a similar way.

The outstanding characteristic of this plastic, compared with cellulose nitrate, is that it is chemically stronger and has higher dielectric strength. Water resistance is not so good as that found in the nitrate, but this has been overcome by some manufacturers by the increase of acetyl content. Again, the imitation of natural products, such as mother-of-pearl, tortoise shell, and ivory, may be produced. The housing for an antenna used on a "prop" plane was made of an acetate. The material came to us in a flat sheet, was placed in an oven at the desired temperature, heated, removed, and stretched over a form. It was made in 2 pieces which were butted and, by capillary attraction of a suitable solvent, cemented together. The weld on this particular piece is probably stronger than the original sheet. Hat-boxes are also made of an acetate, drawn in a similar manner as the fabrication of the antenna housing. A plaque of a flying duck shows its possibilities for dyeing to any desired color. It also shows the possibilities of fabrication. The material is approximately 15 thousandths of an inch in thickness, and has been drawn to better than three-fourths of an inch in less than a 2-in. space, indicating clearly that the material is ideal for motion picture uses.

Cellulose acetate butyrate is made up in a manner similar to the acetate in that it uses a mixture of butyric and acetic acids and the anhydrides. This plastic was developed for the purpose of obtaining a more water-resisting resin, and its outstanding properties are, in addition to water resistance, weathering characteristics. This material is used on special films used in the motion picture industry,

such as Kodachrome, where low moisture absorption, high dimensional and good weather resistance are demanded. It is also used in the manufacture of lacquers and is superior to the acetate not only in its weather resistance and resistance to water, but it has greater adhesion.

We have a tubing made from ethyl cellulose, commonly known when highly plasticized as "ethyl rubber." It is made by the action of a strong alkali, such as sodium hydroxide on cotton linters, followed by a rather involved process. It can be plasticized to a rubbery consistency, or can be made to a rigid hardness. Its outstanding characteristic is its toughness at temperatures ranging from minus 78 F to plus 160 F. Its dimensional stability is excellent and it is the lightest of all the celluloses. Its density is 1.15. Transparency screens made from this material have proved ideal because the screens are strong, weathering characteristics are good, and age will not discolor or make the film brittle. Another possible application within the motion picture industry is that of laminating cloth and fibers into desired forms or shapes.

Another very useful plastic used within the industry is cellophane. This is a regenerated cellulose. Essentially 80 per cent is cellulose, the remainder plasticizers and waxes. Cellophane is manufactured in films, clear and colored, flame proof and moisture proof, in ribbons and strings, in tubes or soda fountain straws, in bags and in fabricated boxes for display purposes. In these many forms we adopt this material, cellophane, for use in draperies, wardrobes, and many forms of interior decoration and special effects.

The vinyl resins are a group by themselves and are not used in this industry to any great extent. Basically, the resins are made from acetylene and acetic acid, or acetylene and hydrochloric acid, under exacting conditions. We find the vinyl acetate, vinyl chloride, vinyl chloride-acetate copolymer, the polyvinyl alcohol, polyvinyl butyral, vinyl acetal, and the vinyl formal.

The most important of this group is the acetate. Its chief use, besides being the base for the manufacture of the alcohol, butyral, acetate and formal resins, is in the laminating field. These adhesives are excellent, and show great possibilities for post-war use.

The vinyl chloride has proved very satisfactory for textile finishes, for waterproofing fabrics, whereas the molding compounds have been used to coat electrical cables where great wear, such as we have in the industry, is demanded. The copolymer of the vinyl chloride and

vinyl acetate is used in sheet stock in laminated films, in coatings and in transcription records.

The polyvinyl alcohol is a water-soluble resin and its typical applications are for adhesives, gelatin substitutes for photo-sensitive stencils, film where high tensile and tear strength is demanded, in sizing of textiles, and as an admix for rubber latex.

The vinyl acetal is used in the manufacturing of safety glass.

All of these resins have excellent properties and great possibilities, but for the duration, unless used for actual war products, we must find substitute materials.

We have a tubing made from vinylidene chloride resin, which is made from coke, lime, and brine. From coke and lime we secure acetylene. From brine we secure chlorine. The combination of acetylene and chlorine under exacting conditions produces a resin which is noted for its resistance to acids and alkalis, its noninflammability, and its high fatigue characteristics. Actual tests of this material have proved that it is one of the best in the field. It has been flexed more than three million times without showing a breakdown. Pipes made of this material stand pressures up to 6000 lb per sq in., with softening point of from 250 to 280 F. In this industry it is being used to replace copper tubing.

The methacrylic resins are made by the polymerization of the monomeric derivatives from the acrylic acids. These resins are noted for their superior transparency and for their abilities to "pipe" light. Within the industry they fit exceedingly well because of their flash and ease of fabrication. The procedure for making a picture frame is to take a rod of the acrylic or methacrylic resins, place it in an oven, heat it until it is flexible, twist it and form it into shape, hold in position, and then allow to cool. Furniture and ornamental personal properties, such as mirrors, cigarette containers, and jewelry boxes, have been used in our set dressings.

Styrene is another interesting transparent material. It is made from ethyl benzene, and by the simple removal of the hydrogen we secure a monomer styrene, which is polymerized to give the polystyrene. Styrene is noted for its chemical and water resistance, high impact strength at low temperatures, and its electrical qualities and low specific gravity. It is also noninflammable. Piping light is also possible. Coaxial cable used in the television field is made with the use of styrene beads. Other sound and electrical installations are also used within the industry. Because of the war effort, in our syn-

thetic rubber progress we have constructed enormous plants for the manufacture of styrene. At the end of the war we may expect to see this transparent plastic become a large competitor in the plastic field, for today the cost is less than the methacrylics, acetates, and vinyls.

Synthetic textile fibers, the rayons, proteins, nylons and vinyls, are used in draperies, wardrobes, coverings for furniture, and numerous other applications.

The manufacturing process of nylon is complicated and exacting. The result is a synthetic linear polyimide. Nylon is noted for its durability, strength, elasticity, colorability, and toughness. As nylon is being used approximately 100 per cent in the war effort, we will probably have to wait until after the war for a more general use of that property.

The rayon fibers are broken down into 2 groups, the regenerated cellulose and cellulose derivatives. The viscose, nitro-cellulose, and cuprammonium are found in the former; in the cellulose derivatives are the acetate (esters) and ethyl (ethers) and a combination of the esters, ethers, or ester-ethers. They are noted for their high tensile strength and light weight. Threads finer than those of silk have been spun from these materials. The luster of these fabrics alone tells the story.

The vinyls include several filaments, the two most important are Vinyon, a trade name of the Carbide and Carbon Chemical Company, which is a copolymer of vinyl chloride and vinyl acetate in the approximate proportions of 90 to 10. The chemical and physical properties are good, for they withstand acids and alkalies very well. They are tough and strong and are noted for their weathering characteristics. The second filament is the vinyladine chloride (Saran) mono-fils. From this resin have been manufactured seat coverings, substitutes for wire, fly screens, ropes, and many other applications where weathering characteristics are required, and which have more than proved their worth.

Proteins, although not as important as other groups, have many applications. They are obtained from both animal and vegetable life. Milk and soybeans are the most commonly used. By special treatment a filament is obtained, but one great drawback to these fibers is that when they become wet they lose approximately 75 per cent of their strength. The greatest protein fiber application is that found in felt hats.

## THERMOSETTING

The thermosetting field of resins is composed of the phenolics, ureas, melamines, furfurals, and a few others. In the motion picture industry, this material lacks the ease of fabrication of other resins in that large pressures and temperatures of 300 F and up are required for fabrication. There are a few exceptions to this, such as low-pressure laminates, no pressure laminates, and liquid cast phenolics. As the low-pressure laminates are just coming into the field we will wait until a future date for the discussion of this principle. Liquid cast phenolics will be discussed later in this paper. The 4 chief contenders in this field are the phenolics, furfurals, the ureas, and the melamines.

In 1909 Dr. Baekeland developed a condensate material from the reaction of phenol and formaldehyde. This resin is used as a binder and is filled with such things as rags, string, cotton, walnut shell flour, cotton flock, and many others. These fillers determine the physical properties of the resin itself. For example, to secure a high impact strength material, a long fibrous filler is used, such as string. Many phenol formaldehyde resin parts, film spool rolls, and prefabricated parts are used on our various pieces of equipment. Laminated phenolic sheets are also used in making specialty items, for example, the special gears for our cameras or single parts for equipment. Resins can be made from this material which give great shock resistance, heat resistance, extremely high impact strength, and high insulation value. However, all these properties depend upon the particular filler that is used. Phenols are available in dark colors only.

Another of the phenol group is the phenol formaldehyde liquid casting resin. This resin lends itself readily to the industry in that inexpensive molds and low-cost equipment can be used in its fabrication. By the introduction of an acid or alkali catalyst, this material will set to a rigid consistency. An example is a skull which can be cast in an inexpensive rubber mold, using a slush molding process; another is an artificial pineapple which can also be made in a like manner.

Urea formaldehyde was commercially introduced into this country about 1928 and it is a truly synthetic resin since all the raw materials are derived from gases, ammonia, carbon dioxide, carbon monoxide, and hydrogen. The straight resin may be used as a bonding agent, such as is sometimes used in plywood panels, or it may be used to laminate sheets of paper or other sheet materials. It is also used

in making up a resin with an alpha-cellulose pulp. This is probably its widest application, since the alpha-cellulose gives a white appearance. Dyes and color pigments may also be incorporated to give various shades as desired.

An outstanding thermosetting resin which is just entering the field is the melamine resin. It has the qualities of being an ideal thermosetting resin because it has the physical properties of the phenolic resins as well as colorability of the ureas. It is probable that this resin may be the answer to many problems heretofore unanswered in the thermosetting field.

There are 2 other resins that have been adopted into the motion picture industry. One, borrowed from the paint industry; the other developed solely for a specific use. Both have the same final results—the manufacture of “breakaway” glass and miscellaneous props. The one borrowed from the paint industry is a cyclo-paraffin resin, made by a very complicated process. The other is a resin developed by the Baker Oil Tool Company using as raw materials phenol, formaldehyde, and a catalyst, keeping at all times the phenol content in excess. Both these resins are water-clear in appearance; both have a critical melting point of around 300 F, and they shatter without leaving cutting edges.

#### RUBBER

Although this discussion is relative to plastics, I feel that the subject of rubber should be mentioned. The war obviously has prohibited the use of rubber props and practically all other applications of rubber in the industry, but before the war rubber and rubber latex were sold in great quantities and made into props—arrowheads, billy clubs, snakes, dishes, foliage for miniatures, artificial flowers, knives, and other applications such as vibration dampeners and other equipment installations.

The latex rubber was the most widely used, again because of its ease of fabrication. Concentrated latex of 60 per cent was compounded, whipped up to a fluffy consistency by the common kitchen beater, poured into molds, placed in an oven, and cured. This process seems very simple but, as a matter of fact, it is a complicated and very difficult procedure. A tommyhawk used in pictures was made from milled stock in a metal mold and cured between hot platens of a temperature of 310 F and a closing pressure of the press. The prop billy was made in a similar manner except that the compounding was

a sponge stock. The mold was partially filled, heat applied while the mold was closed, and the reaction of the compound formed a gas within the mass which filled the mold. We believe that rubber will return to the industry after the war with a greater importance than ever before.

The future of plastics within the motion picture industry is unlimited in its possibilities when taking into consideration the new developments that are being made. The possible use might be the construction of complete sets where design demands. Props from these materials will be either soft and light or hard and heavy, depending upon the desire of the producer. Motion picture film, still retaining the desirable characteristics of cellulose nitrate, will be non-inflammable with no additional cost. Lenses, although this statement may be challenged by many, will be made of plastics, case-hardened to a possible hardness of quartz. Lens treatments will be made of a layer of plastics instead of the now technical vaporization of metals (to decrease light lost by reflection). Plastic furniture will replace the present heavy woods and metals. Draperies, rugs, and seat coverings will be of plastics. They will last not for just one picture, but may be saved and utilized in many. Equipment will be lighter, more durable, more easily fabricated, and much better to handle. Plaster sets which now weigh so much will be made lighter by the incorporation of a plastic which, in addition to its lightness, will increase its durability. Synthetic fiber materials will for once and all replace the natural fibers of today because of their greater life and colorability. Linings in our laboratories' developing tanks will be of plastic and last indefinitely. Plastics will outmode present processes now used in our make-up departments. Special effects required by the industry, such as storms on the high seas, lava flows, and others now difficult to reproduce, will be simplified by the application of plastics.

In conclusion, the plastic field is still in its infancy. No one can predict its ultimate accomplishments because of unlimited possibilities owing to chemical stability, heat resistance, low water absorption, high tensile strength, noninflammability, colorability, lightness in weight, flexural stability, high dielectric qualities, and ease of fabrication.



## WAR STANDARDS FOR PHOTOGRAPHIC EQUIPMENT SPEED MILITARY INSTRUCTION\*

A. G. ZIMMERMAN\*\*

*Ed. Note:* Since the projects of the ASA War Committee on Photography and Cinematography-Z52 were initiated early in December, 1943, members of the Society of Motion Picture Engineers have collaborated with the Armed Forces, the War Production Board, and the motion picture industry, in organizing technical committees to carry out these vital wartime needs. The Society was in an excellent position to make available the long experience and skill of its technical personnel, many of whom had already studied problems similar to those to be considered by the Armed Forces.

Following the unanimous approval of the project by the Board of Governors, the membership of all SMPE technical committees offered their services wholeheartedly and were immediately organized into new groups to undertake the responsibility of preparing specifications for ASA War Standards. In addition to Mr. Zimmerman, Chairman of Subcommittee D, six other SMPE members serve as chairmen or vice-chairmen of Z52 subcommittees.

Mr. Zimmerman's report of the completion of the principal project assigned to Subcommittee D is reprinted from *Industrial Standardization*.

A schoolboy from the University of Minnesota, transplanted to a foxhole in the South Pacific, experiences a dislocation far beyond the imagination of most of us. That same boy must, further, be trained in the art of self-preservation against enemies, both natural and unnatural, and this training must be accomplished in an incredibly short period of time. Under ordinary circumstances an individual's knowledge of the customs, living conditions, and general nature of the people with whom he comes in contact is the result of years of association with his surroundings. War, however, gives no time for such experiences, for individual instruction, or even for ordinary methods of training to develop personal knowledge of the terrain, of enemy customs, customs of friendly natives, or an understanding of

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\* Reprinted from *Industrial Standardization*, 15, 6 (June, 1944), pp. 109-12.

\*\* RCA Victor Division, Radio Corporation of America, Indianapolis, Ind.; Chairman, Subcommittee D, ASA War Committee on Photography and Cinematography-Z52.

new and unfamiliar equipment. The neophyte warrior must be educated in a matter of days, or even of hours, to kill, if he is not to be killed.

The Chinese have a proverb to the effect that one picture is worth a thousand words. Faced with the problem of educating an Army and Navy in the least possible time, those responsible for military training have not ignored this ancient knowledge. As a result, the use of military arms, prevention of disease, and methods of assuring their general welfare under varying geographical conditions, have been taught to our fighting men in a remarkably short period of time.

How has this been done? It has been accomplished largely through the use of the motion picture.

The Armed Forces believe that the motion picture, preceded or followed by printed commentary, is an able substitute for years of experience. Actual scenes, re-enacted by professional or amateur personnel, with an audible description of the action as it occurs, is an improvement of the Seven League Boot variety over the silent "movies."

The fact that motion picture equipment was available immediately for the use of the Armed Forces can some day be written into the annals as a major contribution to the success of our campaigns.

The contribution of the motion picture to the war effort does not stop with its service to the Army and Navy, however. Military success, as everyone knows, is dependent upon preparation, the amount and quality of equipment available, and the speed at which it is provided. When the war first started, the country as a whole was in need of schooled artisans to perform certain functions necessary for the design and manufacture of war matériel. In many cases the operators of machines had never heard of the product that they were to make, much less the machine they were to operate to make that product. Processes and machine tool operations were as foreign to them as though they had been created in a different world.

Those in command of industrial organizations, therefore, as well as those in command of military organizations, were faced with the necessity of preparing, and releasing to the country in general, educational material which would make it possible for them to turn out production, to reduce scrap, and also to protect the health of workers so that schedules could be met. For this, too, motion pictures furnished the means of education.

We can be truly thankful that the equipment for carrying on such a program was available, and that the country was able to fall in line quickly on the preparation of training films.

Fortunately, too, for our men who were called to the colors, the United States had been progressive in the development and partial standardization of the motion picture industry—particularly in the 35-mm or theatrical type of equipment. The nontheatrical or 16-mm type of equipment, however, utilized standard film but practically stopped there, in so far as standardization was concerned. It was unfortunate that the 16-mm equipment which was available at the time hostilities started was of such nature that no two projector mechanisms resembled each other. Each type of projector was manufactured from the designs of engineers varying in their opinions. Each was manufactured in an independent organization catering to a certain clientele.

In peacetime, these manufacturers and consumers were satisfied (or at least partially so) by the performance of the equipment which they had produced or procured. Commercial 16-mm equipment had been designed for what had been considered at that time the most stringent application—that of the classroom, or possibly the sales organization, which required the exhibition of not more than 2 or 3 reels of film per day. The new or military requirement, on the other hand, was such that the machine had to be available for operation any hour of the day without failure. In addition, it had to be used under the most extreme conditions of vibration, shock, high humidity, extreme low- and high-ambient storage and operating temperatures, and salt-and-dust-laden atmospheres. Further, the using personnel could not always be carefully trained motion picture men—any untrained GI might have to operate it under service conditions. And eventually the equipment would have to be repaired. Quick and easy replacement of parts would be necessary, and for example, in the South Pacific jungles, a service man could not be found around the corner and a source of spare parts found 2 miles down the street.

Imagine, then, the dilemma of the Armed Services in attempting to obtain projection equipment which would be satisfactory for continuous use in any climate, and under any conditions.

Here is an example of conditions as they actually exist. Let us imagine that a convoy has left from a port of embarkation under sealed orders. During the interval of time between the embarkation and the arrival at the destination, the enemy has perfected a new

device with which the fighting personnel of the convoy have not been able to familiarize themselves. This information in the meantime has been transmitted to Facilities Branches in the States which have been able to prepare illustrative films, pointing out the advantages and weaknesses of the enemy's new technique. These films are flown to the convoy destination.

Instructions are issued to brief the troops in as short a space of time as possible on the new technique to be used. The motion picture equipment is set up and operates almost continuously, with companies or even regiments in attendance, in order that the greatest number of men can be trained in the shortest space of time.

Let us imagine that there are two machines available at this particular point, each of different manufacture. Let us carry our picture still further and imagine that a particular part of the machine wears out or proves defective under the constant "grind." Immediately the instruction efficiency is cut in half, since only half the personnel can be handled at a time. To carry our point still further, let us suppose that the Procurement Officers have done a perfect job in making spare parts available with the original equipment, but in this particular instance the spare parts that have arrived at the destination are for only *one* of the many types of equipment they are using. As a matter of fact, situations have occurred, and unfortunately still do occur, where the spare parts available are not applicable to either type of equipment in use.

Literally millions of lives depend upon the portrayal of this information in the shortest possible time, and now, through no fault of the expeditionary forces, this information must be passed on either verbally or through a slow and tedious classroom operation.

Conditions such as this became apparent immediately upon our advent into the war, yet the pressure was so great to get material, planes, rifles, ammunition, fuel, *etc.*, that the training media—motion picture equipment and films—although considered highly important by the Armed Forces, was not considered sufficiently important to create any form of standardization. The procurement offices obtained equipment from any source, going on the assumption that war is a wasteful procedure at best. This "civilian" equipment served as a "stop-gap" and despite its shortcomings has played a large part in our successes to date.

As the war has progressed, however, the importance of improving the facilities for instruction work, as well as for field entertainment,

has become more widely recognized. Farsighted individuals connected with training, engineering, and procurement in the Armed Forces have realized that the preliminary training given the troops is only one function which this equipment will be called upon to perform. Our ultimate successes in the field must be followed by additional training, since the occupied countries, as they become such, must be educated to cooperate with the forces of democracy.

This can best be accomplished through the medium of picture and sound.

For our immediate purposes, however, the Armed Forces are particularly interested in the development and design of equipment which will ask no quarter under any field service conditions. Such equipment, in other words, would be able to take its place alongside ordnance equipment in ruggedness and performance efficiencies.

In addition, the Armed Forces are concerned with the solution of service problems, so that field failures, with their disappointments, can be reduced to a minimum, if not eliminated. In the short space of a few months these problems had become only too evident, and the Armed Forces had become only too conscious of the shortcomings of the commercial equipment available, to a great extent due to complete lack of standardization of the 16-mm equipment. Lens barrels, for example, were of different diameters, different tube complements were used (in some instances none of which were interchangeable between equipments), different projection lamps, different motors, *etc.*, necessitated the stocking of literally thousands of parts. In some instances these parts will never be used because they may not be available for the equipment they fit at the time and place they are needed.

With all this in mind, the Army Pictorial Service late in 1943 asked the War Production Board to arrange for standardization of 16-mm photographic equipment for use by the Armed Forces.

First of the important standards completed by this War Committee and approved by the American Standards Association as an American War Standard is the American War Standard Specification for a Service Model 16-Mm Sound Projector, Z52.1-1944. The standard was prepared by Subcommittee *D* of ASA War Committee Z52, under the chairmanship of the writer and the vice-chairmanship of J. A. Maurer.

This specification, for portable 16-mm sound motion picture projection equipment suitable for use under severe service conditions,

has been prepared through the coordinated effort of representatives of industry, the Armed Forces, and the War Production Board. Projectors built to these requirements will give a performance that compares favorably in the quality of the image and sound with the 35-mm projectors used in movie houses all over the country. Packed in three 56-lb cases it will be able to go anywhere that a soldier can go. It is designed to withstand life in the rear end of a jeep; and to give long service in the moisture-laden atmosphere of the South Pacific. For ruggedness and dependability of performance, these specifications call for an operating performance which surpasses any 16-mm projector at present on the market.

One of the most important features of this proposed motion picture projector will be the ease with which it can be serviced. The development specifications call for easily interchangeable lenses, tubes, and other parts that will make these projectors easy to repair at isolated bases.

The sound amplifiers, too, will have to be a lot sturdier than their commercial equivalents. The equipment throughout is designed to be as simple and as foolproof to operate as possible. Attention has also been given to its ability to withstand high temperatures, because it may be stored in shacks on deserts or transported in ships' holds stacked next to steam pipes.

In order to insure a reasonably long life, one section of the new standard provides that the projector shall be operated continuously, except for time consumed in film replacement, for a period of 500 hr with the projection lamp turned on. At the conclusion of the 500-hr run, the projector is to be subjected to all other nondestructive tests and inspections called for in the specification. Other tests include a severe vibration test, tests for resistance to heat and humidity, and a concussion test that corresponds to the firing of a broadside on a cruiser, in order to be sure that the projectors will stand up under military transport and use.

In its present stage, the new War Standard is intended as a development specification for use by the Armed Forces in procuring pilot models of projection equipment which will meet the basic requirements for use by the Armed Forces. Many of the test values in this standard are somewhat higher than those which have customarily been met in the past by projection equipment, which was designed originally for home or light industrial use. After pilot models of projectors meeting the requirements in this specification have been

procured, certain of the requirements will be modified in order to obtain the best all-around compromise of performance with production. The revised specification, it is expected, will then be used by the Armed Forces for quantity procurement of 16-mm portable sound motion picture projection equipment.

In preparing the standard, Subcommittee *D* carried out the following:

(1) Correlated existing military specifications for materials, processes, and tests.

(2) Approved or specified types of acceptable construction.

(3) Stressed coordination of safety and facility of operation.

(4) Established design and performance principles, limitations, requirements and tests—mechanical, optical, and electrical.

(5) Established maintenance requirement limits, particularly as regards field service problems.

(6) Set up standard "tools" in the form of visual test films and equipment which could be used universally for design or acceptance testing. These include the following three American War Standards: Method of Determining Freedom from Travel Ghost in 16-Mm Sound Motion Picture Projectors, Z52.4-1944; Method of Determining Resolving Power of 16-Mm Motion Picture Projector Lenses, Z52.5-1944; and Method of Determining Picture Unsteadiness of 16-Mm Sound Motion Picture Projectors, Z52.6-1944.

Perhaps we have undertaken the first step in a Herculean task. The completion of this task may not be "just around the corner," but certainly we have hopes that this work will be a great advantage to the Armed Forces (in accord with their requirements) and in peacetime will be a yardstick by which the consumer and the manufacturer are able to obtain a mutually satisfactory product.

Following the approval of this standard as an American War Standard on April 28, the standard was submitted to the Armed Forces Committee on Photography and Cinematography. The Committee presented this American War Standard to the Joint Army-Navy Committee on Specifications and with minor editorial revisions, the specification was approved as Army-Navy Specification, JAN P-49, on May 31, 1944.

The Chairman of Subcommittee *D* wishes to express and extend personal gratitude to those members of Subcommittee *D*, as well as the parent committee Z52 of the American Standards Association, who have contributed to the factual portions of the specification. Considering the problems, the speed with which the specification was completed was astounding. Particular credit should be given

to the personnel of the American Standards Association for their ability to have at their finger-tips information regarding previous standards and standards' activities which, in large measure, assisted Subcommittee *D* in moving along rapidly with the preparation of the specification.

It has been said, "It is an ill wind that blows nobody good." In this case it took a war and our common defense to bring together the manufacturers of 16-mm motion picture equipment, in order that a satisfactory specification for military equipment could be prepared. It is expected that this will be merely a beginning in the program of standardization.



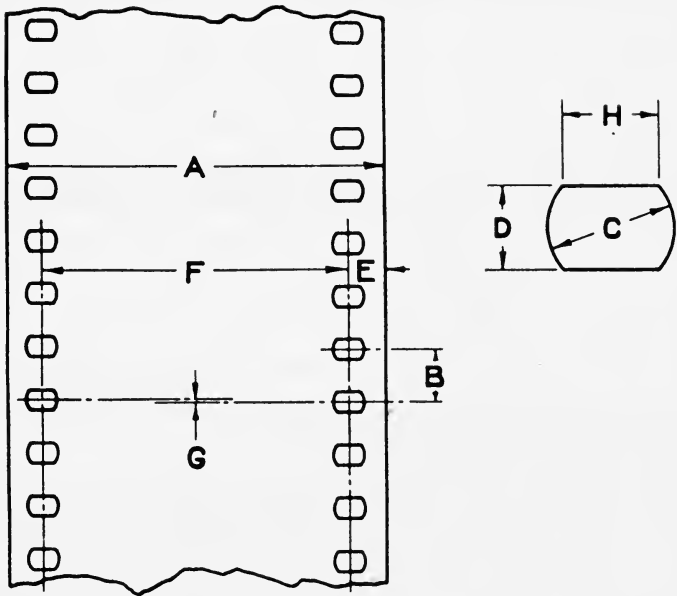
## AMERICAN MOTION PICTURE STANDARDS

The five American Motion Picture Standards which appear on the following pages were recently adopted by the American Standards Association. Prior to that time these specifications had been approved through the Committee on Standards as SMPE Recommended Practices and were published in that form in the JOURNAL of March, 1941, pages 262-66.

The technical material in this present publication is identical with that previously given, the respective specifications having served for a reasonable period as Recommended Practices without evidence of need for any changes. This final step in the normal standardization procedure is thus evidence of the satisfactory completion of the work originated several years ago within our Society.

F. T. BOWDITCH, *Chairman*  
Committee on Standards, SMPE

<b>AMERICAN STANDARD</b> <b>For 35-Mm Motion Picture Film</b>	<b>ASA</b> <b>Z22.34-1944</b>
<b>CUTTING AND PERFORATING NEGATIVE RAW STOCK*</b> <i>(Revision of part of Z22.1—1930)</i>	Approved May 15, 1944



	Millimeters	Inches
A	35.00 ± 0.00 - 0.05	1.378 ± 0.000 - 0.002
B	4.75 ± 0.013	0.1870 ± 0.0005
C**	2.794 ± 0.01	0.1100 ± 0.0004
D	1.85 ± 0.01	0.0730 ± 0.0004
E	3.40 ± 0.05	0.134 ± 0.002
F	28.17 ± 0.05	1.109 ± 0.002
G	Not > 0.025	Not > 0.001
H	2.08 ± 0.025	0.082 ± 0.001
L†	475.00 ± 0.38	18.70 ± 0.015

\*\* Diameter of circle of curvature.

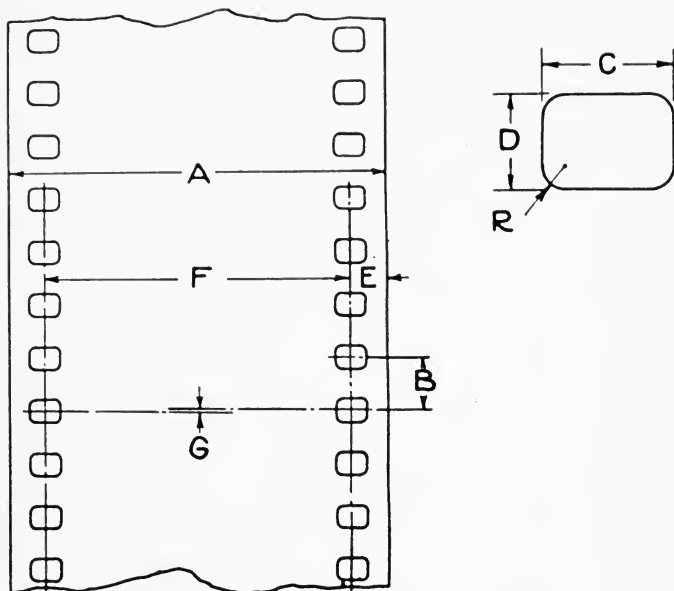
† L = length of any 100 consecutive perforation intervals.

\* For picture negative and certain special processes.

These dimensions and tolerances apply to the material immediately after cutting and perforating.

**AMERICAN STANDARD**  
**For 35-Mm Motion Picture Film**  
**CUTTING AND PERFORATING POSITIVE RAW STOCK\***  
*(Revision of part of Z22.1-1930)*

ASA  
**Z22.36-1944**  
 Approved  
 May 15, 1944



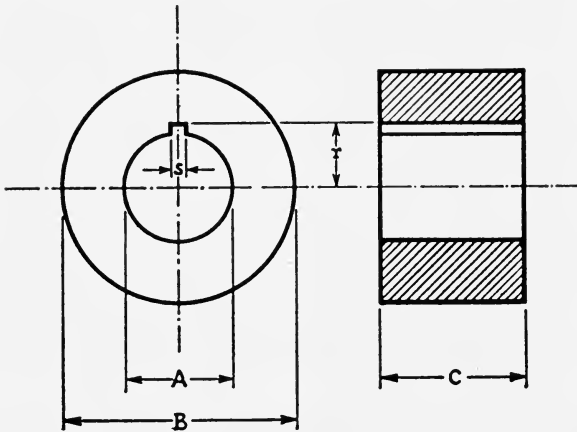
	<i>Millimeters</i>	<i>Inches</i>
A	35.00 + 0.00 - 0.05	1.378 + 0.000 - 0.002
B	4.750 ± 0.013	0.1870 ± 0.0005
C	2.794 ± 0.01	0.1100 ± 0.0004
D	1.98 ± 0.01	0.0780 ± 0.0004
E	3.40 ± 0.05	0.134 ± 0.002
F	28.17 ± 0.05	1.109 ± 0.002
G	Not > 0.025	Not > 0.001
L**	475.00 ± 0.38	18.70 ± 0.015
R	0.5	0.020

\*\* L = length of any 100 consecutive perforation intervals.

\* For positive prints and sound recording.

These dimensions and tolerances apply to the material immediately after cutting and perforating.

<b>AMERICAN STANDARD</b> <b>For 35-Mm Motion Picture Film</b>	<b>ASA</b> <b>Z22.37-1944</b> Approved May 15, 1944
<b>RAW STOCK CORES</b>	



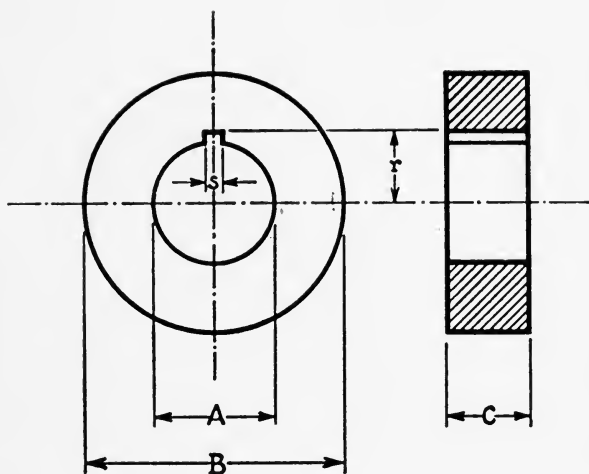
	<i>Millimeters</i>	<i>Inches</i>
<i>A</i>	25.90 ± 0.20	1.020 ± 0.008
<i>B</i>	50.00 ± 0.25	1.968 ± 0.010
<i>C</i>	34.50 ± 0.50	1.358 ± 0.020
<i>Recommended Practice</i>		
<i>r</i>	16.70 ± 0.30	0.657 ± 0.012
<i>s</i>	4.00 ± 0.20	0.157 ± 0.008

Bore *A* to fit freely to hub 25.40 ± 0.1 mm or 1.000 ± 0.004 inch diameter.

AMERICAN STANDARD  
For 16-Mm Motion Picture Film

RAW STOCK CORES

ASA  
Z22.38-1944  
Approved  
May 15, 1944



	Millimeters	Inches
A	25.90 ± 0.20	1.020 ± 0.008
B	50.00 ± 0.25	1.968 ± 0.010
C	15.50 ± 0.50	0.610 ± 0.020
<i>Recommended Practice</i>		
r	16.70 ± 0.30	0.657 ± 0.012
s	4.00 ± 0.20	0.157 ± 0.008

Bore A to fit freely to hub 25.40 ± 0.1 mm or 1.000 ± 0.004 inch diameter.

<b>AMERICAN STANDARD</b> <b>For 35-Mm Motion Picture Film</b>	<b>ASA</b> <b>Z22.39-1944</b>
<b>SCREEN BRIGHTNESS</b>	<b>Approved</b> <b>May 15, 1944</b>

The brightness at the center of a screen for viewing 35-mm motion pictures shall be  $10_{-1}^{+4}$  ft-lamberts when the projector is running with no film in the gate.

## THE REQUIREMENTS OF MODERN PROJECTOR DESIGN\*

R. HOWARD CRICKS\*\*

We are all talking nowadays of post-war planning; one small aspect of it is the cinematograph projector which we may hope to see designed after the war. I propose considering this projector of tomorrow not so much as a piece of mechanism (this aspect of the subject has been very ably dealt with in a number of SMPE papers<sup>1</sup>), but from the point of view of its purchaser, the exhibitor, and its user, the projectionist.

Only professional static types of machines will be considered in this paper; but this does not necessarily rule out the 16-mm projector, professional models of which will find many applications.

For lack of a more comprehensive word, the term projector must include the picture mechanism, the illuminant, and the sound head, as a single entity. For a variety of reasons this approach is inevitable. In spite of the conflicting commercial considerations involved, one or two manufacturers have approached this ideal, with beneficial results.

Projector design had before the war reached a somewhat static state, when comparatively minor innovations, such as novel methods of lubrication, were cited as outstanding advances. The more discerning of buyers assessed competing machines on the basis of less tangible but at least as important factors, such as the quality of materials and workmanship.

**The Demands of the Exhibitor.**—What then is the exhibitor entitled to demand of a projector? That it shall show a steady flickerless picture, sharply focused at all times; the picture shall be lit with a light constant in color and intensity, over the whole area of the picture (except possibly the extreme corners)—a light furthermore whose characteristics shall meet the exacting requirements of modern color processes, and a light which shall remain consistent from hour to hour, and from year to year.

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\* Reprinted from *J. Brit. Kine. Soc.*, 6, 4 (Oct., 1943), pp. 116–31.

\*\* F.R.P.S.; read before the British Kinematograph Society, May 12, 1943.

The sound must be free from all the defects to which the sound head may give rise: variations in film speed causing wow or flutter, faults in the scanning beam giving rise to treble losses or to waveform distortion. The sound head must be adaptable, so far as can be foreseen, to possible developments in the art.

The exhibitor will also demand that, so far as it is within the realm of mechanics, every change-over shall be perfect, with the minimum risk of a black screen, or of the "5-4-3" of the leader appearing on the screen, or of sentences being omitted from the sound track.

The exhibitor will quite rightly demand that the projector shall be inexpensive to operate, both from the point of view of low maintenance costs, and of low current and carbon consumption. His natural desire that it shall also be inexpensive to purchase may seem a little incompatible with the foregoing requirements.

**The Demands of the Projectionist.**—What does the projectionist demand of his equipment? First, it must be easy to thread, which means that the film path must be easily accessible, and—a point noticeably overlooked in many modern machines—have provision to facilitate threading in rack. For his peace of mind while running, the film path must be under observation.

The machine must be kind alike to green prints, old copies, and bad splices. Means must be provided for cooling the gate. The machine must be easy to clean and maintain, and in particular there must be no risk of oil leaking on to the film.

Not the least important demand of the projectionist is a simple and effective change-over system—a system which needs no skill beyond the ability to press a button when the "motor" cue appears on the screen, and again when the "over" dot is seen. The simplicity of change-over is much facilitated by the conception of the whole projector as a single unit. This matter of change-over is stressed, because to the inexperienced projectionist, every change-over is apt to be a test of nerve.

Many well-meaning inventors have sought to provide the projectionist with an entirely automatic change-over system, functioning without the intervention of the projectionist. No doubt such a system will one day emerge, but a necessary preliminary is a different type of cue to be embodied on every film—for instance, a length of frequency track on the perforation edge.

**Safeguarding the Films.**—Two other parties have also a certain interest in the design of our projector. The first is the renter, whose



interest lies in the fact that it is his property that will be ruined by a defective machine. The second is the public, who, in return for their admission fee are entitled to be safeguarded from injury, whether by fire or panic, or less spectacularly by eyestrain or headaches due to a badly focused, badly lit, or unsteady picture.

There is yet another consideration. Without regard to the present immunity of our projection rooms from dangers of fire, our legislators will probably endeavor at some future date to make the use of non-flammable film compulsory—this notwithstanding the failure of such legislation in other countries. The mechanical properties of safety base are of course much inferior to those of nitrate; while improvements will no doubt be made, past experience suggests that closer attention should be paid to the minimizing of film wear and tear.

**Optical Requirements.**—First let us consider the optical aspects. Our ideal should be that in every cinema, no matter what its size, a screen of a size appropriate to the auditorium should be lit with a standard intensity, and with a variation of intensity across the screen falling within specified tolerances. In this country,<sup>2</sup> in America,<sup>3</sup> and in Germany,<sup>4</sup> a considerable amount of work has been done in these directions, but it is to be feared that the industry is slow to take advantage of it.

A suitable screen intensity agreed in this country and the U.S.A. is between 7 and 14 ft-L, with a variation not exceeding these limits in any part of the screen, or from any seat in the auditorium. (Rather lower standards have been accepted in Germany.) Actually, some cinemas have an intensity as low as 2 or 3 ft-L, while in the opposite direction are the news-theaters and various private theaters, where readings of 35 and 40 ft-L are not uncommon. (These high illumination levels may provide some explanation for the exhibitor's repeated complaints of excessively dense prints.)

Every manufacturer of projection equipment should ensure that every installation complies with the standard requirements, by preparing detailed recommendations of type of equipment, lens aperture, arc current, and carbon size, capable of giving a lumens output suitable for any particular condition.

One point often overlooked is that the optical system of the arc lamp, the projector gate assembly and heat shields, and the lens, should have the same effective aperture. One sometimes sees a modern large-aperture lens used unnecessarily, being only partially filled by the cone of light from the arc, and in other cases a considerable

amount of light wasted inside the lens by its having a smaller aperture than the arc condenser system (this also causing deterioration of the lens due to excessive heating).

Another factor is occasionally that the construction of the projector gate and heat-shields gives rise to vignetting, so not permitting the maximum aperture of the arc and lens being efficiently utilized (Fig. 1).

**Arc Lamp.**—The arc should need the minimum of attention, and

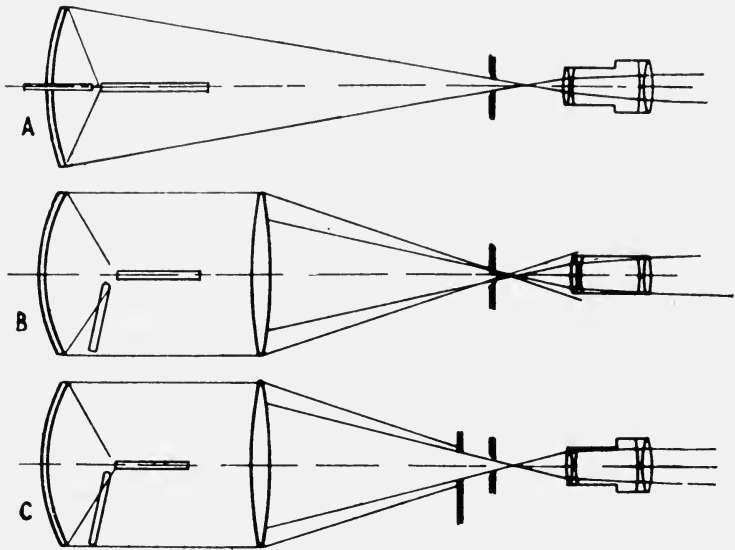


FIG. 1. Faults in projector optical systems; (A) lens incompletely flashed, (B) light wasted around lens, (C) vignetting by heat shield.

should provide the minimum of scope for individual preferences once the adjustments have been set for the particular running conditions. The motor feed should be capable of running a double reel without hand adjustment—and incidentally, the projectionist must be educated to allow it to do so, and must realize that any attempt to interfere with a properly adjusted feed means a loss of consistency in the light on the screen.

To maintain consistency of light, some form of arc control is essential, either by rotation of the positive carbon, or by magnetic means. There is still room for experiment on the latter; a properly designed

magnetic field cannot only stabilize the arc, but materially increase the light output.<sup>5</sup> The difficulty at present is the wide variation in its effects with slight changes in arc current or voltage.

An obvious difficulty in maintaining consistency is the gradual depreciation of the optical components. The silvering of the arc mirror gradually burns off, and condensers become spattered with copper. Such depreciation could be somewhat reduced by an efficient cooling system, but these factors constitute probably the greatest obstacle in the maintenance of screen brightness.

**Maintaining Consistency of Light.**—The gradual, and to the projectionist imperceptible, variation in screen illumination due to these factors suggests that some device should be provided whereby a constant check could be kept upon the light output of the projector.

At the Odeon, Leicester Square, a device is installed which measures the light reflected from the screen, and so permits of a constant check upon the actual screen brightness.<sup>6</sup> This device however introduces two variables which it might seem preferable to measure separately: the varying reflectivity and directivity of the screen, and the atmospheric conditions of the auditorium. If in addition some measuring device were embodied in the projector, it would enable variations in the actual projection equipment to be located.

It is not sufficient merely to measure the light output from the arc, for this would fail to take into account the possibility of alteration in the adjustments of the arc in relation to the projector—a very common source of inefficiency and light loss. The ideal arrangement would seem to be a light-sensitive cell which could be slipped into a preset position between the gate and the objective, so that readings could be taken daily before the start of the performance.

If it were desired not only to measure the total light passing through the gate aperture, but also to check the evenness of illumination over the aperture, such a cell might be used in conjunction with a movable mask, placed in the gate, to enable readings to be taken in say five separate areas within the aperture. Any such device would necessitate a regular plotting of the readings by the projectionist, in order that a continual check might be kept upon the performance of the equipment.

**Film Buckle.**—Having procured our desired intensity and evenness of screen illumination, the next essential is a sharp focus of the picture. The modern objective lens is probably the most perfect

component of the projector. Existing types of gates, however, fall short of perfection in regard to maintenance of the film in the focal plane.

The increasing aperture of modern projection lenses—apertures of  $f/1.9$  are quite customary—draws attention to an important factor in the design of the projector gate: the avoidance of film buckle.<sup>7</sup> With new prints it is rarely a problem; but if a small exhibitor has had the wisdom to install first-class optical equipment, and yet has to take his copies after a number of runs in front of the powerful illuminants of larger halls, his projectionist is apt to find considerable difficulty in maintaining the center of the picture in focus. The problem is therefore two-fold: first, the reduction of gate heat to minimize film buckle, and secondly, the improvement in gate design to hold buckled film flat behind the lens.

The principle of curving the film longitudinally in order to prevent lateral buckle is familiar in the sound head and in other types of equipment; it is also used in some 16-mm projectors. Obviously the actual frame of film being projected must be held flat, and it would seem desirable also that there should be a straight path from the aperture to the intermittent sprocket; but a curved upper part of the gate would surely prove of assistance.

**Gate Cooling.**—There is probably no better method of gate cooling than that employed in a Continental machine: the construction of the gate as a hollow casting, through which passes a stream of water. Air cooling has also been used. Either has the minor objection of needing external connections to the projector.

Use may also be made of two other expedients: the interposition in the light beam of a number of heat-shields, gradually masking the light beam so that the minimum of stray light falls upon the actual gate; and the principle of the reflection of unwanted light and heat by means of a polished face behind the gate.

A number of years ago, I put forward some proposals on these lines, which however met with little response. The idea is shown in Fig. 2.

The casting 24*a* forms the first heat-shield; 25 is a circular heat-shield, intercepting the light beam twice. A current of air is provided by forming the drum shutter 22 in the form of a turbine fan, with blades 23, so cooling both the heat-shield and the gate. To overcome the objection of such systems, that the shutter fan is apt to draw in dirt from the atmosphere upon the film, I proposed drawing the air past a viscous filter, built into the projector.<sup>8</sup>

**Projection Rake.**—A cinema without a projection rake is today an exception. Yet the only expedient for obtaining a reasonably sharp picture over the screen is to cant the screen slightly—a device which actually increases the distortion observable from the front seats. The use of a keystone-shaped gate mask may help to conceal the distortion without improving the focus. The extent of this distortion is perhaps little realized.<sup>9</sup>

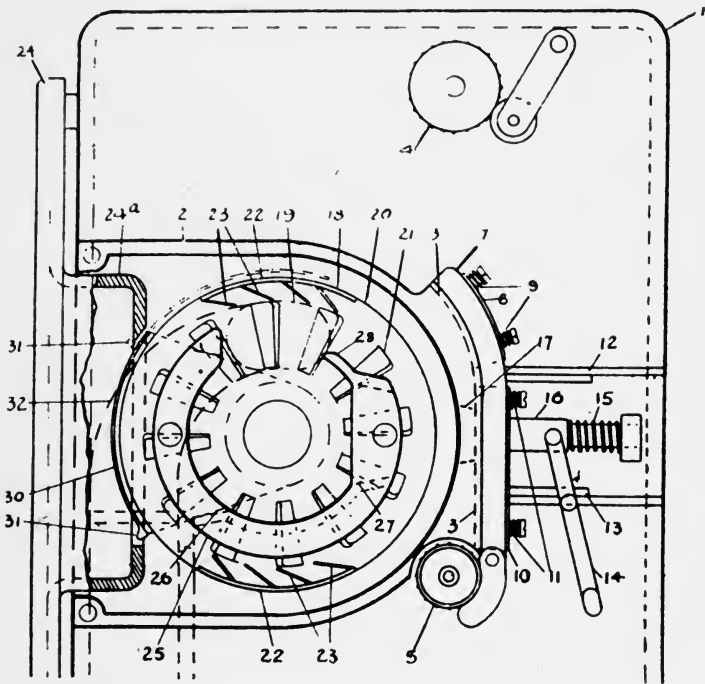


FIG. 2. Proposals for gate cooling system.

The still photographer overcomes an analogous difficulty by the use of a tilting back; unfortunately, if the projector gate were made to tilt, an improvement in definition would be accompanied by an increase in distortion, or vice versa. On at least one projector, it is possible for the lens to be adjusted vertically, but this seems an unsuitable method, since it is obviously desirable to work on the optical axis of the lens. Whether it would be possible to design an optical system to work in this manner is a question for opticians to decide.

**Emulsion Pick-up.**—A cooler gate would of course help in reducing trouble from pickup of emulsion from green prints. If however we are to continue to have to run unprocessed green prints, further steps are necessary.

The invariable cause of emulsion pickup is some cavity or scratch in the runners; the emulsion lodges in these cavities, bakes hard, and acts as a small chisel, gouging out a groove from the edges of the film, and straining the perforations in doing so. The intelligent projectionist will of course clean his gate regularly (but never with steel,

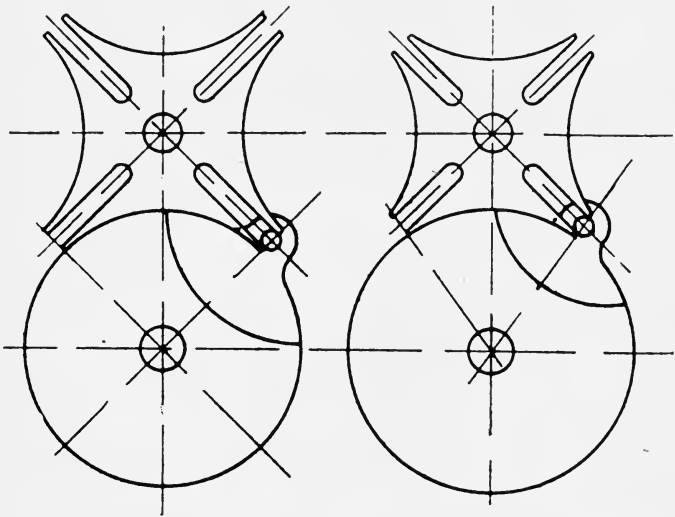


FIG. 3. Maltese crosses giving 90- and 70-degree shift periods.

which may cause scratches); but with all the care possible, scratches do occur in the runners. The use of hardened and ground steel for the runners would, I suggest, assist materially in preventing this source of annoyance and possible danger.

It would, too, be a sound idea if the gate runner or aperture plate were made easily interchangeable, and the projectionist were encouraged to change it between reels, so permitting of a more thorough cleaning than is possible in position. If the aperture plate were made fairly robust, its replacement between reels would assist in keeping the film path cool.

**Intermittent Motion.**—This brings us to the heart of the projector.

the intermittent motion. Many people fail to grasp the fundamental reason for the employment of a Maltese cross in the projector, and one hears frequent suggestions that various types of claw motions would be quite suitable if they could be made sufficiently robust. Such suggestions fail to take account of the fact that no practicable type of claw motion will produce a picture shift of less than 90 degrees with reasonably good acceleration, and if the shift period is not less than 90 degrees, the shutter will have an efficiency

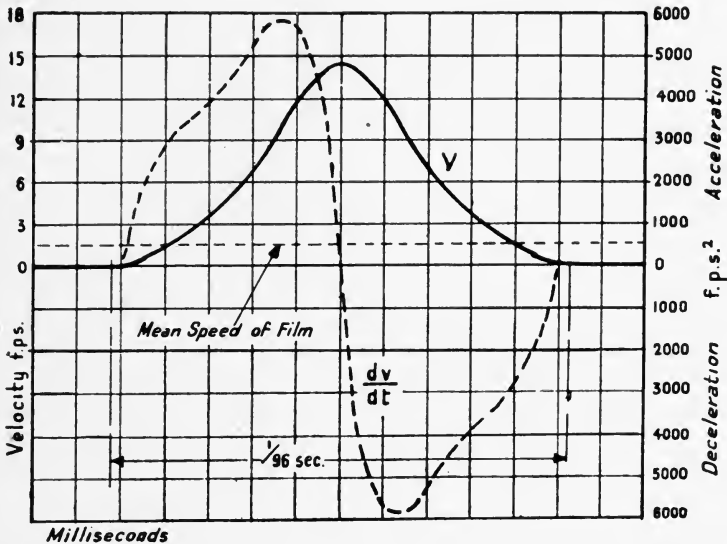


FIG. 4. Velocity and acceleration curves of standard Maltese cross movement (calculated).

of less than 50 per cent (it is essential for the avoidance of flicker that both blades of the shutter should be of approximately equal angle).

Actually, the shift period of a Maltese cross, geometric considerations notwithstanding, is appreciably less than 90 degrees, due to the slight slackness of the striker pin within the cross slots; most projector shutters actually have blades of less than 90 degrees.<sup>10</sup> A still quicker shift period would of course permit of narrower shutter blades and greater light transmission; but it is only with a theoretical shift period of 90 degrees that tangential entry and leave of the striker pin in the slots becomes possible. The old Pathé machine had a shift

period of about 70 degrees; from the commercial point of view the merit of this design was the increased sales of Maltese crosses, due to frequent breakages (Fig. 3).

But it is quite possible to design movements with a quicker shift period. An example was the Powers movement, in which the Maltese cross was replaced by a four-pin cross, actuated by a rather complicated cam. This had a shift period of about 60 degrees.

The objection to any speeding up of the shift period is that of film wear—a point of particular importance if nonflammable base should ever become compulsory. The importance of this point will be appreciated from Fig. 4, which shows the calculated velocity and acceleration curves of 35-mm film fed by a standard Maltese-cross movement at 24 frames per sec; it will be seen that the acceleration reaches at its maximum the enormous figure of over a mile per second per second!

These curves are however purely theoretical. From attempts I have made to record the movement curve of film in an actual projector running at normal speed, it appears that other complications have to be taken into account—play of the striker pin in the slots, and resultant bouncing of the cross, and notably the resilience of the film, due to which the full theoretical acceleration is never reached.

**Reduction of Film Stresses.**—It says much for the mechanical properties of film base that it should withstand this enormous acceleration. The force needed to produce the acceleration will be given by the equation:

$$f_1 = m.a$$

The mass  $m$  will of course depend upon the length of film subjected to the intermittent movement; if we reckon the weight of the film as one-thousandth of a pound, then the force  $f$  will, according to the theoretical curves shown, reach a maximum of nearly 6 lb—applied, remember, 24 times per sec.

But this is far from being the full extent of the film stresses. A certain force  $f_2$  is required to bring the film to rest. One cannot assume that this is effected entirely by gate tension; undoubtedly a large proportion of the deceleration is effected by the sprocket. But there must still remain a considerable proportion of the deceleration curve due to the gate, and this force must with existing types of gates be overcome also during the acceleration period. In practice, an additional force  $f_3$  is encountered, representing the difference be-



tween static and dynamic friction, plus the projectionist's margin of safety to ensure a steady picture. Thus the total force exerted upon the film during the period of maximum acceleration is:

$$F=f_1+f_2+f_3$$

If the gate could be so designed as to exert tension only for the deceleration period, and not during acceleration, the terms  $f_2$  and  $f_3$  could be almost eliminated, and  $F$  would be reduced to possibly a half. The lifting gate is well known in camera mechanisms, but its complications make it unadaptable to the projector. Nevertheless, a similar principle could, I suggest, be applied electrically—for instance, by means of an intermittently energized magnetic system. Given some such system, the stresses on the film could be reduced to perhaps one-third, and a speeded-up shift period could usefully be embodied, permitting of narrower shutter blades.

Since the force needed to accelerate the film is directly proportional to the mass of the film to be accelerated, which is itself dependent upon the length of the gate and of the loops, theory would suggest that the general preference for a long gate is incorrect: that the gate should be kept as short as possible, consistent with the provision of an adequate and not harsh deceleration of the film, and of lateral guidance of the film.

**Shutter Efficiency.**—We come next to the shutter. In addition to its task of masking the movement of the film, a shutter has two requirements: it must eliminate visible flicker, and it must nevertheless pass the maximum amount of light to the screen. A rear shutter also has the advantage of reducing gate heat.

But any attempt to increase the efficiency of the shutter except by a reduction of shift period seems rather pointless. The innumerable "patent" shutters of a few years ago admittedly passed considerably more light, but only at the expense of the blacks of the picture, since their principle was the use of perforated or translucent blades, or of translucent sectors of complementary colors. In either case, the extra light passed was distributed over the whole of the picture, so reducing contrast; and surely contrast in the picture is even more important than brilliancy.

Other than by these incorrect methods, the maximum gain in illumination that can be obtained by modifying the shutter design is of the order of 10 per cent or 15 per cent; a corresponding gain in il-

lumination can be obtained by a slight improvement in the loading or handling of the arc, or by quite a trifling increase in lens aperture.

The drum shutter shows a certain advantage, since the cutoff is effected simultaneously in two planes, and from top and bottom of the picture. In existing conditions, however, a drum shutter has a serious disadvantage: it can be efficiently designed only for one given optical system. Any difference in the angle of light cone from the arc mirror, for instance, will reduce its efficiency. This provides a further argument in favor of the construction of the arc and the projector head as an entity. The combination of front and rear disk shutters, as in one American machine, or of shutters rotating in opposite directions, gains the same advantage of top and bottom cutoff, without the disadvantage mentioned.

**Racking Systems.**—The problem of racking, although it has been closely studied from the mechanical aspect, does not seem to have received its due attention in regard to the needs of the projectionist. On many projectors, it is possible to see whether the film is threaded in rack only by performing gymnastic contortions, placing one's eye in front of the lens while holding a torch behind the gate. It is only of recent years that a proposal I first made many years ago has been adopted: that a duplicate aperture should be provided at the top of the gate, through which the picture could be viewed by means of a racking lamp.

An even better proposal is that, right up to the moment of change-over, an auxiliary optical system should project a small image of the frame in the gate upon the wall of the projection room. This would not only ensure correct racking, but would effectively prevent the last few feet of the standard leader being projected on the screen—a fault by which even West-end audiences are nowadays edified.

Further, if the switching of this auxiliary illuminant were interlocked with the intermittent movement and with the racking lever, two frequent causes of misracks would be eliminated: threading while the intermittent sprocket is in course of movement, and not returning the racking lever to its midway position.

**Unlimited Racking.**—It is perhaps pandering to the less efficient of projectionists to suggest that the modern racking system, with its limited travel, falls short of perfection. It is true that if the film is properly spliced and properly threaded, the racking handle need never be touched; but it may be likened to the bit of rubber at the end of a pencil—it does make allowance for human errors. One occasionally

sees a projectionist when racking his picture move the racking system to its extremity in one direction, and then have to move it in the opposite direction to eliminate a misrack.

Many years ago, the late W. Vinten constructed an experimental projector with unlimited racking—in other words, the racking handle could be turned indefinitely in either direction. True, the design involved a fearsome collection of differential gears to provide for shutter phasing and to keep the film loops constant; but some simplified system should be capable of construction.

**Sound Head Construction.**—I have so far considered the arguments in favor of regarding the projector mechanism and the arc as a single unit. The arguments in favor of constructing the mute and sound heads as a single unit are still stronger.

First comes the simplification of mechanical design. To transmit the drive from the sound head to the separately built mute head necessitates quite a collection of gears—both the so-called adapter gears which carry the drive as far as the shaft at the bottom of the mute head, and the gears inside the mute head carrying the drive from this rather awkwardly placed driving shaft to the various components. If on the other hand the sound head is built integrally with the mute head, a single vertical shaft carries the drive to all components.

The unit construction of mute and sound heads has other advantages: the less complicated mechanism is capable of gaining speed more rapidly; the smaller number of gears lessens the risk of gear-tooth ripple being imparted to the film, and, together with the modern trend towards nonmetallic gears, makes for quieter running.

**Filter Systems.**—One point upon which designers are today unanimous is in condemning the original type of sound head, with its stationary sound gate and the sound sprocket immediately below it. Instead, the sound is scanned upon a rotary drum, and between this and the driving sprocket are provided film loops—either entirely free, or carried on sprung rollers—which effectively smooth out any sprocket ripple. With unstable material such as film, it is impossible for the sprocket teeth to mesh correctly without imparting ripple to the film, and this ripple appears in the speakers as flutter—after poor acoustics the most common cause of unintelligible speech.

The modern types of sound head mechanical filters—notably the magnetic drive or rotary stabilizer<sup>11</sup>—give a virtually complete freedom from wow and flutter. Many equipments are however consid-

erably less perfect, and much of the unintelligible speech heard today must still be attributed to flutter due to inefficient filter systems.

An important point is the isolation of the sound head—or at least the whole of the scanning system—from projector vibration. It is not uncommon for the exciter lamp filament to be vibrated at picture frequency (since the chief source of vibration is the Maltese cross) and so modulate the light reaching the photocell, resulting in the reproduction of cross noise in the speakers. The isolation of the sound head by rubber cushioning is an important advance.<sup>12</sup>

In this connection, it is obviously desirable that the exciter should

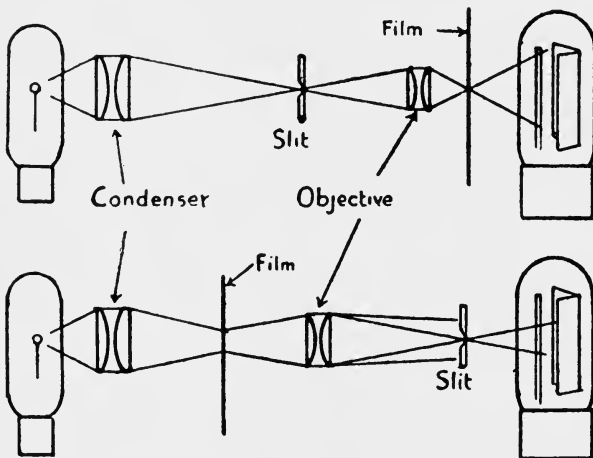


FIG. 5. Two types of sound-head optical systems.

have a thick filament, better able to resist vibration. From this point of view, the 6-v, 1-amp lamp included in the B.S. exciter lamp specification<sup>13</sup> is definitely unsuitable, and in my view its use should be discouraged.

**Optical System.**—Optically, the principal essential of the sound head is that it shall provide a scanning slit sufficiently narrow to ensure the reproduction of the highest frequencies found on the track.

Two distinct types of optical systems are employed (Fig. 5). In the earlier type, the image of the slit is projected upon the film; whatever may be the theoretical width of the slit image on the film, the converging light rays from the objective diverge within the thickness of the emulsion, and light scatter and halation occur, resulting

in the effective width of the image being considerably greater than its theoretical width, and so affecting high-frequency reproduction.

In the alternative type, a magnified image of the sound track is projected upon the slit. In view of the considerable enlargement of the image—in one case seven diameters—a higher scanning standard is assured. Image diffusion is probably less than in the case of a projected slit, while, since the physical dimensions of the optical components are greater, any given departure of the film from the optical plane—as by polygoning on the scanning drum—will have less effect upon the focus of the image.

On the other hand, the former type has the advantage that all the components are built into the one tube, sealed from dirt and more immune from the mishandling.

**Stereophony.**—We have for years been awaiting the introduction of the push-pull track in the cinema. But judging by recent developments, it seems probable that instead we shall have to prepare for stereophonic reproduction.

Any idea that the double-film systems of the Fantasound type will be widely adopted can in my view be dismissed. But there seems every indication that simpler systems, embodying a twin sound track and a control track on the single picture film, will be the next popular innovation.<sup>14</sup> It is to be hoped that before post-war manufacture commences, an authoritative decision may be taken on the type of system to be adopted, and on standards to be employed.

**Open or Enclosed Mechanism?**—A practical point upon which there is much diversity of opinion is whether the film path through mute and sound heads should be open or enclosed. A projectionist does like to be able to see every inch of the film path; on the other hand, an enclosed projector will naturally keep cleaner, and, according to American regulations, is safer from the point of view of fire risk.

I suggest that there is only one way in which these conflicting requirements can be met: by the use of a Perspex molding for the whole of the cover. The film path would thus be completely visible from take-off to take-up, yet effectively shielded from dirt.

Another component that might usefully be made of Perspex (if regulations permit) is the spool-box door. There is no machine in which the aperture allowed for viewing the spool really permits one to judge how much film is left, and most projectionists find it necessary, in defiance of regulations, to open the spool-box door.

**Take-up Design.**—A point in projector design which still falls

short of perfection is the take-up. Innumerable suggestions have been made which would cause the tension to increase as the reel increases in size, so reducing the pull on the first few feet of film.<sup>15</sup> It is rather remarkable that none of these suggestions has found general favor.

Even with the present rather crude friction device, two minor points which would lead to some improvement are the use of ball bearings for the take-up shaft, so enabling a lighter tension to be used; and the provision of a spring buffer to eliminate the sudden snatch on the film in starting up.

**Change-Over Devices.**—It seems inconceivable that, although the need for repeated change-overs has been recognized for the past 30 or 40 years, it is only of recent years that change-over devices have

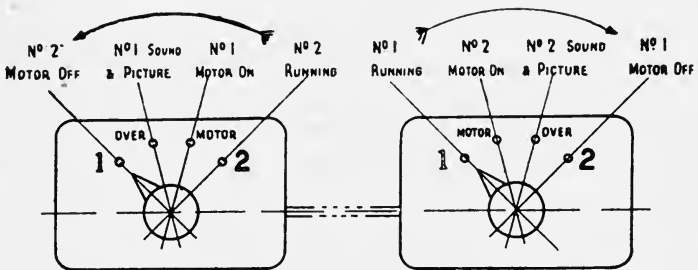


FIG. 6. Proposed change-over system.

become an integral part of certain projectors; today, their adoption is far from universal, and devices for fitting to projectors have met with a wide sale, while one still sees the change-over carried out by a length of string or chain from one lamp-house dowser to the other.

On older equipment, a change-over is really a two-handed job, while even today on most installations, the projectionist is required to make separate and simultaneous change-overs of picture and sound, often at widely separated knobs. A point which is often overlooked is that the projectionist should, at the change-over, be always standing at the side of the *incoming* machine in case of any trouble at the beginning of a reel.

The whole of the picture and sound change-over should, I maintain, be made from either of two interconnected switches, one to the

right of each projector (Fig. 6). When No. 1 projector is running, the switches will be in position 1; when the motor cue-dots appear, the projectionist, standing by No. 2 projector, moves the switches to position 2, and the motor of No. 2 machine starts; in moving from position 2 to position 3 on the appearance of the "over" dots, the picture and sound are both changed over. Then the motor of No. 1 projector can be switched off from either switch, by moving the knob to position 4. In changing over in the opposite direction the sequence is reversed. There seems no difficulty in applying such a principle, always provided that picture and sound mechanisms are considered as a single unit.

**Standardization.**—There has been much talk recently of the need for standardization of projection equipment. But I feel that the exhibitors who have been foremost in urging this have a slightly different idea from that implicit in existing standards.

Hitherto, the insistence has been on the fundamental point, that any film must be capable of running on any projector. The ideas of the exhibitor, I feel, run rather on the lines of ensuring that spare parts shall be interchangeable on all types of projectors.

Within limits, this is a perfectly legitimate basis of standardization, and one which might well be considered by the Society and by the British Standards Institution, to the extent perhaps of specifying as "Recommended Practice" that, for instance, intermittent sprockets should have a bore of either  $\frac{5}{16}$  in. or  $\frac{7}{32}$  in., with specified tolerances, and with an agreed method of fixing.

Manufacturers would however quite justly object to any standardization of a nature likely to inhibit progress, and for this reason it may be felt undesirable to stabilize such dimensions to the degree suggested by a formal standard.

**Future Developments.**—I have so far confined myself to minor improvements in equipment substantially of existing types. There are however two major developments of the future which will, I am convinced, have a far-reaching effect on the design of projection equipment. The first is the substitution of the discharge lamp for the arc, and the second is the development of the nonintermittent principle.

As an instance of the revolutionary design rendered possible by the substitution of the arc by a discharge lamp, we have the Philips projector, seen just before the war.<sup>16</sup> Here, we have both projector heads in the one unit, one above the other, with the capillary-type wa-

ter-cooled mercury lamp, immediately behind the gates. This machine has of course been designed with the possibility in mind that it can be run by a single projectionist—a common thing in projection rooms everywhere except in this country, but not a practice to be commended.

No engineer would dispute the value of the nonintermittent principle. There are of course technical difficulties to be overcome; but I feel that the chief difficulty is the conservatism of our industry, in conjunction with the fact that, until the recent requirements of stock economy, nobody was particularly interested in enabling prints to have a longer working life than at present, since their life is already adequate to satisfy the number of bookings generally obtainable. It is the small exhibitor who would chiefly gain, in improved condition of copies, by the installation of nonintermittent projectors in the larger cinemas. However, the prospect of having to use nonflammable stocks may alter this situation.

The only striking nonintermittent projector we have seen has been the Mechau Arcadia, made by Leitz, and demonstrated just before the introduction of sound.<sup>17</sup> Notwithstanding its obvious advantages for sound reproduction, the fact that it could not be easily adapted to standard types of sound equipment damned it as far as this country was concerned, although it is I believe still used on a small scale in Germany.

I see no reason why the nonintermittent machine should be so much more cumbersome and expensive than an intermittent machine—rather the reverse. The difficulties of the nonintermittent principle are well known,<sup>18</sup> and one may hope that post-war research may make it a practical proposition.

If the nonintermittent projector were to come into general use there would be some advantage in reducing the separation between picture and sound on the film, so taking advantage of the steady continuous motion needed for projection, to scan the track.

We may look still further into the future—to the day of the all-electronic cinema to which the President referred in the recent symposium.<sup>19</sup> When large-screen television is perfected and universally installed, it might be preferred to run the film program on the television equipment rather than install separate film projectors. We could then have a nonintermittent scanning apparatus with purely electronic compensating arrangements—from many aspects an ideal arrangement.



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- <sup>2</sup> *J. Brit. Kine. Soc.*, May, 1938, p. 68; July, 1939, p. 153. B. S. Spec. 930, 1940.
- <sup>3</sup> *J. Soc. Mot. Pict. Eng.*, July, 1937, p. 40. *Better Theatres*, Aug., 1941, p. 24; Sept., 1941, p. 33.
- <sup>4</sup> *Kinotechnik*, Aug., 1939, p. 196.
- <sup>5</sup> *cf.* Br. Pat. 381,952.
- <sup>6</sup> *J. Brit. Kine. Soc.*, July 1939; p. 153.
- <sup>7</sup> *J. Soc. Mot. Pict. Eng.*, July, 1943, p. 69.
- <sup>8</sup> Br. Pat. 431,416.
- <sup>9</sup> *Ideal Kinema*, Nov., 1936, p. 40.
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- <sup>12</sup> *Ideal Kinema*, June, 1936, p. 50.
- <sup>13</sup> B. S. Spec. 1015, 1942.
- <sup>14</sup> *Better Theatres*, Dec., 1940, p. 30. *J. Soc. Mot. Pict. Eng.*, Oct., 1941, p. 147. *Internat. Proj.*, Dec., 1941, p. 10.
- <sup>15</sup> *Ideal Kinema*, Apr., 1937, p. 42. *Kine. Weekly*, Jan. 18, 1940, p. 41. *J. Soc. Mot. Pict. Eng.*, Mar., 1942, p. 256. U. S. Pat. 1,398,680.
- <sup>16</sup> *J. Brit. Kine. Soc.*, July, 1939, p. 170.
- <sup>17</sup> *Filmtechnik*, Oct. 9, 1937, p. 163.
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- <sup>19</sup> *J. Brit. Kine. Soc.*, Jan., 1943, p. 3.

## DISCUSSION

MR. A. G. D. WEST: Manufacturers should take to heart many of the points made by the lecturer. The nonintermittent system and the discharge lamp in particular should receive close attention.

MR. S. T. PERRY: Are not the Mechau and Philips projectors silent?

THE AUTHOR: The Mechau was in its original form; but I understand that sound models are in use in Germany. The Philips machine was originally designed for sound; it is exceedingly compact, with the amplifiers contained in the pedestal.

MR. S. T. PERRY: Personally, I feel it would take a lot to cancel out the ease of operation of present projectors. An objection of the twin machine would be the difficulty of replacing the mechanisms in the event of an emergency.

MR. C. G. HEYS-HALLETT: The accessibility of the Philips projector is infinitely superior to outfits where the amplifiers are mounted on the wall. The mechanisms are quite easily replaced.

MR. H. R. A. DE JONGE: Mr. Perry's views must be considered. Manufacturers have to think seriously before manufacturing these modern designs; when they are offered for sale, everyone wants the older types.

THE AUTHOR: It is up to the Society to educate the industry regarding developments in design.

MR. P. G. A. H. VOIGT: If we in this country do not press on with development, somebody else will.

A MEMBER: What is the power of the Philips lamp?

THE AUTHOR: One kilowatt, plus 500 w loss in conversion gear. D-c must be used, because of mains flicker, although an alternative would be to increase projection speed to 25 frames per sec. Discharge lamps have been made up to  $2\frac{1}{2}$  kw. One French firm marketed a 16-mm machine with a discharge lamp, but the weight and bulk of the rectifier was a disadvantage.

MR. S. T. PERRY: The color of the light from the discharge lamp is unsuitable for color films.

THE AUTHOR: Yes, in demonstrations I have so far seen, there is considerable distortion of color; the reds turn maroon. For black-and-white, the color is very pleasing. The difficulty of the discontinuous spectrum may some day be overcome by means of luminescence.

MR. R. T. DEALEY: Is there any reason why discharge lamps should not be adapted to existing types of projectors, in place of the arc lamp?

THE AUTHOR: I see no objection at all. The special optical system would of course be required.

MR. M. SMITH: Would the discharge lamp make much difference to the gate temperature?

THE AUTHOR: Quite an appreciable difference, although I have no figures.

MR. A. DAVIS: For back-projection in the studio, where the arcs are usually over-run, we have used carbon dioxide for cooling the gate. Is there any reason why this should not be generally used?

THE AUTHOR: I went into the question of using solid CO<sub>2</sub> for gate cooling some years ago. The only objection seems to be the cost; it worked out at several pence an hour, and I felt that few exhibitors would consider even such a small expenditure justified.

MR. F. N. G. LEEVERS: We have come to accept the Maltese cross as the standard motion for projectors. I have for some time used a six-sided Maltese cross for 16-mm machines; it is the smoothest motion I have come across.

MR. W. HARCOURT: We have also used a Maltese cross for 16-mm both in printers and projectors; it is more satisfactory and steadier than the claw, and causes less wear to the film.

THE AUTHOR: The objection to the Maltese cross for 16-mm machines is that a four-sided cross necessitates an intermittent sprocket too small to give sufficient wrap for the film. A six-sided cross means that the striker pin does not enter tangentially, and the motion is noisy and subject to wear.

MR. P. G. A. H. VOIGT: You mentioned some experiments which suggested that the actual acceleration and deceleration of the film was not in accordance with your calculated curves. Might this not be due to damped waves set up in the film?

THE AUTHOR: My own suggestion is that the discrepancy is due to the film bouncing on the sprocket teeth, but the two effects might well be connected.

MR. C. G. HEYS-HALLETT: To my mind, the most important part of Mr. Cricks' paper was his references to screen brightness. It is most important that standards should be set up whereby exhibitors would be able to buy the right equipment for a particular type of hall.

## 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

25 (May, 1944), No. 5

Thomascolor (p. 154)

Walt Disney Studio—A War Plant (p. 156)

A. WYCOFF

C. NATER

### British Kinematograph Society, Journal

7 (Jan.-Mar., 1944), No. 1

Coated Lenses (p. 7)

Recent Advances in the Physics of Colour (p. 10)

Picture Definition (p. 14)

Fundamentals of Photo-Electric Emission (p. 19)

Sound Measurement and Analysis (p. 21)

K. M. GREENLAND

H. V. WALTERS

L. H. BEDFORD

A. SOMMER

J. O. ACKROYD

### Educational Screen

23 (Apr., 1944), No. 4

Post-War Implications for Education in the Audio-Visual Programs of Our Armed Services (p. 153)

The School Made Film for Purposes of Supervision of Instruction (p. 157)

Motion Pictures—Not for Theatres, Pt. 58 (p. 161)

P. WENDT

M. SHERMAN

A. E. KROWS

### International Photographer

16 (Apr., 1944), No. 3

Shooting Snow in Sunlight (p. 5)

"Mille," the Dolly (p. 8)

No Camera Is Better than Its Finder (p. 10)

16 (May, 1944), No. 4

New Portable Processing, Printing and Editing Kit (p. 5)

Time and Temperature Control (p. 22)

Future of Technicolor (p. 29)

E. O'TOOLE

J. YOLO

H. BOYCE

D. WOOD

M. LESHING

H. T. KALMUS

### International Projectionist

19 (Apr., 1944), No. 4

Action of Complex Electric Currents in Projection Room Circuits (p. 7)

H. B. SELWOOD

Motion Picture Projection in Italy (p. 10)

A. NADELL

Television Today, Pt. VII—Television Transmitters

(p. 20)

J. FRANK, JR.

**Motion Picture Herald**

155 (Apr. 29, 1944), No. 5

Is Projection Above and Behind Screen Practical? (p. 85)

C. E. SCHULTZ

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*We regret to announce the death of J. S. MacLeod, Active member of the Society, on July 3, 1944.*



## HOTEL RATES

The Hotel Pennsylvania management extends to SMPE members and guests the following per diem rates, European plan:

Room with bath, one person.....	\$3.85-\$7.70
Room with bath, two persons, double bed.....	5.50- 8.80
Room with bath, two persons, twin beds.....	6.60- 9.90
Parlor suites: living room, bedroom, and bath..	\$10.00, \$11.00, \$13.00 and \$18.00

## RESERVATIONS

The Hotel Pennsylvania room reservation cards will be mailed to the membership of the Society early in September. If attending the Fall Conference, return your card with checked accommodations *immediately* to the hotel so your reservation, which is subject to cancellation prior to October 15, can be booked and confirmed. *No accommodations will be guaranteed unless confirmed by the hotel management.*

## REGISTRATION

The Fall Conference registration headquarters will be located on the 18th floor of the hotel adjacent to the Salle Moderne where all technical and business sessions will be held. Members and guests are expected to register, the fee for which is used to defray Conference expenses.

## TECHNICAL SESSIONS

Members and others who are contemplating presenting papers during the Fall Conference can greatly assist the Papers Committee in the early assembly of their program by mailing in the titles of their papers not later than September 1, and complete manuscripts not later than October 1, to the East or West Coast Papers Committee chairmen, or to the Society's New York office. Your cooperation is solicited so that pre-Conference notice of the papers which will be presented can be given.

## FIFTY SIXTH SEMI-ANNUAL DINNER-DANCE

The Fifty-Sixth Semi-Annual Informal Dinner-Dance, award presentations, and social get-together, will be held in the Hotel Georgian Room, on Tuesday evening, October 17, (dress optional). In order to make the necessary hotel arrangements for this function, the Committee must know in advance the number of persons attending the dinner. Therefore, tickets may be procured or reservations made at the Society's office at the Hotel Pennsylvania, or through D. E. Hyndman, Chairman of the Dinner-Dance Committee, on and after October 1. Checks should accompany requests for tickets and should be made payable to W. C. Kunzmann, Convention Vice-President.

## LADIES' RECEPTION HEADQUARTERS

Although there will be no prearranged ladies' entertainment program during the Fall Conference, a reception parlor will be available in the hotel for the ladies' daily get-together and open house with Mrs. E. I. Sponable serving as

reception hostess. The ladies are invited to attend the Conference social functions. Ladies attending the Conference should register to receive badges and identification cards.

#### MOTION PICTURES

Conference identification cards issued to registered members and guests will be honored through the courtesy of the following *de luxe* motion picture theaters in New York:

CAPITOL THEATRE  
 PARAMOUNT THEATRE  
 RADIO CITY MUSIC HALL  
 ROXY THEATRE  
 WARNER'S HOLLYWOOD AND STRAND THEATRES

There are many entertainment attractions available in New York to out-of-town members and guests, and information concerning these may be obtained at the hotel information desk or at the SMPE registration headquarters.

### *Tentative Program*

#### *Monday, October 16, 1944*

- 9:00 a.m. *Hotel, 18th Floor: Registration.*
- 10:00 a.m. *Salle Moderne: Morning Session.*
- 12:30 p.m. *Luncheon period.*
- 2:00 p.m. *Salle Moderne: Afternoon Session.*
- 8:00 p.m. *The program for the evening of this date will be announced later.*

#### *Tuesday, October 17, 1944*

- 9:00 a.m. *Hotel, 18th Floor: Registration.*
- 10:00 a.m. *Salle Moderne: Morning Session.*
- 12:30 p.m. *Luncheon period.*
- 2:00 p.m. *Salle Moderne: Afternoon Session.*
- 8:00 p.m. *Georgian Room: Dinner-Dance and social get-together. The evening's program will be announced later.*

#### *Wednesday, October 18, 1944*

- 9:30 a.m. *Hotel, 18th Floor: Registration.*
- 10:00 a.m. *Salle Moderne: Morning Session.*
- 12:30 p.m. *Luncheon period.*
- 2:00 p.m. *Salle Moderne: Afternoon Session and Adjournment.*

#### IMPORTANT

*When you receive your hotel room reservation card, please return it immediately if attending the Fall Conference. There will be no rooms available or guaranteed unless booked in advance of the Conference dates.*

W. C. KUNZMANN  
*Convention Vice-President*

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# JOURNAL OF THE SOCIETY OF MOTION PICTURE ENGINEERS

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## HIGH-QUALITY COMMUNICATION AND POWER TRANSFORMERS\*

E. B. HARRISON\*\*

### PART ONE

#### POWER TRANSFORMERS AND FILTER REACTORS

The sound engineer is waging a never-ending fight against extraneous noises entering a sound channel. One of the greatest sources of noise is the complex field created by the many power transformers and filter reactors in the system. Of the methods of elimination, that which is aimed at the reduction of the fields at their source is perhaps the most effective. There are several ways of reducing, and in some instances virtually eliminating, the stray fields radiating from these coils.

For a transformer of conventional shell-type design with a given load rating, the shape and magnitude of the stray field depends on several factors, among which are the size of the transformer, flux density at which the transformer core is operated, the geometry of the core structure, and the magnetic shielding surrounding the structure. Since the stray field increases with the size of the transformer and increases with increased flux density, it follows that there is an optimum size, other things being equal, which will result in the lowest stray field.

In any shell-type design utilizing a single coil, this lowest stray field will still be large enough to modulate the program in adjacent audio transformers and tubes. Its influence can extend to audio transformers as much as 3 to 4 ft away, which means practically that even though the power equipment is located away from the audio components of its own channel, it may affect other channels in adjacent racks.

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\* Presented Oct. 20, 1943, at the Technical Conference in Hollywood.

\*\* Altec Lansing Corporation, Hollywood.

It has been found desirable, therefore, to produce a series of transformers designed for operation in crowded racks. These transformers are built on a core-type magnetic circuit having 2 coils astatically balanced. They occupy less space than the conventional design, and operate at high efficiencies, that is, with low temperature rise.

Fig. 1 is a sketch of the core structure around which this type of

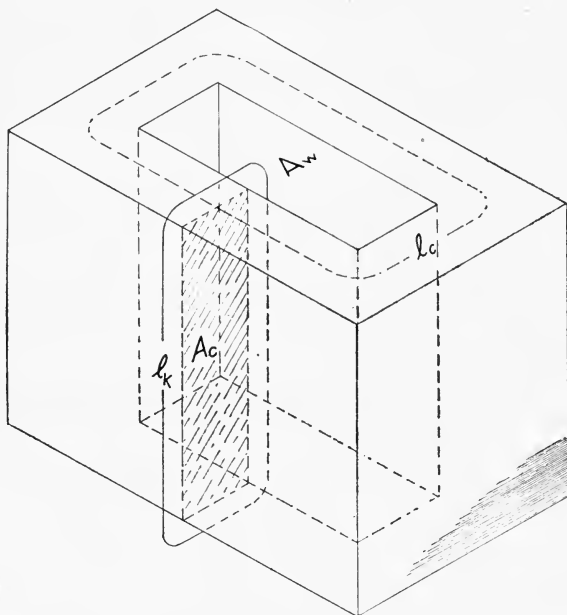


FIG. 1.

transformer is built. It can be shown that for the most efficient designs the following approximations hold:

- (1) The core loss in watts is equal to the copper loss in watts.
- (2) The mean length of the magnetic circuit is equal to the mean length of the copper circuit.
- (3) The cross-sectional area of the core is equal to the cross-sectional area of the window.

The geometry of the structure is such that the coils are long solenoids with their magnetic axes closely spaced, resulting in an almost perfect astatic balance of their fields. Measurements made on transformers built around these proportions indicate that the

field is so low that moderately shielded low-level input transformers may be operated next to them without hum pickup.

The narrow width of the core was chosen to insure a fairly uniform flux distribution which is further aided by the method of stacking, reducing the usual areas of high flux density with their resulting high loss.

In a fully interleaved core assembly (*i. e.*, 1 and 1) the reluctance of the air gap at the lamination joint causes a portion of the flux to

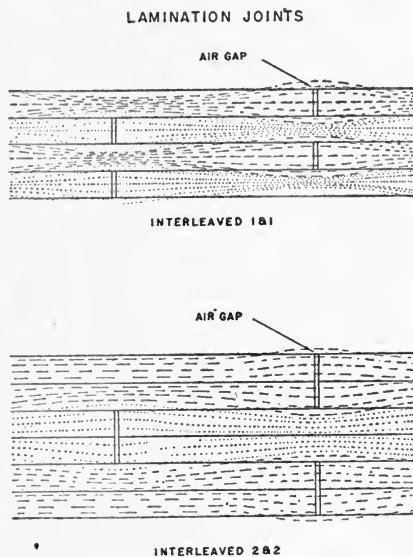


FIG. 2.

seek a path through the adjacent laminations, raising the flux density and losses therein (Fig. 2). Now, when the extent of the interleaving is reduced by stacking the laminations in pairs ( $2 \times 2$ ), the reluctance of the leakage path through the adjacent laminations is increased, because the length is effectively increased, forcing a greater portion of the flux to flow across the joint air gap. The reduction of high flux density areas by this method of stacking increases the permeability of the total core structure as shown in Fig. 3, where the solid line represents the permeability of the  $1 \times 1$  stack, and the dotted line that of the  $2 \times 2$  stack.

Fig. 4 shows a transformer built around the foregoing principles.

Note that at all points the transformer is close to the case housing it, providing more rapid dissipation of heat to the outside air. Note also that almost two-thirds of the coil surface is exposed, that no thick-walled coil sections exist, and that core heat is conducted to and radiated from the 2 ends of the core which also are close to the housing.

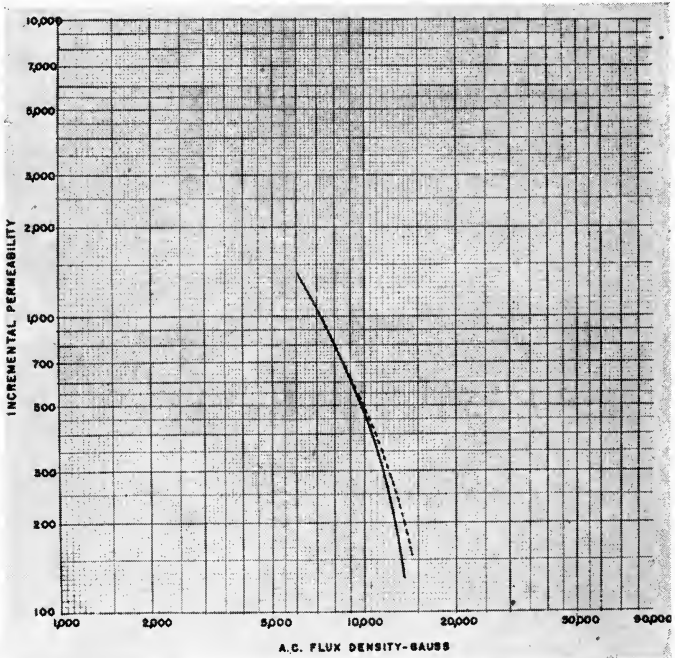


FIG. 3.

Fig. 5 illustrates the compactness of the design in comparison with a conventional unit of the same rating. Both transformers were designed to operate with the same temperature rise—less than 40 C. Consider particularly the comparison of the operating efficiencies, weights, and chassis space occupied.

	TM-579	TW-604
Volt-amperes	350	360
Efficiency	96 per cent	92.7 per cent
Watts dissipated	15	27.7
Weight, lb	17½	29¼
Chassis space, sq in.	23	47

Since their fields generally are of the most vicious type, being made up of not one but many frequencies, the companion power filter reactors were built around the same principles of design. The



FIG. 4.

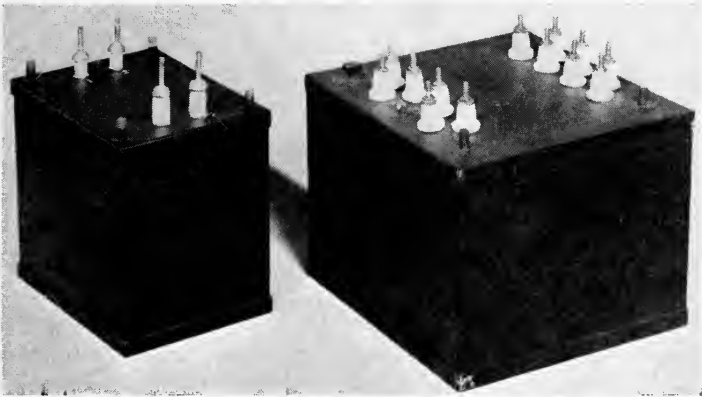


FIG. 5.

astatic balance is carried to the point of locating the air gap in the center of the coils where the possibility of leakage is lowest (Fig. 6). In practice, 2 stacks of U-shaped punchings are clamped together in the coils against insulating spacers to maintain the correct gap.

The clamps and bolts are so located that very little magnetic flux

passes through them (Fig. 7). The removal from the magnetic circuit of these relatively high coercive force steels eliminates all of the harmonics generated by the common commercial type of filter choke which is clamped together between steel frames secured by bolts passing through the core, all of which carry magnetic flux. The  $Q$  of the choke is raised appreciably, so that for a given inductance substantially better filtering action is obtained. Incidentally, audio chokes designed on these principles have shown a  $Q$  of 70 at 1000 cycles.

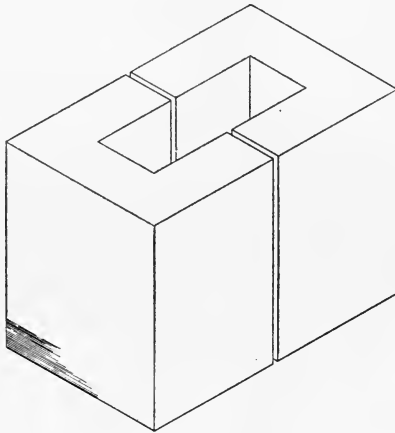


FIG. 6.

## PART TWO

### AUDIO TRANSFORMERS

The last few years have witnessed great improvements in audio transformer design. Not the least of these are due to the many kinds of core material now available. Audio transformers operate at low inductions, ranging from several thousand gauss in a high-level output transformer down to one gauss and less in low-level input and interstage transformers. The low induction hysteresis and eddy current losses must be small, and the initial permeability should be high. Since eddy current losses vary inversely with the resistivity of the core material, and as the square of the thickness of the laminations, the core stock must also have high electrical resistivity, and be used in thin sheets.



The presence of eddy currents in the core results in a phenomenon known as skin effect or shielding effect. This effect is merely the

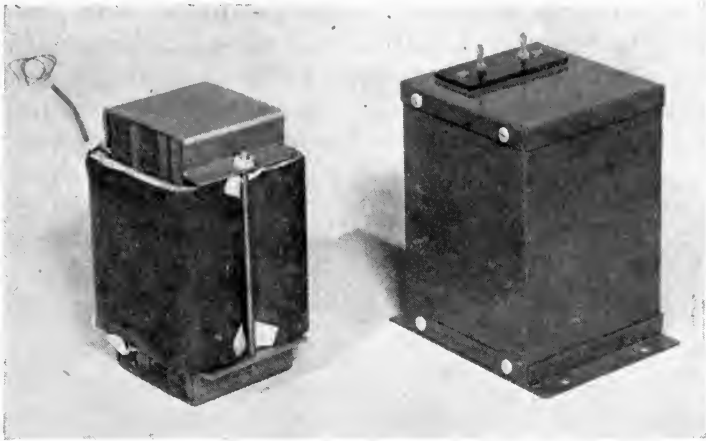


FIG. 7.

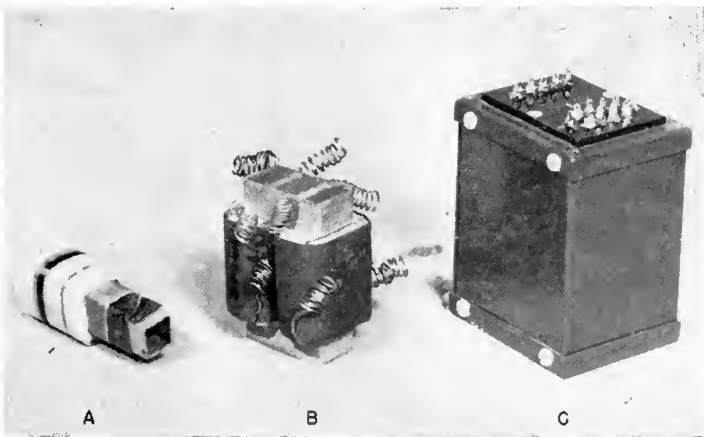


FIG. 8.

observed result of the loading caused by the secondary current circulating around the individual laminations. The counter-emf generated by these currents prevents the penetration of flux to the center of the plate or lamination. This means that as the frequency



the tube grids. The deviation usually is quite pronounced well below the frequency of resonance, and the point at which a measurable difference is found should be taken as the upper limit of the range which the transformer can cover.

The capacitive balance between the windings can be improved—at least controlled—by the introduction of shield windings or sheets. Sometimes the shield is connected to a section of the winding; more often it is tied to ground. Frequently windings are placed in a coil at a place where they act as shield windings because in the circuit in which they are used they are connected externally to ground.

When the shield is introduced between the primary and secondary windings, and connected to ground, electrostatic shielding is also



FIG. 10.

obtained, which prevents the transmission of incoming longitudinal currents past the barrier thus set up.

Since magnetic flux is not only in the core, but also linking every part of the winding, leakage links are present, causing the induction of a lesser voltage in some coils than in others with equal turns. For this reason each winding must be symmetrically located with respect to the other windings. In the case of a push-pull transformer, both secondary windings must cut the same amount of leakage flux, and the leakage flux around the start of the primary must be the same as the leakage flux around the end of the primary winding. It is this leakage flux which does not thread all of the windings of all of the coils, that is responsible for the leakage reactance in a transformer, resulting in a drooping response at high frequencies. Many transformers have had incorporated in their design just the proper amount of leakage reactance to resonate with the high distributed

capacity across the secondary windings at a predetermined high frequency. Such a transformer will show an excellent frequency response characteristic, but will not have the same time constant for all frequencies. Neither will it reflect a constant load to the line. These faults can be only partially corrected by secondary loading, as a loss of high frequencies is sure to result.

The windings on each side of a balanced transformer must have equal resistance. In the case of a symmetrical coil arrangement this usually follows as a matter of course. However, in some designs of a special nature where one part of a coil is wound on top of another, it may be necessary to change the wire size to accomplish the desired result.

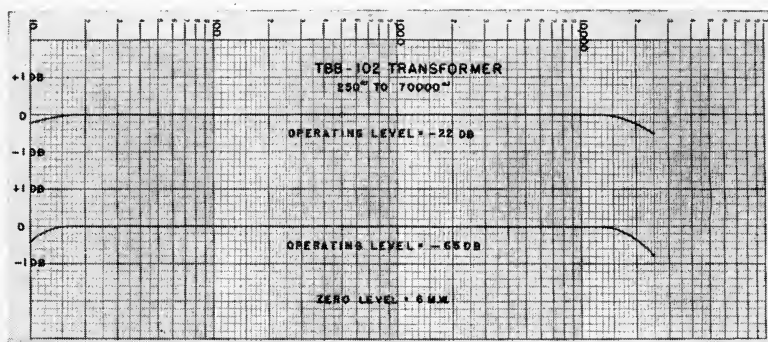


FIG. 11.

In the effort to keep the over-all size of a transformer small, very fine wires are used in the high-impedance windings. These wires are also reduced in size because the spacing between winding layers must be large to keep the distributed capacity low. The presence of any moisture in the coil or in the paper insulation would seriously impair the balance between the coils and the high-frequency response of the transformer. This moisture would also facilitate electrolytic action between the bare coil ends where they are attached to the lead wires. It is necessary, therefore, that the coil be thoroughly desiccated and then sealed.

This is accomplished by a vacuum impregnation system in which the coils are heated under pressure and then maintained in a heated condition at a high vacuum from 12 to 16 hr. While still heated and

under vacuum the transformers are immersed in a high melting point amorphous wax which has been highly refined to remove impurities. Pressure is then applied to the surface of the hot fluid wax to force it into the coil and between the laminations. The layer paper becomes a framework to support an insulating layer of wax, each individual wire is fully coated, and the individual laminations are insulated from each other by a coat of wax. The wax chosen for this purpose has a low dielectric constant, lower than any of the plastic films except polystyrene. It is sufficiently plastic at all operating temperatures, even those below zero, to prevent cracking. Long life is assured.

Fig. 8 illustrates an output transformer (*TP-204*) designed for operation between a single-ended or push-pull tube, and a line in the range between  $-20$  db and  $+20$  db level. Because this rather small

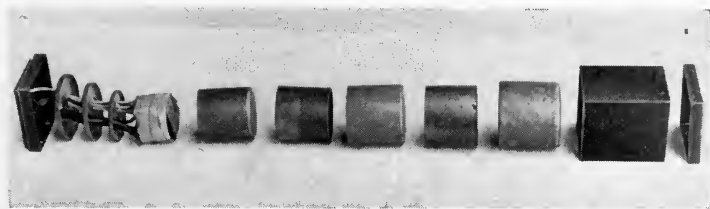


FIG. 12.

transformer has to handle large signals, many turns of wire per volt of signal were required to keep the flux density low, making it necessary to lengthen the magnetic path to keep the inductance of the windings down to the proper value. In addition, the mean length of the copper circuit was kept low to reduce the series resistance insertion loss. Since the winding length was quite long, the high-impedance primary winding was broken up into several pieces to reduce the developed voltage per layer, and consequently the effective distributed capacity. Under certain conditions of operation the magnetic flux leakage near the ends of the long legs of the core could become great enough to develop an appreciable leakage reactance. To prevent this and retain good high-frequency performance the tubes surrounding the core, and on which the coils are wound, have built into them an eddy current shield, consisting of a single wrap of heavy sheet copper with an overlapped, insulated high reluctance joint (Fig. 8A).

The astatically balanced construction also reduces external hum pickup which is down about 30 db from an uncased shell-type design of corresponding size. The entire unit is potted in a 3-section case which provides an additional 30 db of shielding. The performance of this transformer over a wide range of operating levels is shown in Fig. 9.

Fig. 10 illustrates a small input transformer (*TBB-102*) designed for operation at a  $-35$  db level. The response measured at  $-22$  db and  $-65$  db is shown in Fig. 11. A core was chosen with a very short magnetic path and with lap joints located near the center of the coil structure. A large core area was chosen to keep the operating

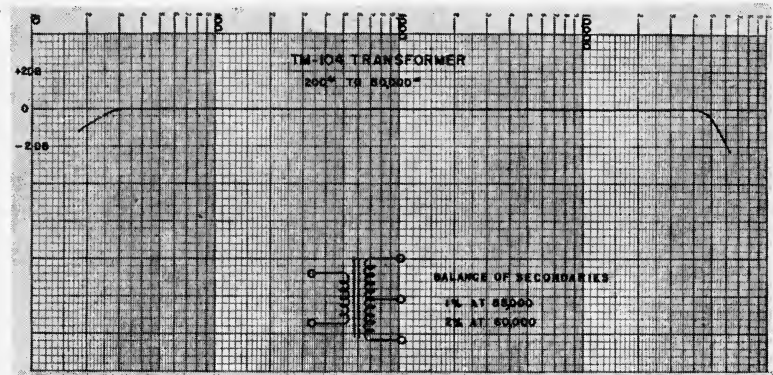


FIG. 13.

flux densities at low values: of the order of gaussses rather than hundreds of gaussses. The choice of core permitted the winding of a small-size coil which even with its small spacing between layers has a low distributed capacity. The thickness of the laminations chosen allows the development of a small quantity of eddy current which, acting on this short magnetic length core, effectively limits the high-frequency inductance of the windings, permitting excellent low-frequency response at low core densities without objectionably reducing the high-frequency response. Sheet copper shielding is used between the primary and the secondary windings, and is so spaced in the coil structure that the capacities from both ends of every coil to ground are equal.

A transformer of this sort with its high operating impedances, in this instance 70,000 ohms, and its consequent sensitivity to external fields, needs adequate shielding. For this purpose the transformer is cased in a seamless, drawn, round can of high permeability alloy. Surrounding this high permeability can is a heavy short-circuiting turn of copper. This assembly goes into another can of high permeability alloy surrounded by copper, and finally into a third high permeability can. Fig. 12 is an exploded view of the assembly, which is then vacuum impregnated and potted in its protective case. This type of shielding is good for about 30 db per can of high permeability alloy, the entire assembly attenuating external fields about 90 db.

A companion interstage transformer has been developed with the same characteristics and size as the transformer illustrated. It is designed to operate single ended or push-pull between 10,000 and 40,000 ohms.

Fig. 13 shows the frequency response characteristic of a transformer which is an outstanding example of wide frequency range and excellent balance combined with light weight. It is designed for operation at -10 db to zero level, has electrostatic shielding between the primary and secondary windings, and is potted within a 30 db shield can. Excellent high-frequency balance is obtained across the 2 halves of the secondary, being less than 1 per cent at 55,000 cycles, and only 2 per cent at 60,000 cycles. No unbalance at lower frequencies is measurable. The transformer is potted in a case  $1\frac{3}{4} \times 1\frac{3}{4} \times 2\frac{3}{4}$  in. and weighs 10 oz.

## THE DUPLEX LOUDSPEAKER\*

JAMES B. LANSING\*\*

*Summary.*—The Duplex Loudspeaker is a combined two-way loudspeaker mounted in an integral unit so that the high-frequency energy is radiated from a small multicellular horn mounted on the face of the low-frequency diaphragm.

Separate permanent magnets of improved magnetic material are now used for the fields of each voice coil.

The crossover has been selected at 1200 cycles so that the high-frequency horn can be placed in the center of the low-frequency diaphragm.

A signal input up to 25 w can safely be applied to the speaker. The intermodulation products are very low as a result of the two-way principle. The configuration of the high-frequency horn produces an angle of radiation which is 60 degrees in the horizontal plane and 40 degrees in the vertical plane. Due to the type of construction a high degree of uniformity between units can be maintained in manufacture.

The unit is capable of efficient radiation beyond 15,000 cycles.

The practical application of the Two-Way Multicellular Loudspeaker System for theater use began in 1935. Since that time there has been a gradual improvement in its quality and general performance. The wide acceptance of the high performance standard set by this two-way loudspeaker system indicated that the benefits to be realized by applying the same principles to loudspeakers for recording, monitoring, and broadcast radio work would be considerable.

Since the large size of the theater system (Fig. 1) precluded its use in monitoring booths, the immediate requirement was that a substitute be found for the large folded horn used for the low-frequency band. Reduction in the size of the low-frequency horn called for a corresponding decrease in the size of the high-frequency horn in order to make the whole equipment compact.

The first development to meet these requirements for a smaller system made use of a 500-cycle crossover network and a high-frequency horn designed to give proper acoustic loading at crossover.

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\* Presented Oct. 20, 1943, at the Technical Conference in Hollywood.

\*\* Altec Lansing Corporation, Hollywood.



The folded-type horn, much reduced in size, using a 15-in. speaker was retained for the low-frequency end. While this design had adequate frequency range for most small rooms and is being used in large numbers by our armed services, it was still too bulky for the "cubbyhole" type monitoring room. The effect of separate sources for the different frequency bands was annoying when used in close quarters.



FIG. 1.

In 1937, the first two-way loudspeakers using the multicellular high-frequency horn in conjunction with a resonated low-frequency baffle were made available under the name of Iconic Loudspeakers (Fig. 2). A crossover frequency of 800 cycles was used with a corresponding decrease in the size of the high-frequency horn, compared to that used with the 500-cycle crossover systems. These loudspeakers were far more compact than those using horns of various configurations for the low-frequency band. Operating efficiency, while not as high as in the larger systems, was still high when consideration was given to the decrease in size.

During 1941, intensive work was undertaken to find a method of producing a loudspeaker of still more compact form, retaining the same performance characteristics of the larger systems, and at the same time totally eliminating the tendency to radiate from split sources when used in close quarters.

The intermodulation distortion effects produced by a single diaphragm, when operating at a multiplicity of frequencies simultaneously, precluded the use of a single diaphragm for all frequencies.<sup>1</sup>

A metal diaphragm designed to operate as a piston up to frequencies above the limits of audibility, was chosen for the high-frequency reproducing system. Aluminum alloy was used because of its high mass stiffness and high velocity of transmission. The resulting lightweight diaphragm is stiff enough to prevent its breaking up as a piston and thus introducing the intermodulation effects so common to the familiar paper and other fibrous types of diaphragms.

Careful consideration was given to the type of high-frequency radiation system to be used. If the diaphragm was to radiate directly and was

made small enough to avoid sharp beam effects at high frequencies, it became too small to handle enough power, near the crossover region, for practical purposes. Accordingly, the multicellular type high-frequency horn was chosen as the radiating medium.

The final design for the high-frequency horn was a  $2 \times 3$  configuration of 6 cells, with a 900-cycle cutoff, which could be enclosed by the low-frequency cone. The maximum angle of horizontal distribution was held to approximately 60 degrees in order to prevent interference from the mounting baffle at the high frequencies.

Fig. 3 is a cross-sectional view of the completed Duplex Loud-Speaker showing the arrangement of the functional parts in their

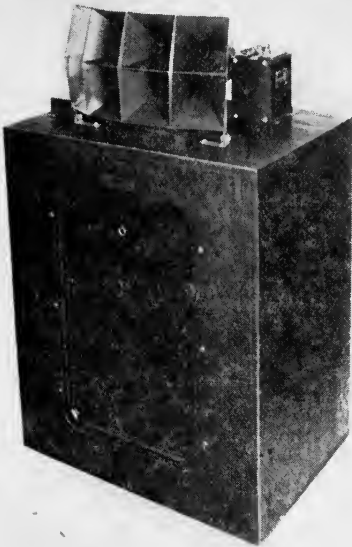


FIG. 2.

proper relation. The high-frequency horn is shown mounted on the end of the low-frequency unit pole piece, which is bored out to permit the passage of sound from the high-frequency unit. A fine mesh bronze screen at the junction of the pole pieces prevents the entrance of foreign particles into the high-frequency sound chamber. Positive alignment of the bores of the 2 pole pieces and of the horn mounting flange avoids discontinuities which would cause destructive interference along the high-frequency sound transmission path.

The high-frequency horn is covered with a sound deadening ma-

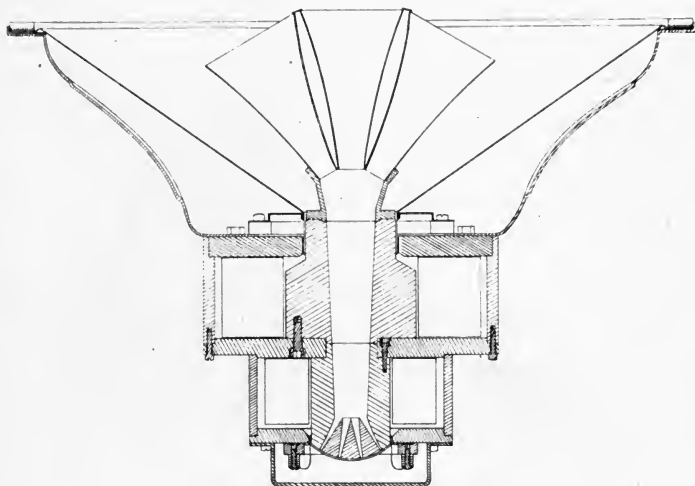


FIG. 3.

terial, but is not finished with a smooth surface which would set up a regular reflection pattern for sounds being generated by the surrounding low-frequency cone. The dome-shaped high-frequency diaphragm is shown in place over its transducer, which effectively prevents destructive interference from being set up in the sound chamber. The high-frequency voice coil is wound with aluminum wire to hold the mass of the moving system to a minimum. The low-frequency system consists of a 15-in. paper cone with its actuating motor system and surrounding mechanical structure.

A frequency dividing network of the constant impedance type is used with a crossover frequency of 1200 cycles (Fig. 4). The selection of the 1200-cycle crossover point permits the 900-cycle cutoff

horn to adequately load the high-frequency unit down to a frequency where it transmits little power. This eliminates any tendency to produce the distortion effects which would be caused if the acoustic loading were to cut off sharply at crossover, and effectively prevents any damage to the high-frequency unit because of unloading when the maximum rating power is applied in the crossover region.

Fig. 5 shows the Duplex Loudspeaker and its dividing network. These networks use iron cored reactors capable of being operated over a wide voltage range with negligible change in their inductance

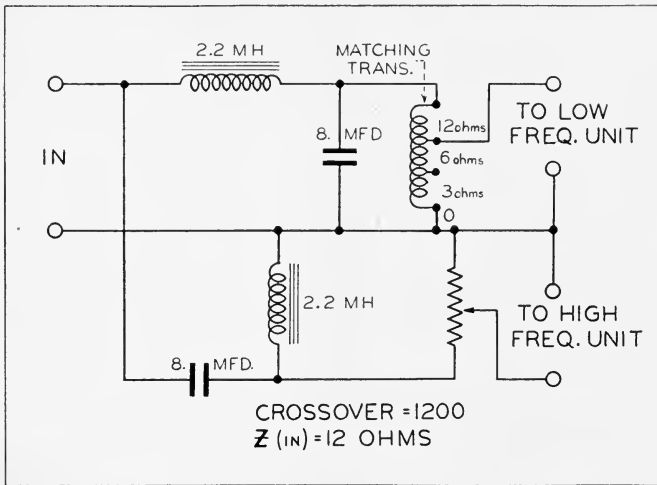


FIG. 4.

value. The networks are not affected by their proximity to other apparatus. The assembly shown has been used with various shapes and sizes of resonated baffles, but most satisfactory results have been achieved when a baffle with a volume of 6 to 9 cu ft was used. A 6-cu ft baffle when properly ported\* will permit good response down to 60 cycles. A 9-cu ft baffle will permit good response down to

\* The port is used to allow the energy which is radiated from the rear of the cone to be admitted out the front side in phase with that portion of the energy coming from the front of the cone. The effect is to maintain a more constant acoustic impedance down to the cutoff of the enclosure. The area of the port is a function of the size of the box enclosure and the mechanical resonance of the loudspeaker unit.

approximately 40 cycles. Care must be taken in the construction of the baffle to prevent "breathing" effects from the pressures built up in it at the lower frequencies. The inner wall of the baffles must be covered with sound absorbent material in order to prevent reflections which would give a "hang-over" or "echo" effect.

Comparative tests of the Duplex Loudspeaker with the larger systems have been highly satisfactory as to reproducing characteristics and efficiency. At a distance of 2 ft from the new unit, all frequencies being reproduced appeared to come from a single source. The high-frequency radiation angle of 60 degrees by 40 degrees is small enough to avoid reflections from the baffle as the sound leaves

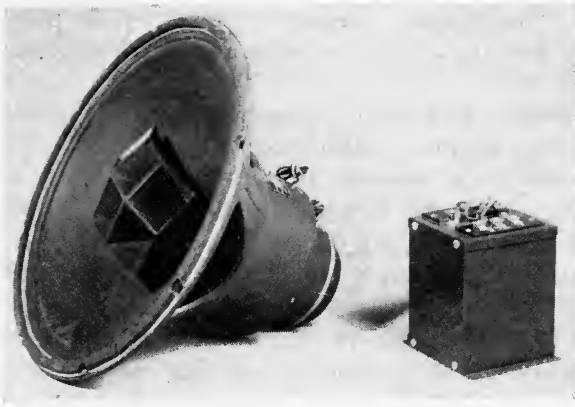


FIG. 5.

the high-frequency horn, but is still ample to permit the listener to move about with considerable freedom.

The uniform characteristics which can be maintained from unit to unit should make the Duplex Loudspeaker ideal as a monitoring standard. The elimination of vertical spacing between the source of high frequencies and the source of low frequencies brings about a point source of reproduction which is found to be very realistic and helpful in the critical judgment of quality.

#### REFERENCE

<sup>1</sup> BEERS, G. L., AND BELAR, H.: "Frequency Modulation in Loudspeakers," *J. Soc. Mot. Pict. Eng.*, **XL** (Apr., 1943), p. 207.

## SIXTEEN-MM COLOR TO 35-MM BLACK-AND-WHITE\*

CARROLL H. DUNNING\*\*

*Summary.*—Because of the increasing interest in the enlargement of “blow-up” of 16-mm to 35-mm, this paper offers some timely “do’s and “don’t’s” taken from practical experience.

Newsreels often show scenes of heroic rescues, aerial blitzes, and other “on-the-spot” thrillers. Sometimes the photography is noticeably bad, lighting is poor, focus hazy and grain size most annoying.

Probably they were photographed originally in 16-mm black-and-white and then blown up for theatrical release.

I have never felt, however, that a cameraman on a tossing ship in a stormy sea should be severely criticized for not resetting his focus between bursts from a diving Stuka.

In studio photography, “Oscars” are won with the slight assistance of “gaffers,” “juicers,” “key-lighting,” “baby spots,” “ears,” “goboes,” assistants, “loaders,” “grips” and an easy chair and other simple appurtenances. Therefore such vital subject material should be viewed from the standpoint of audience interest and not as a yardstick by which to judge the value of 16-mm blow-ups.

It seems rather paradoxical to suggest the use of 16-mm color originals for ultimate 35-mm black-and-white results, but the reason is quite apparent. Kodachrome, as an example, is a dye product. It contains no silver. Therefore, the problem of grain magnification is eliminated.

Another impelling reason for the use of Kodachrome originals is the opportunity it affords for selective alteration of contrast in the 35-mm negative produced therefrom. For example, the coloration of live actors in a scene is naturally on the red end of the spectrum, while sky and foliage are generally complementary in hue and tone. The sky may be overemphasized in deep blue when photographed

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\* Presented Oct. 21, 1943, at the Technical Conference in Hollywood.

\*\* President, Dunningcolor Corporation, Hollywood.

opposite the sun, and particularly in aerial shots photographed approaching the zenith. When enlarging under these conditions the use of a compensating filter within the blue range will suppress the complementary reddishness of the faces, and allow a greater over-all exposure to be used on the 35-mm negative. This will give a heavier deposit in the sky portions of the negative without increasing the negative weight of the faces. The final black-and-white positive will then have a normal gray sky instead of black, and the over-all values will be more nearly in balance.

On the other hand, if confronted with a flat, yet properly exposed desert scene with light skies, dun-colored earth, and filled with soldiers in khaki, you have an over-all reddish characteristic. You can increase the contrast of this original by the use of the same series of complementary compensating filters.

Conversely, the over-all contrast can be *lowered* by using compensating filters in the same tonal range as the over-all characteristic of the scene.

An alternative, of course, for altering over-all contrast may be attained by varying the time period of negative development.

Amateurs have turned in a wealth of material, some beautiful and *some!* They have shot with pockette cameras, magazine loads and daylight loads, all very satisfactory for *their* needs. These individual magazines having their own positioned apertures are at best made only of stamped metal and the aperture does not always accurately coincide with the static position of the pull-down pins in the camera to which it is attached. But if Kodachrome is to be used for copy enlargement it is imperative that the photographed frame line be *centered* across each set of perforations.

Naturally an optical printer is a precision instrument and is lined up to enlarge each 16-mm frame having a picture field bounded top and bottom by frame lines centered across the pairs of perforations in the original. If these vary from scene to scene as they often do, then they will be reproduced in the enlarged 35-mm blow-up within the visual field of the resultant projected image. To limit the field to be enlarged to the restricted area within the possible wanderings of these frame lines, is about as logical as eating the heart of a watermelon and throwing the rest away, and optical printers have no automatic means of anticipating this change of frame line in relation to perforations from scene to scene.

The solution—simply forego the urge to blow-up everything from

Boulder Dam to baby's first tooth (because it's such a swell shot and the president's son took it himself).

Start with a 16-mm camera that has been tested for standard frame-line accuracy, and if this is off standard have the aperture repositioned. If you have several magazines, as part of a good camera equipment, test all of them. Hire a cameraman of proved ability in the 16-mm color field. Insist upon the use of needle-sharp color corrected lenses. Enlargement does not enhance definition. Scenes that are soft focus in character or indifferently sharp, may appear satisfactory in the original but their faults may be glaring in the blow-up.

On the exterior shots where controlled lighting is impossible it is better, if feasible, to adhere to flat lighting with the sun at your back. Remember that color rendition does its own modeling.

Kodachrome is a fairly short scale medium, and blocked in shadows with empty high lights caused by cross and back lighting give an effect of unpleasant high contrast in the final black-and-white enlargements.

For interiors, or close-ups, where light sources can be controlled, it is not only permissible but effective to accentuate your modeling by cross or back lighting, provided your over-all front fill light has definitely filled in your shadow detail.

In all professional photography, your entire effort, worthy or otherwise, as well as your investment, is vested in your master negative and is guarded as such. Kodachrome originals occupy exactly the same position and are likewise the repository of your entire investment. But being a reversal process and positive in form there seems to be an almost uncontrollable yen to project them "just once" you know, just once for the boss. *Don't Do It.*

The smallest projection scratches and rewind cinch marks are magnified about 6 times their size on the enlarged 35-mm negative, and the refractive characteristic of a scratch even increases the ratio.

The safe and satisfactory procedure is to make a duplicate Kodachrome print of your "dailies" immediately. Then when you have edited the latter and eliminated all definitely unusable sequences, you can conform your original and blow-up the sequences which may possibly appear in the picture.

There are many advantages in the use of 16-mm Kodachrome. The photographic equipment is light in weight and its smaller size makes it extremely practical in confined spaces. Further, the ease of



handling as against a more cumbersome equipment make it ideal in many situations. For example, a follow shot of a bomb released through the bomb bay door of a plane, or a remote control shot from the rear of a *P38*, and for atmosphere or "pick-up" shots the 16-mm camera is unexcelled. The public simply accepts it as a commonplace amateur instrument and does not realize that you are making movies.

As I said before, there is no grain size to be enlarged, for Kodachrome is grainless. And the selective alteration of contrast is an attractive factor. In these wartimes, good 16-mm equipment is scarce, but wars will end.

In view of the fact that Kodachrome had its first success in the realms of "you press the button—we do the rest," we are apt to belittle its unquestioned and varied uses in the professional field.

Kodachrome's history has almost paralleled the course of radio, but remember radio passed through the growing pains of crystal sets in the hands of amateurs—and now look at the darn thing!

## WHAT TO EXPECT OF DIRECT 16-MM\*

LLOYD THOMPSON\*\*

*Summary.*—People who are using direct 16-mm productions for the first time, or those thinking of using them, will naturally have a lot of questions to ask about the method. They will want to know the advantages of the system, what can be done in the way of photography and sound, and what production and laboratory facilities are available. They will also want to know what may be expected of the final product in this field. The following paper will consider these questions and state what may be expected of direct 16-mm as it is known today.

The advantages of making pictures by the direct 16-mm method have been discussed before this Society and in various publications from time to time. Producers have not always been able to profit from these advantages because some of the services needed or some of the equipment required have not been generally available, but improvements are correcting this situation.

There seems to be an opinion that in a few years all the pictures made in the industrial field and most entertainment films will be shot on direct 16-mm. The individuals closest to the 16-mm industry think that direct 16-mm is going to play an ever-increasing role in certain types of production, but that there are certain places where it definitely should not be used. To use this method of production where it is not suitable will do the industry more harm than good.

The following are the general types of motion pictures, but not necessarily in order of importance:

- (1) Industrial.
- (2) Educational.
- (3) Entertainment.
- (4) Propaganda.

Direct 16-mm producers, and many not in this business, think that in the future a high percentage of the industrial films will be made

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\* Presented Oct. 21, 1943, at the Technical Conference in Hollywood.

\*\* The Calvin Company, Kansas City, Mo.

by the direct 16-mm method. The distinction between industrial films and the other types is very indefinite because such films are often also educational, may be entertaining, and may contain propaganda. In general, they are designed to present special subjects to selected audiences, and are not generally released to the public. Many of these films are made by professional film producers, but some are made by company organizations themselves.

Many of the thousands of industrial films being made today can be classed as educational films, and a number of such films are being produced by the U. S. Office of Education as well as by the Army and Navy. Many war factories are making films to teach such things as indoctrination, safety and operation of machines. A great many of these films can be and are being made by the direct 16-mm method.

There have been several entertainment films made by the direct 16-mm method, such as the shorts produced by Warner Bros. a year or so ago, and the short sections of the recent Walt Disney film *Saludos Amigos*. These films were produced on 16-mm Kodachrome and later enlarged to 35-mm Technicolor. Most people directly connected with the direct 16-mm industry do not think that this procedure has anything in particular to recommend it, and that a better job can be done by the conventional method, except in taking war films where 16-mm offers advantages, especially when photographing in color. They do think that a few entertainment films can be made by this method of production where all of the distribution is to be limited to 16-mm. However, as a rule, entertainment films must first be made on 35-mm film for the theater because there is not sufficient demand for 16-mm prints to make it profitable to produce good entertainment films by this method.

Few people like to have their films called propaganda films although a great number of them listed under other classifications should probably be called propaganda. A great many such films are made by civic organizations and other groups wishing to promote some special plan or idea. Since such groups usually do not have a great deal of money to spend, an ever-increasing number of such films are made by the direct 16-mm method.

Some of the things the prospective user of 16-mm films may ask is whether they can be made in black-and-white or color, whether they must be silent or can have sound, or whether sound can be added to silent color films. The answer to all of these questions is "yes."

Synchronous sound with dialogue or sound effects can be used, or

the picture can be shot as a silent "show" and later sound effects, narration, and music added. The prospective user of a direct 16-mm production may be interested in making his own show, or he may be interested in letting some commercial producer make the show for him. In that case, he will be interested in knowing what production facilities are available and just how complete these facilities are for direct 16-mm production. There are commercial organizations set up to do direct 16-mm work whose services include practically everything which can be obtained from any industrial organization working in 35-mm. If the user of direct 16-mm film wishes, he may turn his entire production over to one of these organizations and they will do the entire job from script to finished projection print in black-and-white or color, with sound.

What does such an organization have to offer? First, there is the sales department. As a rule, this part of the organization is tied together very closely with the chief director. After the show has been sold, the chief director works with the client in order to determine exactly what is to go into the show. After this has been determined, the chief director then gives the specifications to the production director, who with the camera crew starts working on it.

There are sound stages as large as some in Hollywood studios, where the pictures may be shot in synchronous sound or as silent shows with sound added later. Such studios are equipped with camera dollies, professional 16-mm cameras, professional lighting equipment such as Mole-Richardson, and where sets are built as they would be on a Hollywood stage—but usually not as elaborate.

Complete laboratory facilities are maintained for developing black-and-white reversal films, sound tracks, work prints, and release prints. All work on color films is done except developing which is still performed by the manufacturer.

Production facilities include script writers, editing rooms, editors, cutters, printers for adding special transitional effects, recording facilities for working on 16-mm film or acetate disks, recording facilities for blending music, voice, and sound-effect tracks into a final printing track; an art department for making special titles, and an animation department for doing animation work in either black-and-white or color. To my knowledge, there is only one organization that has all of these facilities within one organization and that is The Calvin Company. However, any of the direct 16-mm producers who so desire can purchase any of the services which he is not

able to perform himself. Naturally, there are not as many direct 16-mm producers who are as completely equipped as there are 35-mm producers.

The prospective user of direct 16-mm productions may desire to make his own show or a part of it, and then avail himself of certain services such as sound recording, editing, and perhaps laboratory facilities. Just as in the case of the producer who does not own all of his equipment, the user doing his own show can purchase any of these items.

Direct 16-mm photography which is to be printed and shown as 16-mm can be as good as, and in some cases better than, 35-mm which has been reduced to sixteen in either black-and-white or color. Naturally, this does not mean that all 16-mm photography is good because there is a lot which is not. On the other hand, there is a lot of 35-mm photography which is not good. If good results are to be expected from either method of production, certain definite rules must be followed. The people doing the photography must understand the problems if the best results are to be obtained. Owing to the shorter length of lenses used on 16-mm to cover the same area, it is sometimes possible to shoot certain scenes with less light and still obtain the same depth of field. However, too many people have the idea that because they are shooting 16-mm they can use amateur lighting equipment, and in much less quantities than any professional shooting 35-mm would think of using. This is not the case.

If good results are to be expected, scenes must be properly lighted and there must be plenty of light available in order to have properly exposed film. Direct 16-mm production does offer distinct advantages in shooting color. Kodachrome film is balanced for photo-flood illumination, therefore it is possible to get considerably more light without overloading lines, an important factor in industrial production.

The larger the appropriation for producing a show, the less important becomes the cost of the raw stock necessary, but a high percentage of the shows suitable for direct 16-mm production is made on limited budgets, and in such cases the cost of the raw stock, transporting it from various parts of the country to the laboratory, and other such items, add up to a considerable amount and become important items. It has recently been determined that for every client who can afford to spend \$15,000 to \$20,000 in making a show, there are eleven more prospects who cannot, and for these people

direct 16-mm may be the answer. In such cases a saving of several thousand dollars may mean the difference between having a show or not having a show.

Since 16-mm equipment is smaller and lighter in weight, there are cases where it can be substituted for the bulkier equipment, resulting in an economy in manpower.

As previously stated, sound for direct 16-mm productions can be made as either "sync" sound or off-stage sound. There are a few sound shots which are made by the single system method, but the serious producers of direct 16-mm use only the double system method of making sound. Almost anything which can be made by the 35-mm method can be done by direct 16-mm. This does not mean that the sound quality of direct 16-mm is as good as the best 35-mm. However, it can be as good as 16-mm reduced from the best 35-mm sound. Many times we have heard direct 16-mm sound tracks which have been better than 35-mm, but in such cases we felt that it was due either to a lack in the 35-mm equipment or in the way in which it was handled.

In making direct 16-mm sound, we follow as a rule the most direct course possible, such as using direct optical positives to be used for printing with Kodachrome thus eliminating one step. Direct 16-mm film can be rerecorded, but we do not believe that it can be rerecorded 3 or 4 times as is sometimes done with 35-mm. In most commercial shows it is not necessary or desirable to do this. A method which is gaining some favor for certain synchronous sound shots such as sound effects, is to record the original sound on acetate disks and then "dub" it off to a sound track. There are also times when it is desirable to record shows on disks and transfer to film. Many independent workers are finding this more desirable than buying film recording equipment. By using this method they can hear their results immediately. Where synchronous sound effects are desired, this is quite satisfactory and desirable as it eliminates certain chances taken during the recording of any synchronous sound, especially if it happens to be out of the studio.

Laboratory service for original reversal picture film in black-and-white is pretty well taken care of and standardized. There are certain precautions which should be observed, and if this is done there are laboratories from coast to coast which can do a good job with the original photography.

As yet there are comparatively few laboratories that are able to

develop sound tracks, make reversal prints, dupe negatives, positive prints from dupe negatives and release prints. However, the lack in number of laboratories is no serious handicap, because if fast service is wanted, air express can be used and at least one of these laboratories can be reached overnight from almost any point in the United States.

The production of large numbers of release prints from direct 16-mm originals at low cost is still one of the biggest problems of the industry. So far the cost of good prints from 16-mm originals has been fairly high and the laboratories producing them have justified these high costs as resulting from the extra care and special machinery necessary to turn out good work. Also, this machinery has been of a type which does not permit fast printing and perhaps this has increased the cost of release prints more than it should.

Until recently comparatively few prints have been ordered from most 16-mm shows naturally making the print cost higher, but this additional print cost has not been serious because of the small number of prints generally used. However, the war has changed this situation and large numbers of prints are now being made from the original films.

The Calvin Company has been working to correct this release print situation so that large numbers of prints can be made in a reasonable time and at a cost somewhat less than has been possible in the past. A number of special printers have been, or are being, constructed, and we have taken over a new building which will be devoted entirely to the production and laboratory work of direct 16-mm. Printing will be done in filtered air-conditioned rooms, all prints will be developed on automatic processing machinery, and all processes will be kept under strict control.

To give an example of what this expansion means we will describe the method used in printing Kodachrome sound prints with optical effects in the photography and sound. In the past it has been necessary to print this on a special printer at a rather slow speed. It was necessary to double print the picture material, taking approximately an hour and ten minutes per 400-ft reel to print the photography and the sound on each release print. A new high-speed printer has been designed for printing the photography with optical effects and a sound track in one operation, and it is now possible to print a complete 400-ft reel in approximately  $6\frac{1}{2}$  min.

The printer will be practically automatic in operation and will run

in both directions. It will only be necessary for the operator to thread raw stock in at the end of each reel, turn it on and wait for it to stop, and then thread it with fresh stock again. Once the printer is set up to operate like this, all the light changes will be made automatically with absolutely no chance for error, and thus a great many color sound prints with optical effects can be turned out in a very short time. The printers are capable of handling 1200 ft or 3 reels at one time, thus the average 16-mm show can be printed in one continuous length.

We have already said that the relatively high cost of good 16-mm prints has worked against the direct 16-mm idea somewhat. Another disadvantage of the direct 16-mm process has been the slowness with which release prints could be made. There have been 2 reasons for this: The laboratories in a position to make good 16-mm prints have been swamped for about 3 years, and their printers have been too slow and too limited in number.

In the new setup which The Calvin Company is making it is our desire to eliminate this particular bottleneck, and we expect to be able to deliver large numbers of high-quality prints in a very short time. It is not necessary that this be done on all shows, but there are many times when some large national concern wishes to release a picture over the entire territory at one time. In such cases it is very necessary that a large number of high-quality prints be released within a few days after the first print has been approved.

Naturally these services will first be used by the Armed Forces and other governmental agencies producing 16-mm films, but it is believed that before too long a certain percentage of these facilities will be available for private industry and other producers. At the present time, the facilities are available only after high priority work is completed.

After the show has been completed, the owner will then want to know what kind of projection equipment he should use, and what kind of equipment is available. In this field he has an almost unlimited choice, practically all of it much more portable than any 35-mm equipment. If the show is to be exhibited to only a few people, say, 10 or 15 at a time, the Movie-Mite projector can be used very successfully. This is a machine which weighs only 24 lb, has a 200-w projection lamp, and has ample sound volume to use with an audience of 30 or 40 people. This machine is extremely portable and carries a speaker and screen in the same case with the amplifier and



projector. It sells at a low cost and is especially suitable for shows in individual offices or homes.

On the other hand, if it is desired to exhibit before a larger group, say, from 50 to 200 people, the exhibitor can use one of the conventional sound projectors on the market such as Bell & Howell, Ampro, Victor, or Eastman. These come in various models and usually have 750-w lights and an amplifier with a power of approximately 6 to 15 w.

If the exhibitor wishes to project before more people than the conventional-size machine can successfully handle, he may go to the Bell & Howell 1200-w projector which fills a much larger screen. This machine has a great deal more power in the amplifier, and when used with one of the better types of speakers it will give excellent sound reproduction.

The exhibitor may wish to project before 1000 or more people, in which case several arc lamp projectors are available with which it is possible to cover an average-size theater screen. A high-quality amplifier system is available with this unit, with excellent sound reproduction.

With this excellent choice of 16-mm sound projectors, a very flexible program for exhibiting direct 16-mm films or any 16-mm film can be easily arranged, and the projection can be tailored to suit the audience group.

The 16-mm camera and projector were developed in order that more people might enjoy and use motion pictures. The direct 16-mm method of production has been developed in order that more people may enjoy the benefits derived from the use of motion pictures.

#### DISCUSSION

MR. SLYFIELD: Which do you consider better for 16-mm Kodachrome prints variable-density or variable-area sound tracks?

MR. THOMPSON: Our experience has been pretty largely confined to variable area as nearly all of the 16-mm recorders available are using the variable-area method. When properly made, and properly controlled, we feel that either method is capable of giving excellent results. There are bound to be some differences in printing and processing Kodachrome sound tracks from day to day, and we believe that the variable-area methods give more latitude in this respect without harmful effects on the sound track than the variable-density method. Kodachrome is a reversal process and we know from experience that in printing black-and-white reversal prints we have considerably more latitude with variable area than we do with variable density. I might also mention that all of our tracks have been developed in Kodak laboratories where the sound track is given

special treatment. If this is not done, variable-area tracks on Kodachrome are unsatisfactory.

MR. WOLFE: In its Hollywood plant, RCA has employed both variable-density and variable-area recording on 16-mm film. In general it has been our experience that the differences in quality which exist on 35-mm film between these 2 recording systems also exist on 16-mm film thus either system is capable of providing a commercially satisfactory job. Under normal circumstances, we employ variable area although special conditions involved in the processing of color prints have shown preferences. Under some conditions, better results have been obtained with variable-density recording, and under other conditions better results have been obtained with variable-area recording.

## A RERECORDING CONSOLE, ASSOCIATED CIRCUITS, AND CONSTANT B EQUALIZERS\*

WESLEY C. MILLER AND HARRY R. KIMBALL\*\*

*Summary.*—This paper describes a two-position console developed to handle multi-track rerecording requirements using sliding volume controls and pre-set equalization with which the mixer has at his command combinations of equalizers that may be connected into the circuit upon cue as required.

Also a variable-type attenuation equalizer circuit, arranged to give improved equalization characteristics as the control dial is varied from step to step, is discussed.

The demands upon the rerecording equipment at Metro-Goldwyn-Mayer Studios have been growing since the inception of sound on film. This is the result of normal factors accompanying any healthy industry, such as growth, and change in techniques to improve the product. At various instances in the past improvements have been made in the kinds and amounts of equipments available for our rerecording purposes, but these of necessity have mostly been of the nature of additions to existing equipments.

Shortly before the present war, work was started to engineer almost completely new rerecording equipment, primarily to provide expanded facilities, but also offering an opportunity to secure a rerecording plant incorporating the results of our experiences as to the type and amount needed.

This paper describes the salient features of a rerecording console and associated electrical network circuits provided in connection with this project. Emphasis is placed upon the features that are new to the industry.

Rerecording requirements at Metro-Goldwyn-Mayer Studios have developed in such a manner that more sound tracks are generally involved than is the case in many of the other studios. The average number of tracks is about 8, but sometimes as many as 15 or 20 tracks may be used. It is the policy at this studio to handle these tracks with one mixer most of the time with a second mixer to help out

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\* Presented Apr. 17, 1944, at the Technical Conference in New York.

\*\* Sound Dept., Metro-Goldwyn-Mayer Studios, Culver City, Calif.

on the more complicated jobs. This is not especially a matter of economy but rather to realize on the advantages to be gained by concentrating the controls in the hands of a limited number of people. Therefore, a fundamental requirement of the rerecording facilities is that they should be as simple to handle as possible so that the mixer may give a minimum of attention to the mechanics of his work, and devote most of his efforts toward accomplishing the dramatic effects desired. Where rerecording equipments are awkward to operate, or are not sufficiently flexible in their patching arrangements, the mixer is unduly handicapped in accomplishing his dramatic objectives.



FIG. 1. Front view of rerecording console.

The mixer console and associated network equipment described herein reflect our experiences in providing adequate mixer facilities so far as we are able to engineer and supply them at the present time.

It is proper to point out that the future of rerecording will undoubtedly provide for the automatic control, and repetition for rehearsal purposes, of the many things which the mixer has to do. Without attempting for the present the solution of the detailed mechanical and electrical problems, the ultimate rerecording system should provide means for making a progressive record of everything the mixer does, so that for each successive rehearsal the equipment adjustments used throughout the previous rehearsal will be automatically repeated. With such measures available his work during

a rehearsal and the final recording will be of a "touch up" nature rather than a complete repetition of all the previous equipment adjustments, leaving him free to concentrate on quality and dramatic requirements.

The exact pattern this development will take is not yet clear, but in the design of the Metro-Goldwyn-Mayer console every attempt has been made to anticipate the adaptations which might be required and to provide for their later inclusion to the maximum practicable extent. In general, such a system might well involve having nothing

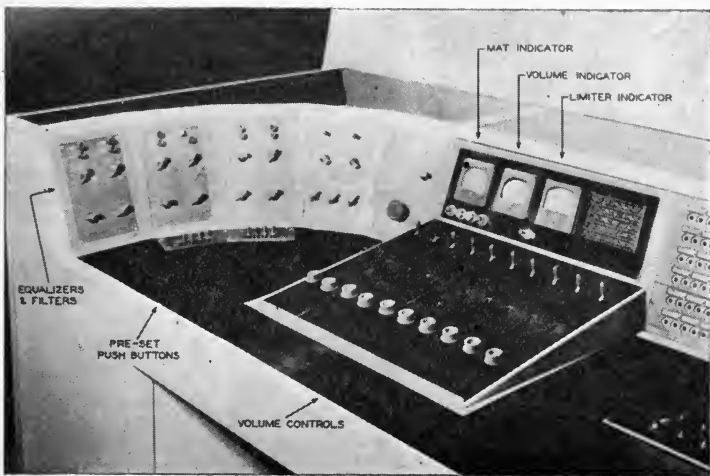


FIG. 2. Front view of rerecording console showing master mixer position.

but controls in the console, with all the voice equipment mounted in another location.

**General Console Features.**—The particular design which has been adopted for the console is shown in Figs. 1 to 5, inclusive. The console is arranged for operation by two mixers when necessary, and following our usual practice the left-hand side is the master position; that is, the position used when only one mixer is working, or when one mixer is in charge of an assignment involving two men.

The volume controls are placed on the slightly sloping surface in front of the mixer, and the network controls are arranged in semi-circular banks facing the mixer positions. Following our customary practice these equipments are so placed that the volume controls, for

the master position, are operated by the right hand and the network controls are operated by the left hand. The reverse procedure, of course, applies for the right-hand or secondary mixer position. A volume indicating meter and limiter indicator are in front of each mixer. The squeeze mat indicator is in front of the master mixer only, and is controlled by him by means of a foot pedal.

The console table itself is, in effect, a mounting frame for various equipment elements. It is kept low in height to permit good vision to the screen and to avoid acoustic pockets. The sides, top and back

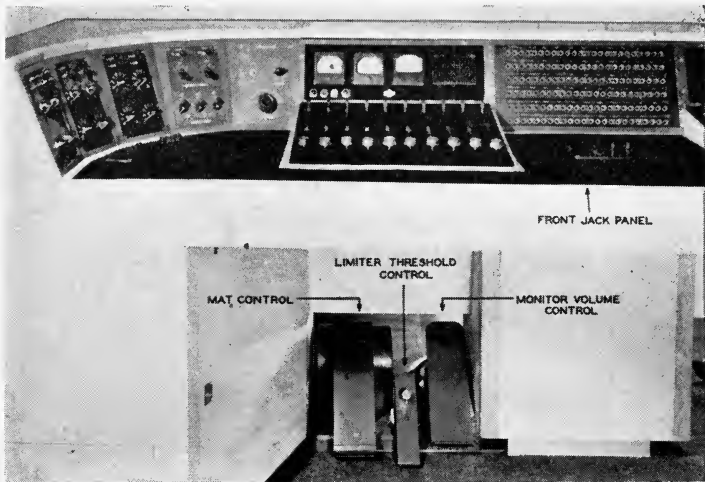


FIG. 3. Front view of rerecording console showing foot controls.

are removable for installation and maintenance purposes. All apparatus mounted in the console is of unit-type construction, complete in itself including controls. The units are physically arranged to allow sliding into the proper position with their controls within easy reach of the mixer. Specialized mounting arrangements are avoided by using the same type of mounting framework for each apparatus unit. This construction is excellent from the standpoint of original installation as the complete console is assembled and wired by the manufacturer and its installation is a matter of connecting external trunks to terminal blocks and mounting and connecting unit pieces of apparatus. The unit-type construction for the equipments also

facilitates maintenance replacements which can be made quickly when trouble develops.

Ten volume controls are placed in front of each mixer position making a total of 20 sound tracks which can be handled without employing auxiliary facilities. These controls, as contrasted with the usual rotating type, are of the sliding up and down controlled-type used by our studio for many years. This control movement is an important feature as it gives the mixer a certainty and dexterity of control unknown to mixers familiar only with the rotating type of volume

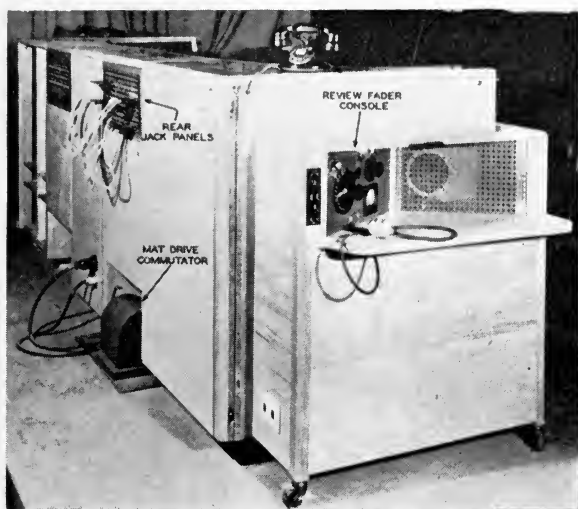


FIG. 4. - Rear view of rerecording console.

control. Much time and effort has been expended in developing this fader. The volume control assemblies are also of unit-type construction, 2 attenuators to a unit. The units are easily removed and replaced by spares.<sup>1</sup>

Patching jacks of the single-plug type appear on the console midway between the two mixer positions and within reach of either mixer. These are shown in the figures. In order to avoid using more jack space in the front of the board than necessary, the jack positions of secondary importance were located in the back of the console where patching can also be made when necessary.

The figures also show a fader control position at one end of the

console. It is common practice to use the same room interchangeably for rerecording and for review purposes. The fader control position facilitates this interchangeable use.

**The Console Circuit.**—The basic circuit for the console is shown in Fig. 6. It is arranged to connect to incoming or outgoing circuits of 200 ohms impedance. Equipment patching points are provided at a number of places within the circuit to permit the insertion of apparatus, such as equalizers, when needed. All apparatus patched into the console circuit is likewise designed for 200 ohms image

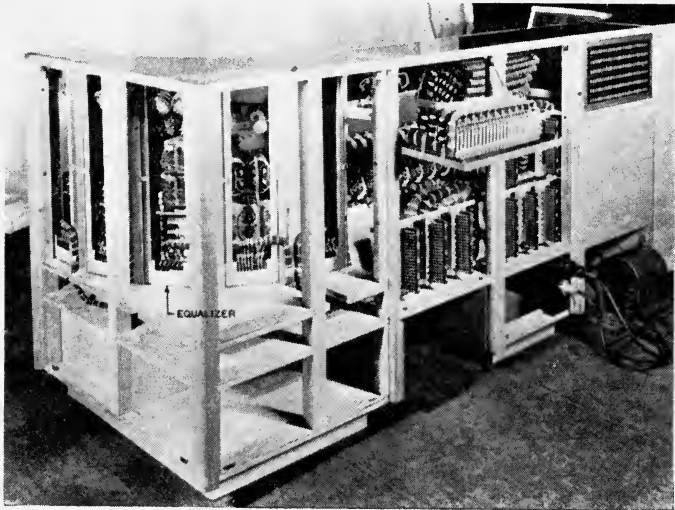


FIG. 5. Rear of rerecording console with cover panels removed.

impedances. The patching points permit the inserting of apparatus to affect the signals of the incoming circuits in groups of one, two, four, or the total of circuits. This has been found to be a practical setup for the rerecording work of our studios. It affords a maximum of flexibility in the use of patched in apparatus, but, more important, the mixer is able to use variable networks with groups of sound tracks thus reducing his mechanical work.

The patching points are obtained by the use of the transformers shown which are known as mixer transformers. This transformer is an extended design of the well-known hybrid coil, the revised design of which was developed at Metro-Goldwyn-Mayer Studios for our



mixer purposes. By its use any number of incoming circuits in multiples of two can be effectively joined together on a matched impedance basis with a minimum of transmission loss to form one outgoing circuit, or conversely. More information is given later concerning the design of this transformer for multicircuit use.

The basic console circuit has a transmission loss of about 23 db. This is divided among the circuit parts as follows: The volume controls used are of the slide-wire type having a minimum loss of about 6 db. Each of the two-position mixer transformer has a theoretical

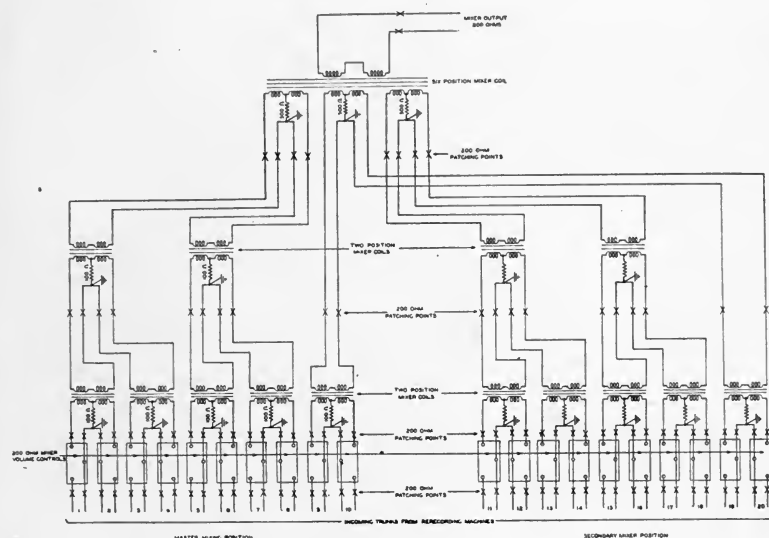


FIG. 6. Basic console mixer circuit.

loss of 3 db, or an actual loss of about 4 db. This makes 8 db for 2 such coils in any circuit. The six-position mixer coil has a theoretical loss of 7.8 db, or an actual loss close to 9 db.

**Electrical Networks.**—The controls for a variety of electrical networks appear in front of each mixer position as shown in the figures. These include variable high and low pass filters, special effects networks, and a generous supply of variable equalizers. Except for the equalizers the networks are of conventional design provided with controls for step-by-step variation of their insertion loss characteristics by means of tapped electrical elements. The variable equalizer networks, called Constant *B* Equalizers, were specially designed in

connection with the provision of these new facilities to give greatly improved variable equalization characteristics and control features over our past supply of such networks. Being of a design new to the industry engineering information concerning them is given later on in this paper.

**Pre-set Circuit.**—Another feature of the console which is proving of great value is a circuit called a Pre-set Circuit shown diagrammatically in Fig. 7. A large number of the variable equalizers supplied for the console are "normalled" to the pre-set circuit. This circuit as a whole, including its normalled apparatus, may be patched into any one of the patching points shown in Fig. 6. Essentially the pre-set arrangement allows the pre-setting of banks of equalizer

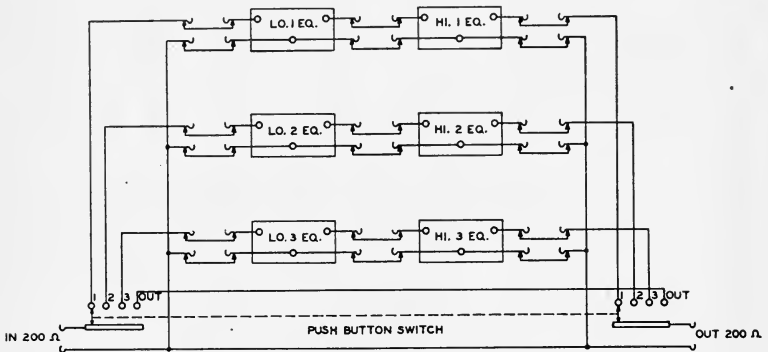


FIG. 7. Pre-set circuit.

equipment for some definite equalization condition and its switching into the console circuit at any desired place in a reel of film. Its use has reduced the mechanical work of the mixer and freed his attention for other things by accomplishing in one movement what might have required several with an accompanying diversion of attention.

The switching controls for the circuit to switch from one pre-set condition to another are push buttons appearing on the mixer console near the volume controls. Three pre-set conditions and a normal are provided with each pre-set circuit, and each mixer position has one such circuit. The pre-set buttons for the secondary mixer position are multiplied over to the master position for his use when needed. The equalizers normalled to the pre-set circuits may be patched out and used in other places, if desired, or additional networks may be patched into the pre-set circuits by means of the jacks provided.

**Mixer Transformers.**—As previously mentioned the mixer transformers used with the console circuit are an extended design of the conventional hybrid coil. Consider the circuit of Fig. 8A which shows an unbalanced hybrid coil in the usual form. For mixer purposes, a mixer coil is assumed to be one which effectively joins a number of “collecting” circuits to one “receiving” circuit. A match of impedances at all points where the circuits join the transformer, and a minimum of transmission loss is desired and obtained. For the circuit of Fig. 8A a double winding, that is, windings A and B, provides the means for obtaining 2 collecting circuits. We might also have put on another pair of these double windings, as shown in

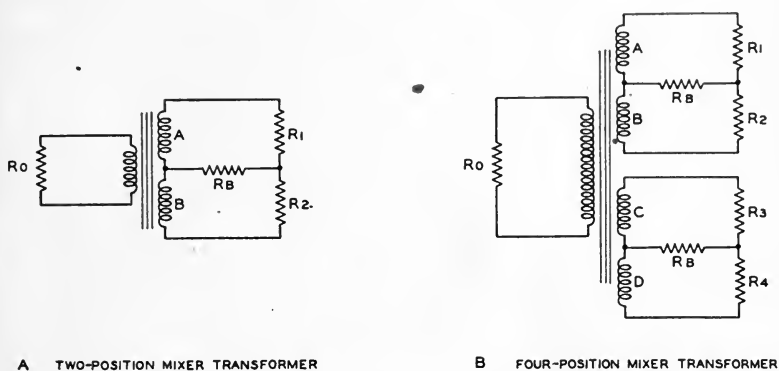


FIG. 8. Mixer transformers.

Fig. 8B by windings C and D, and obtained 4 collecting circuits. In fact, each time another pair of windings is added 2 more collecting circuits are made available. A general mixer transformer, then, is one which has “ $n$ ” collecting circuits and “ $n$ ” associated windings with the restriction that the windings and circuits must occur in pairs.

For Fig. 8B the resistors  $R_1$ ,  $R_2$ ,  $R_3$ , and  $R_4$  represent 4 collecting circuits. The resistors  $R_1$  and  $R_2$  form a pair of such circuits, and  $R_3$  and  $R_4$  form another pair. The circuit resistances of any pair of collecting circuits must both be alike, but the impedances of the pairs may differ among themselves providing the design takes this condition into account. However, for this paper it is assumed that the resistances of the collecting circuits and the receiving circuit are all

alike and equal to  $R_0$  ohms. In other words, the console mixer circuit maintains a constant resistance of  $R_0$  ohms throughout.

The resistors  $R_B$  provide the means for obtaining matched impedances at the circuit connecting points. For "n" collecting circuits having impedances of  $R_0$  ohms, all the  $R_B$  resistors are alike and have the following value:

$$R_B = R_0 \left[ \frac{n-1}{2} \right]^2$$

The transmission losses among the different circuits connected to the mixer coil are as follows:

$$\left[ \begin{array}{l} \text{Loss from any collecting circuit to the receiving} \\ \text{circuit or conversely} \end{array} \right] = 10 \text{ Log}_{10} [n] \text{ Decibels}$$

$$\left[ \begin{array}{l} \text{Loss from one collecting circuit to another collect-} \\ \text{ing circuit of the same pair} \end{array} \right] = 20 \text{ Log}_{10} \left[ \frac{n}{n-2} \right] \text{ Decibels}$$

$$\left[ \begin{array}{l} \text{Loss from one collecting circuit to another collect-} \\ \text{ing circuit of different pairs} \end{array} \right] = 20 \text{ Log}_{10} [n] \text{ Decibels}$$

The mathematical means of deriving the above formulas will not be given in this paper. From a circuit standpoint such analysis is not difficult, but the actual manipulation of the circuit equations is somewhat tedious unless approached from the right point of view. In connection with the above losses it should be remembered that these are for theoretical transformers not dissipating power themselves. In practice the transformer loss must be added to the above losses. The transformer loss for mixer transformers is of the same order as for any transformer of a comparable design.

It is not the purpose of the paper to go into the detailed design of the transformer. However, it may be said that for "n" collecting circuits, "n" associated windings are needed, arranged in pairs as shown in the schematics. If the inductance of each of the collecting windings is L henrys, then the inductance of the receiving winding is (nL) henrys. Also looking into the transformer from the receiving side with the other sides loaded with collecting circuits, the balancing resistors  $R_B$  are not effective in determining the impedance. Hence the "n" collecting windings of L henrys each may be placed in series and attached to a load of (n  $R_0$ ) ohms. For this condition the transformer is the same as any conventional transformer working from  $R_0$  ohms on one side to (n  $R_0$ ) ohms on the other side. This gives a convenient basis for carrying out the detailed design work.

Thus the mixer transformer is a means of dividing one signal cir-



equalizers constant resistance circuits are available in many forms. Variable characteristics are usually obtained in a step-by-step manner by means of control dials associated with tapped electrical elements.

Continuously variable networks have not been used to any great extent as yet in motion picture work. Variable equalizers for rerecording work usually require 2 degrees of freedom of control; that is, the amount of equalization and its frequency placement must be independently adjustable. An equalizer, for instance, arranged for equalization control with fixed frequency placement is not of much use to a mixer except for special purposes.

One method which has been used extensively in the past for designing equalizers is to associate reactive circuit elements with re-

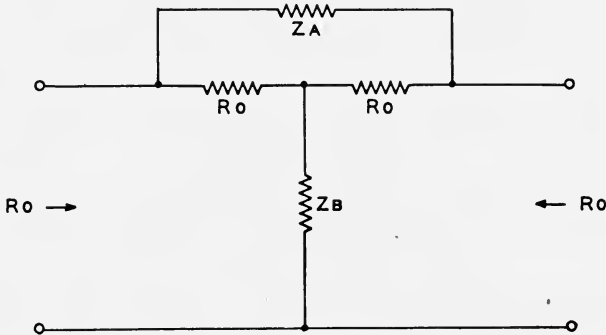


FIG. 10. Constant resistance equalizer section schematic.

sistors forming attenuators of the various types. For variable networks conventional step-by-step attenuators are often used instead of individual resistors. In order to vary the frequency placement of such networks it is necessary to employ tapped reactors whereby the actual values of the circuit reactances are changed by means of a control dial. To vary the amount of equalization it is customary to change the setting of the attenuator dial. This, however, is not a completely desirable procedure because the slopes of the family of equalization curves so obtained change from one attenuator setting to another. Fig. 9 shows a family of curves obtained in this manner where the change in slope may be noted.

To acquire design control of the shape of these characteristics it is again necessary to simultaneously alter the reactance values. But where the tapped reactance method is used for frequency placement

it is obviously not practicable to repeat the process to control the amount of equalization. The use of the constant  $B$  attenuator provides an alternate method for controlling the slopes of the equalization curves without using tapped reactors, thus reserving this feature for frequency placement.

Consider first the simple conventional constant resistance circuit of Fig. 10. For this circuit the resistors  $R_0$  are the same as the associated line resistances. The impedors  $Z_A$  and  $Z_B$  are general in nature, composed of any circuit arrangement of resistors, and inductive or capacitive reactors, with the restriction that  $Z_A$  and  $Z_B$

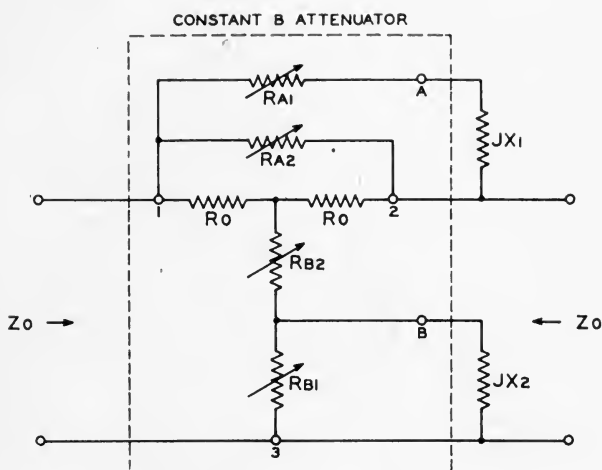


FIG. 11. Constant  $B$  equalizer schematic.

are mutually inverse to each other, or  $Z_A Z_B = R_0^2$ . Because of this relation, when one of them is known the other is determinable. Hence formulas associated with this network need to include only one or the other of the impedors. Inverse networks are discussed in the aforementioned book.<sup>2</sup> The insertion loss of the network of Fig. 10 is:

$$\text{Insertion Loss in Db} = 20 \text{ Log}_{10} \left[ 1 + \frac{Z_A}{R_0} \right] \text{ Decibels} \quad (1)$$

The general circuit schematic for the constant  $B$  design is shown in Fig. 11. The circuit portion included within the dotted lines is the constant  $B$  attenuator. Resistors  $R_0$  are, as before, of the same

value as the line resistance. Resistors  $R_{A_1}$ ,  $R_{A_2}$ ,  $R_{B_1}$ , and  $R_{B_2}$  form the variable portion of the constant  $B$  attenuator. They correspond to the tapped resistors used in conventional attenuators. Constant  $B$  attenuators may be constructed physically in the same manner as conventional attenuators except that provision must be made to vary 4 resistors instead of the usual 2 or 3 resistors. The reactors  $JX_1$  and  $JX_2$  are general in their circuit arrangement but, as before, must be inverse to each other;  $(JX_1)(JX_2) = R_0^2$ . In association with the constant  $B$  attenuator they complete a constant  $B$  equalizer.

The numerical impedance of any theoretically pure reactance or combination of reactances, as  $JX_1$  and  $JX_2$  are assumed to be, varies with frequency between a zero value at the resonant frequencies and an infinite value at the anti-resonant frequencies. For 2 mutually inverse reactances, one passes through zero reactance at the frequency for which the other exhibits infinite reactance, and conversely. Referring to Fig. 11 at the frequency for which  $JX_1$  is zero and  $JX_2$  is infinite, the resistances  $R_{A_1}$  and  $R_{A_2}$  are in parallel and  $R_{B_1}$  and  $R_{B_2}$  are in series. Also, at the frequency for which  $JX_1$  is infinite and  $JX_2$  is zero neither of the resistances  $R_{A_1}$  nor  $R_{B_1}$  is effective in the circuit. This, then, fixes the minimum and maximum losses over the frequency range. Using Eq (1) and letting  $R_P$  be the parallel resistance of  $R_{A_1}$  and  $R_{A_2}$  we have

$$\text{Maximum Loss} = 20 \text{ Log}_{10} \left[ 1 + \frac{R_{A_2}}{R_0} \right] \text{ Decibels} \quad (2)$$

$$\text{Minimum Loss} = 20 \text{ Log}_{10} \left[ 1 + \frac{R_P}{R_0} \right] \text{ Decibels} \quad (3)$$

Another loss called the equalization loss or simply equalization, is defined as the difference between the maximum and minimum losses, that is

$$\text{Equalization} = \text{Maximum Loss} - \text{Minimum Loss}$$

$$\text{Equalization} = 20 \text{ Log}_{10} \left[ \frac{1 + \frac{R_{A_2}}{R_0}}{1 + \frac{R_P}{R_0}} \right] \text{ Decibels} \quad (4)$$

Note that equalization, as herein used, is a difference value not depending on frequency. For any particular design the equalization is varied by means of a control dial associated with the constant  $B$  attenuator. In most cases it is convenient to arrange the equaliza-



tion to vary in db, or multiple db steps from zero to some maximum amount obtained on the top step of the control dial. Equalization, then, and the manner in which it is to be varied, is assumed to be known design information.

Another parameter useful in the design of equalizers is a frequency which we will call ( $f_b$ ) and for which, on any control step, one-half the equalization loss for that step is obtained. That is, the equalizer loss varies from the minimum loss of Eq (3) to the maximum loss of Eq (2) and at one or more frequencies in between these 2 extremes, one-half the difference loss is obtained. Where  $f_b$  is multivalued with frequency, use is made of the lower value in the formulas of the book, *Motion Picture Sound Engineering*,<sup>2</sup> and this concept is retained herein.  $f_b$ , then, is known design information defined as follows:

$$f_b = \text{Frequency of One-half Equalization Loss} \quad (5)$$

Since equalization has been taken as the difference between the maximum and minimum losses as given in Eqs (2) and (3), it is obvious that a given amount of equalization can be obtained for an infinite number of values for these 2 losses as long as their difference is unchanged. But although this difference may remain constant, the equalization characteristics so obtained shift in the  $f_b$  frequency. Then, for any definite amount of equalization, adjusting the maximum and minimum losses while keeping their difference constant provides a means of placing  $f_b$  at a desired frequency. Constant  $B$  equalizers hold  $f_b$  at a constant frequency for all of the steps of the equalizer. The following equation supplies the design means for adjusting the maximum and minimum losses at the proper values for holding  $f_b$  constant throughout the constant  $B$  attenuator range:

$$\text{Sinh}^2 \left[ \frac{\text{Max. loss on any step}}{2 \times 8.68} \right] = \text{Sinh} \left[ \frac{\text{Equalization on same step}}{2 \times 8.68} \right] \times \text{Sinh} \left[ \frac{\text{Max. Equalization on top step}}{2 \times 8.68} \right] \quad (6)$$

This is a coupling equation relating the 2 known losses contained in the right side of the equation to the unknown loss embodied in the left side of the equation. Eq (6) is derivable by rigorous mathematical processes not given here. Any equalizer having the circuit of Fig. 11, and having its attenuation losses related as in Eq (6) will maintain  $f_b$  constant with frequency for all its attenuator steps and for any pair of associated inverse reactance circuits.

An important simplification of Eq (6) can be made which avoids the use of hyperbolic functions in most cases. For equalizers having

maximum losses not greater than 15 or 20 db, the hyperbolic angles embodied in the equation are small angles. For small hyperbolic

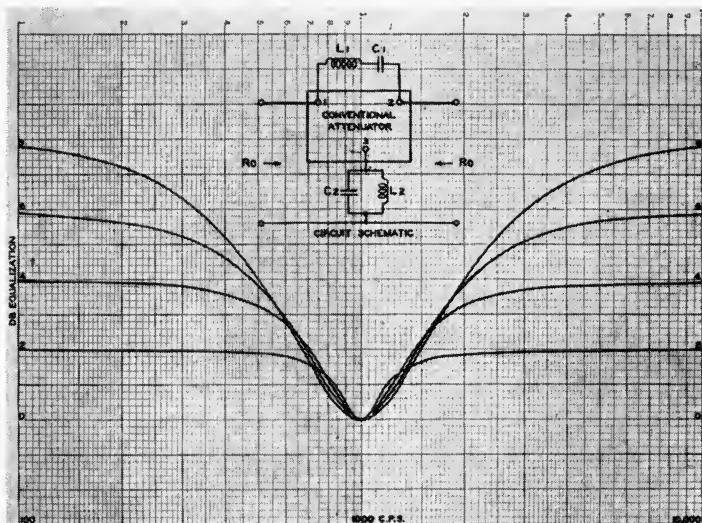


FIG. 12. Constant B equalizer characteristics.

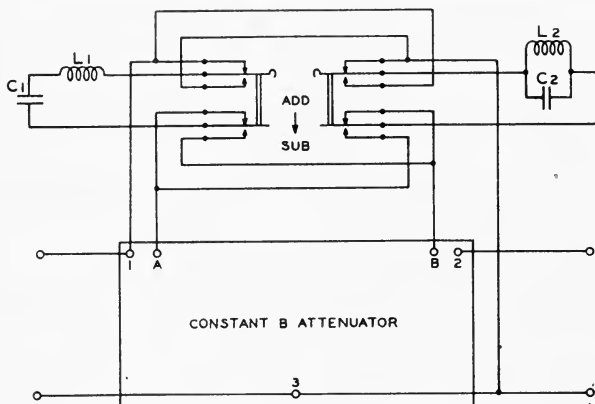


FIG. 13. "Add" and "Subtract" constant B equalizer schematic.

angles, the sinh of the angle is approximately equal to the angle itself. Then we may write as a close approximation of Eq (6)

$$\left[ \text{Max. loss on any step} \right]^2 = \left[ \text{Equalization on same step} \right] \times \left[ \text{Max. Equalization on top step} \right] \tag{7}$$

All the information needed to design the constant  $B$  attenuator portion of Fig. 11 is now before us. Knowing the items expressed in the right side of Eqs (6) or (7), the maximum loss as given by the left side of the equations for each equalization step may be computed. Then by means of Eqs (2) and (3) the values of the tapped resistors  $R_{A_1}$  and  $R_{A_2}$  for each equalization setting are obtainable. Since  $R_{B_1}$  and  $R_{B_2}$  are, respectively, inverse to  $R_{A_1}$  and  $R_{A_2}$  these resistors may now be computed for each equalization step.

The reactances  $JX_1$  and  $JX_2$  are designed to place the half loss frequency  $f_b$  at the desired place in the frequency range. Because  $f_b$  remains constant after being established, we may design the reactances in connection with any of the equalizer steps we desire. The most convenient step is the top step where the equalization is a maximum and is also equal to the maximum loss as seen from Eq (7). This means that the minimum loss is zero on the top step or  $R_{A_1} = 0$ . For this maximum loss condition then, the constant  $B$  equalizer circuit of Fig. 11 reduces to the conventional types discussed in *Motion Picture Sound Engineering*.<sup>2</sup> The reactances  $JX_1$  and  $JX_2$  may therefore be designed for the maximum loss condition, in accordance with the information given therein and used with the constant  $B$  attenuator.

Fig. 12 shows a constant  $B$  equalizer circuit and its character-

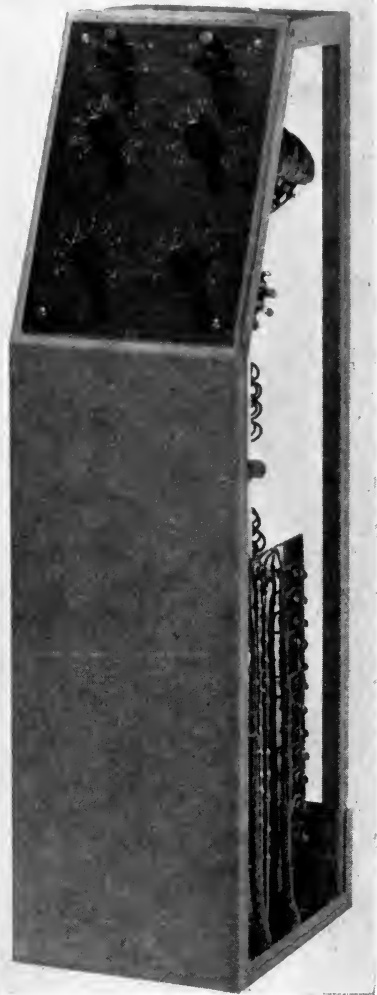


FIG. 14. Front view of console equalizer unit.

istics designed in accordance with the foregoing. The reactances employed with the constant  $B$  attenuator of this circuit are the same as those used in Fig. 9 in connection with a conventional attenuator. The difference in the equalization characteristics for the 2 cases is noted. The maximum equalization characteristic is the same in both cases.

The equalizer of Fig. 12, when inserted in a circuit carrying a signal, effectively increases the relative volume of the frequency components in the vicinity of 1000 cps. This equalizer can be made to decrease the relative level of these signal components by interchanging the series and shunt reactance circuits. Fig. 13 shows a circuit for accomplishing this purpose where the switching positions are designated as "Add" and "Subtract" corresponding to a relative increase or decrease of these frequency components. The families of equalization characteristics obtained for the add and subtract conditions are not necessarily symmetrical, but can be made to be so by placing a limitation upon the maximum loss of the constant  $B$  attenuator. Reference to the design formulas given in *Motion Picture Engineering*<sup>2</sup> for these 2 types of networks indicates that symmetrical add

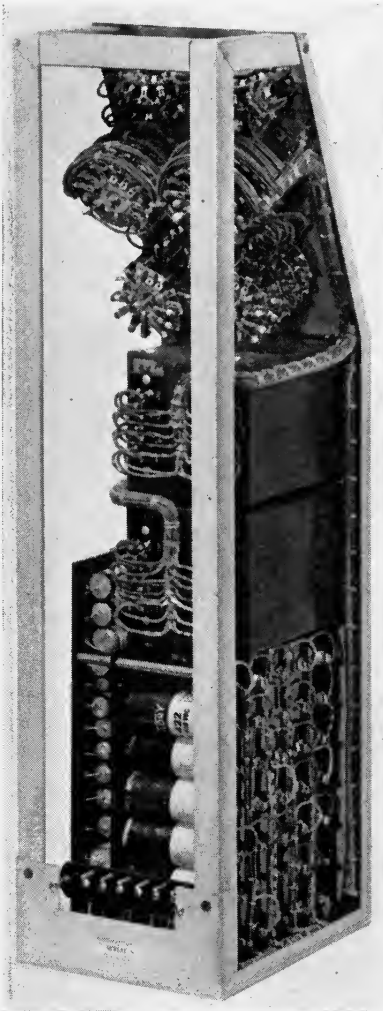


FIG. 15. Rear view of console equalizer unit.

and subtract characteristics will be attained when the maximum loss of the constant  $B$  attenuator is 8.36 db. This is the loss corresponding to the relation  $(K-1)/\sqrt{K}=1$  or  $K = 2.62$  and loss =  $20 \log 2.62 = 8.36$  db.

The design of the equalizer units used in the rerecording console shown in Figs. 14 and 15, is an application of the above information. Six of these units are included in each rerecording console. Their constant  $B$  attenuators are designed to have the above-mentioned maximum loss of 8.36 db to make the add and subtract characteristics symmetrical.

The reactors employed are tapped and associated with dials on the control panel to allow sweeping of the equalization characteristics throughout the frequency range. Because of the difficulty in securing tapped reactors having sufficient range, each equalizer

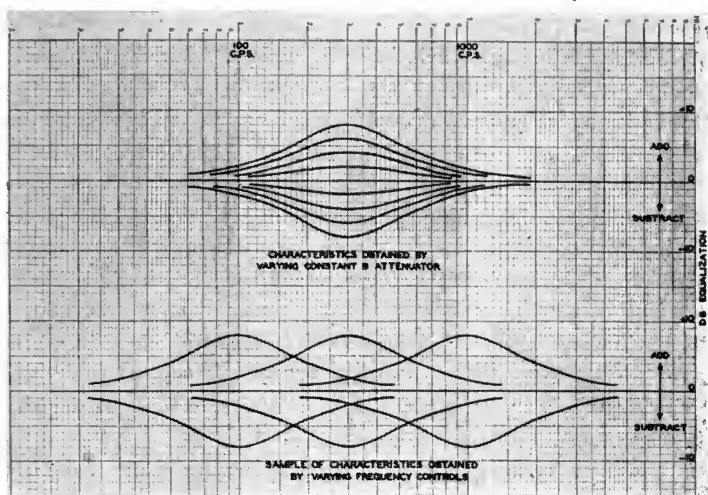


FIG. 16. Typical "Add" and "Subtract" constant  $B$  equalizer characteristics.

unit is really 2 units connected in series, one to cover the frequency spectrum below 1000 cps and the other effective above 1000 cps. This is indicated in the pre-set circuit schematic of Fig. 7.

The frequency control dials consist of 20 steps, 10 for the lower unit, and 10 for the upper unit. These equalizer units, then, provide 2 degrees of control freedom independent of each other, one to sweep the frequency range, and a second to vary the equalization. Fig. 16 shows samples of the equalization characteristics obtained.

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## REPRODUCTION OF COLOR FILM SOUND RECORDS\*

R. GÖRISCH AND P. GÖRLICH

The question of a sound record on color film seemed to have arrived at a final solution, because only a few of the proposed color film processes satisfied the constantly increasing requirements, and therefore the possibilities for sound recording became less numerous. Silver sound tracks were recommended for the more successful color film processes, as for example, in the case of Agfacolor film, where by means of a special protecting method, a black-and-white instead of a colored track was obtained, or in the Technicolor process, where black-and-white stock already containing the sound record served as a base on which color transfers were made. However, this technical development was interrupted, when, for reasons of simplicity and perhaps of cost, it was tried in the Agfacolor process to produce a colored sound track exactly in the same manner as the picture. The following discussions deal with the phenomena occurring in the reproduction of such colored sound tracks. In conclusion and for the evaluation of the results new types of photoelectric cells will also be discussed.

Even the first educational and advertising films prepared by the Agfacolor process showed that the correct reproduction of sound offered greater difficulties with a colored track than in the case of black-and-white. This phenomenon was not particularly studied at that time because this color process was only in the experimental stage. However, since regular features are now produced by this process, it seems worth while to study the problem more closely. Even when the first experiments were made, it was found that the volume control of the reproducer had to be adjusted to a higher setting if a colored track was played, and that the noise level of such a track was much increased. High in the case of fresh prints, it rapidly became unbearable, as the film wore out.

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\* Reprinted from *Kinotechnik*, 24 (Apr., 1942), pp. 43-46; translation by Werner Eichler, Research Laboratories, Eastman Kodak Company, Rochester, N. Y.

For a study of the question of whether these two phenomena are connected, and what is their cause, we have made some experiments which will now be reported. First, however, we shall briefly mention previous publications on the question of the reproduction of colored sound tracks.

The question of colored sound tracks has been discussed for a long time in connection with earlier 2-color films. These films used positive stock coated on both sides with emulsion layers that were toned in complementary colors, and the question arose on which side the sound track should be printed. Otis<sup>1</sup> found that this question cannot be answered in a general way, but that it was important to know the spectral sensitivity of the photoelectric cell used for reproduc-

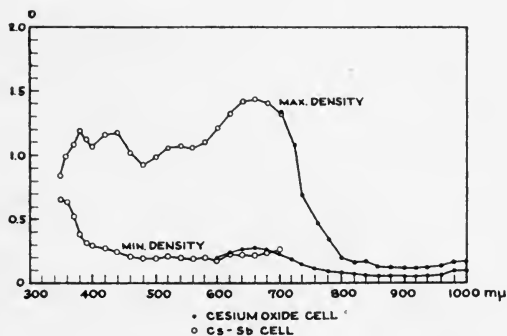


FIG. 1. Density of Agfacolor sound track as a function of wave length.

tion. He found, for example, that, if the sound track of the multi-color film is in the blue layer, the film is much better reproduced with a red-sensitive caesium cell than with a blue-sensitive potassium cell. The reason for this is that the light modulation of the blue-toned sound track runs between blue and white, and that blue light does not appear appreciably darker to a blue-sensitive cell than white light. To a red-sensitive cell, however, the blue parts of the track appear almost opaque.

Because of these considerations, it was proposed<sup>2</sup> that each of the several colored layers could contain a different sound record, perhaps in different languages or covering different frequency ranges, *etc.*, and anyone could be selected for reproduction by changing the photoelectric cell, or by using colored filters in connection with a cell sensitive to all colors. As interesting as this proposition was, it failed

because the absorption regions of the available dyes overlapped. Later it was tried to place identical tracks in all layers and thus eliminate the defects characteristic of a single-layer sound track.<sup>3</sup> This consideration led to the suggestion of the black-and-white silver sound track, as described in the beginning.

The fact that a color-developed sound track cannot be avoided in certain processes suggested investigations of the expected noise level,<sup>4</sup> and also of the sound volume and distortion.<sup>5</sup> The results of these investigations do not show that these simplified colored sound tracks are necessarily unsatisfactory.

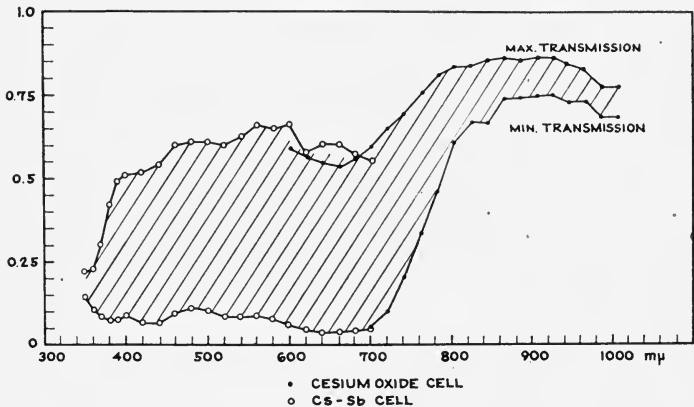


FIG. 2. Transmission of Agfacolor sound track and fog as a function of wave length.

The chemical structure of the sound track is immaterial, and the results are mainly determined by its absorption characteristics in the spectral regions in which the reproducer photoelectric cell is sensitive. The investigation of the question, why the sound volume is low and the noise level high, must start at this place. Fig. 1 shows spectrophotometric curves of Agfacolor sound track made at areas of maximum and minimum densities.

The abscissa [Fig. 1—translator] shows the wave length of the light and the ordinate the corresponding density. The measurement was carried out in 2 steps, first for the visible light and the long-wave ultraviolet, and then for the infrared and the connecting red part of the spectrum.

In order to show more clearly the phenomena in sound reproduc-



tion, Fig. 2 shows the same measurements converted from density to transmission. The distance between the 2 curves at any wave length represents the greatest possible sound modulation at that wave length for this type of track. Therefore, the region between the 2 curves is crosshatched in Fig. 2. If we start from the premise that the spectral sensitivity of the photoelectric cell must be adapted to the region of greatest possible modulation, we should use for this film a photoelectric cell which has a sensitivity only in the visible region, especially at about  $650 \text{ m}\mu$ . However, this is not the case in modern photoelectric cells. Their sensitivity maximum lies in the

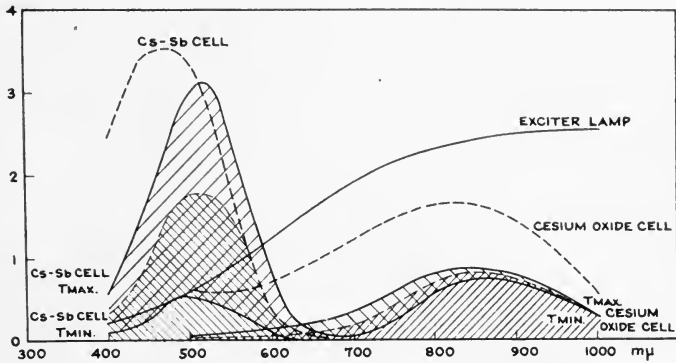


FIG. 3. Relationship between photocell current and wave length for Agfacolor sound track and 2 photocells of a different type. The spectral sensitivity curves of the 2 photocells as reduced to equal energy input and the spectral characteristic of the exciter lamp are also shown.

infrared, therefore, in a region in which the maximum density of the sound record is low, their transmission, therefore, is very great. In addition, the sound lamp radiates more strongly in the infrared than in the visible spectrum. If we multiply for each wave length the 3 factors influencing the magnitude at the photoelectric current, that is, film transmission, sensitivity of the cell, and sound lamp radiation, as is done in Fig. 3, we obtain the spectral distribution of the product for these cells as shown by the curves of Fig. 3 represented by the designation caesium oxide cell. The 2 cases of maximum and minimum density are shown. The area lying between such a curve and the abscissa corresponds to the total current flowing through the photoelectric cell. The area between the average of the 2 curves and the abscissa represents, therefore, the average photocell current,

the area between the 2 curves the photocell modulation. For the caesium oxide cell we cannot expect good results on account of the poor relation between the 2 areas.

If we substitute for the infrared-sensitive photoelectric cell, a cell which has its sensitivity maximum in the region of the blue light (Cs, Sb cell), entirely different curves are obtained. These curves are also recorded in Fig. 3, and the sound lamp radiation is considered as before. It is seen that for these cells a much more favorable relation exists between the photocell rest current and the modulation alternating current.

In order to extend these results to the practice, a sound strip was photometered with the same cells. The following values were obtained:

	Caesium Oxide Cell <i>Per Cent</i>	Cs, Sb Cell <i>Per Cent</i>
$T_{max.}$	88	60
$T_{min.}$	70	7
$\Delta_T$	18	53
$T_R$	79	33.5

These values clearly explain the low sound modulation with the use of the customary cells. Küster<sup>5</sup> compared in his work the color reversal film with a silver reversal film. He found a lower modulation for the color film which revealed scattered values even if photocells of one type were used so that, apparently, small differences in individual cells have a considerable effect. However, only caesium cells were studied.

On the question of background noise it has been found previously<sup>4</sup> that in the conversion of a silver image to a dye image a change of the background noise occurs. This may be calculated by determining the change in the transmission of the layer. However, this is merely noise from grain, or that part of the background noise which is based on the grain structure and which is heard only with entirely undamaged film. This is less important in practice because the so-called scratch noise, including all the noises due to dust particles, scratches, dirt spots, *etc.*, is normally stronger and increases considerably after the film has been used for some time. This scratch noise is proportional to the average transmission of the sound track, because all dust particles and other irregularities cause a much greater light impulse, if the film is more transparent. The last line of the table shows that for normal photocells the average transmission  $T_R$  of

the color sound track is very high and, consequently, when this cell is used a very strong background noise must be expected, which is even increased as the reproducer gain is raised on account of the low modulation.

Therefore, the two phenomena of low sound modulation and high ground noise are connected with each other, and both have their cause in the improper adaptation of the photocell to the absorption of the dyes composing the sound record. It is clear that the use of other photocells will give much better results. The right column of the table contains the values for a blue-sensitive photocell. It is seen that the modulation is much greater than that of the caesium cell and that the average transmission is decreased. Practice has shown that color-developed sound records can be reproduced well with these cells.

These explanations show why the external photoelectric effect was chosen for sound reproduction from the group of photoelectric phenomena. In addition to the advantage of the great internal resistance of these cells<sup>6</sup> they have the further advantage neglected for many years, that the spectral sensitivity of the cell can be changed according to the purpose and depending on the choice of the cathode material or the cathode layer. The caesium oxide cell generally fulfilled the requirements of sensitivity and spectral distribution for the reproduction of silver sound tracks. We disregard here the frequent desire to shift the spectral distribution of these cells beyond 1200  $m\mu$  toward the infrared in order to be able to use the red rays of the sound lamps better.

Research in the field of high-sensitive oxidized alkali cathodes, among which is the caesium oxide cathode, was promoted mostly by Asao, de Boer, Kluge, and Görlich and, referred to the caesium oxide cathode, gave approximately the following picture:<sup>7</sup> The caesium oxide layer coated on a silver support contains caesium atoms. Adsorbed caesium atoms are on the surface and decrease the energy necessary to liberate electrons so that the degree of coverage plays an important part. The photoelectric sensitivity may be increased by additional introduction of foreign metal atoms.

The requirement of the photocell with respect to colored sound track, namely, a spectral distribution in the blue and violet part of the visible spectral region, is fulfilled not only by potassium oxide cells, which were studied mainly by Kluge,<sup>8</sup> but also by potassium hydride cells, studied by Elster and Geitel.<sup>9</sup> With respect to the

total photoelectric sensitivity, however, even potassium oxide cells are not satisfactory.

It was, therefore, natural to adapt the caesium-antimony alloy cathode (Cs, Sb)<sup>10</sup> to meet the requirements of sound reproduction. This layer possesses high absolute sensitivity in addition to the desired spectral distribution (the long-wave maximum of sensitivity lies between 430 and 460  $\mu$ m). This is shown in Fig. 4. In this figure the product of  $V_\lambda S_\lambda$  is plotted against wave length  $\lambda$  for the caesium oxide layer and also for the Cs, Sb layer. The integral

$$J_{ph} = c \int V_\lambda S_\lambda d\lambda$$

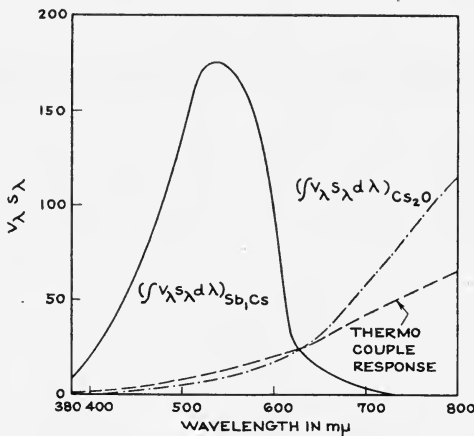


FIG. 4. Relative spectral response of caesium oxide and Cs-Sb photoelectric cells.

gives the photoelectric current expected from the spectral distribution  $V_\lambda$  and the energy distribution of the light source with known color temperature  $S_\lambda$ . Simultaneously, Fig. 4 gives the thermoelectric current which must be measured for the reduction of data to the same incident energy.<sup>11</sup> Practical workers will be interested to know that it has been possible to make gas-filled photoelectric cells with Cs, Sb layer in production which, when measured in the light of a normal sound lamp heated with 4.5 amp, have a sensitivity of 250  $\mu$  A/Lm, which is similar to that of gas-filled caesium oxide cells. This indicates that the Cs, Sb cell can be used for the reproduction of a colored sound track as well as for the silver track, and therefore, has a great advantage over caesium oxide cells. It is to be expected that

further investigations will show the way to make cells with still higher sensitivities.

The maximum of the spectral distribution may be shifted toward the red by about 100  $m\mu$  by sensitization with oxygen. Therefore, considerable specific adaptation to the spectral characteristics of any given film is possible. It will be of interest here to mention that even Schinzel's suggestion,<sup>2</sup> the use of a white-sensitive cell, can be carried out practically. By combination of a transparent Cs, Sb layer with a caesium oxide layer<sup>12</sup> in one cell, a photocell can be made which has a uniform sensitivity over the entire visible spectrum up to the near infrared. However, this cell may be expensive, because its preparation requires the use of 2 different sensitization methods.

In spite of a multitude of publications,<sup>7</sup> it is not yet clear in all details what causes the great quantum efficiency of the Cs, Sb layers (maximum quantum efficiency of 30 per cent in comparison with 1 per cent with caesium oxide cathodes). It seems that the electrons are liberated in a polyatomic layer of an alloy of Cs and Sb, whereby a fixed relation between both alloy components is necessary for the best results. In order to reduce the work function, a single-atomic Cs layer must be present on the surface of the alloy.

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- <sup>6</sup> Cf., e.g., GÖRLICH, P.: *Kinotechnik*, **17** (1935), p. 307.
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## BOOK REVIEW

**A Guide to the Literature of Photography and Related Subjects.** Compiled by Albert Boni, Quarterly Supplement No. 18 for the Photo-Lab-Index, by Henry M. Lester, *Morgan & Lester*, New York, 94 pp. 8 × 5½ in.

A compilation of titles of books on photography and articles in photographic publications.

Although the introduction to the book states "This guide makes no claim to being a complete index," the usefulness of any such compilation is greatly minimized if it is not reasonably complete.

Among the general references to subjects such as cinematography, the outstanding foreign language journals, such as *Kinotechnik* and *Journal of the British Kinematograph Society*, are omitted.

Like many authors of photographic books and articles, the author of this work has failed to give adequate references to the many articles on practical and theoretical photography contained in the *Transactions* and *JOURNAL of the Society of Motion Picture Engineers*.

In many cases reference is made to the SMPE Index, while in other cases reference is made to the particular SMPE article, but it would seem logical either to refer exclusively to the SMPE Index (for articles prior to December 1935), or to refer to the specific SMPE articles in all cases. A brief abstract is given of some of the references but this emphasis should not be taken as an index of the relative importance of the articles in question.

It would seem advisable in future editions to omit the abstracts and utilize the space for more complete references. The following subjects would appear to be worthy of mention: Aeration of Developers, Agitation, Chrome Alum Fixing and Stop Baths, Fog, High Temperature Development, Rapid Processing, Replenishment of Developers, Resistivity of Construction Materials, Single Solution Dye Toning, Stains, Water Supply.

J. I. CRABTREE  
July 17, 1944

## 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**

25 (June, 1944), No. 6

Cameras of the Past (p. 188)

Television Picture Definition (p. 191)

Monopack Processes (p. 192)

Pola Screen and Filter Holders (p. 194)

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Experiments by an Army Cameraman (p. 229)

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New Mercury Vapor Lamp Announced (p. 238)

I. BROWNING

L. H. BEDFORD

J. S. FRIEDMAN

F. DUPATY

K. M. GREENLAND

W. C. MILLER

CAPT. T. E. HUNT

P. TANNURA

J. HARTLINE

**Communications**

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T. T. GOLDSMITH

**Educational Screen**

23 (May, 1944), No. 5

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L. CHADBOURNE

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J. FRANK, JR.





## HOTEL RATES

The Hotel Pennsylvania management extends to SMPE members and guests the following per diem rates, European plan:

Room with bath, one person.....	\$3.85-\$7.70
Room with bath, two persons, double bed.....	5.50- 8.80
Room with bath, two persons, twin beds.....	6.60- 9.90
Parlor suites: living room, bedroom, and bath..	\$10.00, \$11.00, \$13.00 and \$18.00

## RESERVATIONS

The Hotel Pennsylvania room reservation cards will be mailed to the membership of the Society early in September. If attending the Fall Conference, return your card with checked accommodations *immediately* to the hotel so your reservation, which is subject to cancellation prior to October 15, can be booked and confirmed. *No accommodations will be guaranteed unless confirmed by the hotel management.*

## REGISTRATION

The Fall Conference registration headquarters will be located on the 18th floor of the hotel adjacent to the Salle Moderne where all technical and business sessions will be held. Members and guests are expected to register, the fee for which is used to defray Conference expenses.

## TECHNICAL SESSIONS

If you wish to participate in the Conference through presentation of a technical paper, it is essential that the title of the paper, name of author and abstract be mailed immediately to the Chairman or Vice-Chairman of the Papers Committee. Complete manuscripts must be received not later than October 1 for listing in the final program.

## FIFTY-SIXTH SEMI-ANNUAL DINNER-DANCE

The Fifty-Sixth Semi-Annual Informal Dinner-Dance, award presentations, and social get-together, will be held in the Georgian Room of the hotel on Tuesday evening, October 17 (dress optional). Because of labor and rationing problems, the Dinner-Dance Committee must know in advance the number of persons attending this function. Therefore, it is essential to procure tickets from or make reservations through D. E. Hyndman, Chairman of the Dinner-Dance Committee, or through the General Office of the Society, Hotel Pennsylvania, on and after September 18. Tickets are \$7.50 per person, taxes included. Check or money order should accompany requests for tickets and should be made payable to W. C. Kunzmann, Convention Vice-President. Only by receiving wholehearted cooperation can the Committee provide adequately for your evening's entertainment.

## LADIES' RECEPTION HEADQUARTERS

Although there will be no prearranged ladies' entertainment program during the Fall Conference, a reception parlor will be available in the hotel for the ladies' daily get-together and open house with Mrs. E. I. Sponable serving as

reception hostess. The ladies are invited to attend the Conference social functions. Ladies attending the Conference should register to receive badges and identification cards.

#### MOTION PICTURES

Conference identification cards issued to registered members and guests will be honored through the courtesy of the following *de luxe* motion picture theaters in New York:

CAPITOL THEATRE  
PARAMOUNT THEATRE  
RADIO CITY MUSIC HALL  
ROXY THEATRE  
WARNER'S HOLLYWOOD AND STRAND THEATRES

There are many entertainment attractions available in New York to out-of-town members and guests, and information concerning these may be obtained at the hotel information desk or at the SMPE registration headquarters.

### *Tentative Program*

#### *Monday, October 16, 1944*

- 9:00 a.m. *Hotel, 18th Floor:* Registration.
- 10:00 a.m. *Salle Moderne:* Morning Session.
- 12:30 p.m. *Luncheon period.*
- 2:00 p.m. *Salle Moderne:* Afternoon Session.
- 8:00 p.m. The program for the evening of this date will be announced later.

#### *Tuesday, October 17, 1944*

- 9:00 a.m. *Hotel, 18th Floor:* Registration.
- 10:00 a.m. *Salle Moderne:* Morning Session.
- 12:30 p.m. *Luncheon period.*
- 2:00 p.m. *Salle Moderne:* Afternoon Session.
- 8:00 p.m. *Georgian Room:* Dinner-Dance and social get-together. The evening's program will be announced later.

#### *Wednesday, October 18, 1944*

- 9:30 a.m. *Hotel, 18th Floor:* Registration.
- 10:00 a.m. *Salle Moderne:* Morning Session.
- 12:30 p.m. *Luncheon period.*
- 2:00 p.m. *Salle Moderne:* Afternoon Session and Adjournment.

#### IMPORTANT

*When you receive your hotel room reservation card, please return it immediately if attending the Fall Conference. No rooms will be available or guaranteed unless booked in advance of the Conference dates. Also, procure tickets for the Dinner-Dance before October 14 to insure accommodations.*

. W. C. KUNZMANN  
Convention Vice-President

## SOCIETY ANNOUNCEMENTS

### AMENDMENTS OF BY-LAWS

At a meeting of the Board of Governors held in New York on April 16, 1944, it was unanimously voted to submit the following proposed amendments of By-Laws I and III to the membership of the Society for voting at the Fifty-Sixth Semi-Annual Technical Conference in New York, October 16-18, inclusive:

#### *Proposed Amendment of By-Law I, Sec. 3 (c) and (d)*

"Sec. 3 (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.

"Sec. 3 (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."

#### *Proposed Amendment of By-Law III, 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."

At a meeting of the Board of Governors held July 18, 1944, it was resolved to submit proposed amendments of By-Laws V and VI to the membership of the Society for voting at the Technical Conference in October, as follows:

#### *Proposed Amendment to By-Law V, 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."

#### *Proposed Amendment to By-Law VI, Sec. 3 (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."

## COMMITTEES OF THE SOCIETY

(Correct to August 15)

The Board of Governors voted recently to publish in the JOURNAL regularly the personnel and scope of all standing committees of the Society. It is believed these data will be of value not only to committee chairmen and members in having an up-to-date list of committee membership, but will be of interest to others who may be unfamiliar with the general nature of activities engaged in by the various technical and nontechnical committees of the Society.

« »

**ADMISSIONS.**—To pass upon all applications for membership, applications for transfer and to review the Student and Associate membership list periodically for possible transfers to the Associate and Active grades respectively. The duties of each committee are limited to applications and transfers originating in the geographic area covered.

(East Coast)

M. R. BOYER	A. S. DICKINSON, <i>Chairman</i>	D. E. HYNDMAN
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	GEORGE FRIEDL, JR.	

(West Coast)

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H. W. MOYSE		H. W. REMERSHIED

**BOARD OF EDITORS.**—To pass upon the suitability of all material submitted for publication, or for presentation at conventions, and publish the JOURNAL.

J. I. CRABTREE	A. C. DOWNES, <i>Chairman</i>	C. R. KEITH
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	C. W. HANDLEY	
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**CINEMATOGRAPHY.**—To survey the field of motion picture photography in an endeavor to bring before the Society any information on current or future practice, and also to continually review this field for possibilities of standardization of any specific procedure.

C. G. CLARKE	J. W. BOYLE, <i>Chairman</i>	ARTHUR REEVES
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**COLOR.**—To survey the field of color in motion picture photography in an endeavor to bring before the Society any information on current or future practice, and also to continually review this field for possibilities of standardization of any specific procedure.

F. T. BOWDITCH	R. M. EVANS, <i>Chairman</i>	A. M. GUNDELFINGER
L. E. CLARK		A. C. HARDY

\* Advisory Member.

**CONVENTION.**—To assist the Convention Vice-President in the responsibilities pertaining to arrangements and details of the Society's technical conventions.

	<i>W. C. KUNZMANN, Chairman</i>		
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*JULIUS HABER	H. F. HEIDEGGER		R. O. STROCK

**EXCHANGE PRACTICE.**—To survey the field of exchange practice in an endeavor to bring before the Society any information on current or future practice, and also to continually review this field for possibilities of standardization of any specific procedure.

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	H. C. KAUFMAN	

**FELLOW MEMBERSHIP.**—To consider qualifications of Active members as candidates for elevation to Fellow members, and to submit such nominations to the Board of Governors.

	<i>EMERY HUSE, Chairman</i>		
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A. C. DOWNES	C. W. HANDLEY		E. A. WILLIFORD
	D. E. HYNDMAN		

**HISTORICAL AND MUSEUM.**—To collect facts and assemble data relating to the historical development of the motion picture industry, to encourage pioneers to place their work on record in the form of papers for publication in the *JOURNAL*, and to place in suitable depositories equipment pertaining to the industry.

	<i>J. E. ABBOTT, Chairman</i>		
O. B. DEPUE	RICHARD GRIFFITH		TERRY RAMSAYE

**HONORARY MEMBERSHIP.**—To diligently search for candidates who through their basic inventions or outstanding accomplishments have contributed to the advancement of the motion picture industry and are thus worthy of becoming Honorary members of the Society.

	<i>E. A. WILLIFORD, Chairman</i>		
J. I. CRABTREE		EMERY HUSE	
A. N. GOLDSMITH		L. L. RYDER	

**JOURNAL AWARD.**—To recommend to the Board of Governors the author or authors of the most outstanding paper originally published in the *JOURNAL* during the preceding calendar year to receive the Society's Journal Award.

	<i>SYLVAN HARRIS, Chairman</i>		
F. G. ALBIN		C. R. KEITH	
J. G. FRAYNE		J. A. MAURER	

**LABORATORY PRACTICE.**—To survey the field of motion picture laboratory practice in an endeavor to bring before the Society any information on current or future practice, and also to continually review this field for possibilities of standardization of any specific procedure.

	<i>H. E. WHITE, Chairman</i>		
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\* Advisory Member.

**MEMBERSHIP AND SUBSCRIPTION.**—To solicit new members, obtain nonmember subscriptions for the JOURNAL, and to arouse general interest in the activities of the Society and its publications.

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J. G. FRAYNE	G. E. MATTHEWS	W. V. WOLFE
	G. C. MISENER	

**NONTHEATRICAL EQUIPMENT.**—To survey the field of nontheatrical motion picture equipment in an endeavor to bring before the Society any information on current or future practice, and also to continually review this field for possibilities of standardization of any specific procedure.

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J. A. HAMMOND		A. G. ZIMMERMAN

**PAPERS.**—To solicit papers, and provide the program for semi-annual conventions, and make available to local sections for their meetings papers presented at national conventions.

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J. L. FORREST	G. E. MATTHEWS	W. V. WOLFE
	P. A. MCGUIRE	

**PRESERVATION OF FILM.**—To survey the field for methods of storing and preserving motion picture film in an endeavor to bring before the Society any information on current or future practice, and also to continually review this field for possibilities of standardization of any specific procedure.

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**PROCESS PHOTOGRAPHY.**—To survey the field of process photography in an endeavor to bring before the Society any information on current or future practice, and also to continually review this field for possibilities of standardization of any specific procedure.

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\* Advisory Member.

**PROGRESS.**—To prepare an annual report on progress in the motion picture industry.

	<b>G. A. CHAMBERS, <i>Chairman</i></b>	
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**PROGRESS MEDAL AWARD.**—To recommend to the Board of Governors a candidate who by his inventions, research or development has contributed in a significant manner to the advancement of motion picture technology, and is deemed worthy of receiving the Progress Medal Award of the Society.

	<b>J. I. CRABTREE, <i>Chairman</i></b>	
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**PUBLICITY.**—To assist the Convention Vice-President in the release of publicity material concerning the Society's semi-annual technical conventions.

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**SOUND.**—To survey the field of motion picture sound recording and reproducing in an endeavor to bring before the Society any information on current or future practice, and also to continually review this field for possibilities of standardization of any specific procedure.

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**STANDARDS.**—To survey the various fields or branches of the motion picture industry in an endeavor to bring before the Society any information on current or future practice or methods that would lead to possibilities of standardization of any specific procedure.

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**STUDIO LIGHTING.**—To survey the field of motion picture studio lighting in an endeavor to bring before the Society any information on current or future practice, and also to continually review this field for possibilities of standardization of any specific procedure.

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\* Advisory Member.



**TECHNICAL NEWS.**—To survey the fields of production, distribution, and exhibition of motion pictures, and allied industries, to obtain technical news items for publication in the JOURNAL.

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J. I. CRABTREE	C. W. HANDLEY	H. W. REMERSHIED
	EMERY HUSE	WILLIAM THOMAS
	H. R. LUBCKE	

**TELEVISION.**—Technical consideration of the uses of motion picture television service; technical consideration of the phases of television which effect origination, transmission, distribution, and reproduction of theater television.

	P. C. GOLDMARK, <i>Chairman</i>	
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R. L. CAMPBELL	L. B. ISAAC	*PAUL RAIBOURN
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**TEST FILM QUALITY.**—To supervise the quality of prints of test films prepared by the Society.

F. R. WILSON	C. F. HORSTMAN
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**THEATER ENGINEERING.**—The Committee on Theater Engineering comprises the membership of the four subcommittees listed below and is under the general chairmanship of DR. ALFRED N. GOLDSMITH.

**Subcommittee on Film Projection Practice.**—To make recommendations and prepare specifications for the operation, maintenance, and servicing of motion picture projection equipment, projection rooms, film storage facilities, and stage arrangements as they effect screen dimensions, placement, and the maintenance of loudspeakers.

	L. B. ISAAC, <i>Chairman</i>	
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A. S. DICKINSON	C. F. HORSTMAN	A. T. WILLIAMS
	I. JACOBSEN	

**Subcommittee on Television Projection Practice.**—To make recommendations and prepare specifications for the construction, installation, maintenance, and servicing of equipment for projecting television pictures in the theater, as well as the projection room arrangements necessary for such equipment, and such picture-dimensional and screen-characteristic matters as may be involved in theater television presentation.

L. B. ISAAC, <i>Chairman</i>
M. D. O'BRIEN, <i>Secretary</i>

(Under organization)

\* Advisory Member.

**Subcommittee on Screen Brightness.**—To make recommendations, prepare specifications and test methods for determining and standardizing the brightness of the motion picture screen image at various parts of the screen, and for specific means or devices in the projection room adapted to the control or improvement of screen brightness.

	F. E. CARLSON, <i>Chairman</i>	
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E. R. GEIB	W. B. RAYTON	H. E. WHITE
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**Subcommittee on Theater Engineering, Construction, and Operation.**—To deal with the technical methods and equipment of motion picture theaters in relation to their contribution for the physical comfort and safety of patrons so far as can be enhanced by correct theater design, construction, and operation of equipment.

(Under organization)

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# JOURNAL OF THE SOCIETY OF MOTION PICTURE ENGINEERS

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*(The Society is not responsible for statements of authors.)*

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*Industrial Arts Index* available in public libraries.

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# JOURNAL OF THE SOCIETY OF MOTION PICTURE ENGINEERS

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\*\*Term expires December 31, 1945.

†Chairman, Pacific Coast Section.

‡Chairman, Atlantic Coast Section.

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## THE PHYSICAL PROPERTIES AND DIMENSIONAL BEHAVIOR OF MOTION PICTURE FILM\*

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*Summary.*—A general discussion is given of the physical properties of both nitrate and safety motion picture film and how these properties are influenced by heat, moisture and other factors. Some of the improvements made in safety base in recent years are described together with some of its present weaknesses.

The manufacture of film base is mentioned briefly and the influence of structure on physical properties is pointed out. The effects of moisture on film are discussed including the relation between equilibrium moisture content and relative humidity, the rate of swell in water, the rate of drying, and the rate of conditioning. The physical changes which occur in the processing and drying of film by continuous machine are described.

The mechanical properties of film, such as tensile strength, elongation, modulus of elasticity, cold flow, folding endurance, and tearing resistance, are discussed and comparisons made between various films. The effect of relative humidity and temperature on the brittleness of film is described, with particular reference to low relative humidities and subzero temperatures. Tackiness is mentioned briefly.

Temporary and permanent film shrinkage of various types is explained, and the factors which affect shrinkage throughout the life of the film are discussed. The shrinkage characteristics of a number of Eastman motion picture films are tabulated. The cause of curl is explained, as well as the changes in curl, which occur during processing and storage. Recommendations are made throughout on the handling and storage of film to obtain the best performance.

The proper performance of motion picture cameras, printers, processing machines, and projectors and, therefore, the screen quality, depends to a very large degree on the physical properties of the photographic film. The useful life of the film itself is determined to a considerable extent by its physical characteristics. A large increase in the use of safety film for Army and Navy training purposes during the war has led to many new problems, due in part to the differences between nitrate and safety base and in part to the severe

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use to which such training films are put. The purpose of this paper is to describe a few of the fundamental physical characteristics of motion picture films which, it is hoped, will give a clearer understanding of both nitrate and safety materials. A discussion of how the physical properties of the film affect several specific practical problems is given by R. H. Talbot.<sup>1</sup>

#### THE MANUFACTURE OF PHOTOGRAPHIC FILM

Present-day motion picture films consist essentially of a light-sensitive gelatin layer coated on a flexible cellulose nitrate or acetate base.\* In common with various other plastic materials, photo-

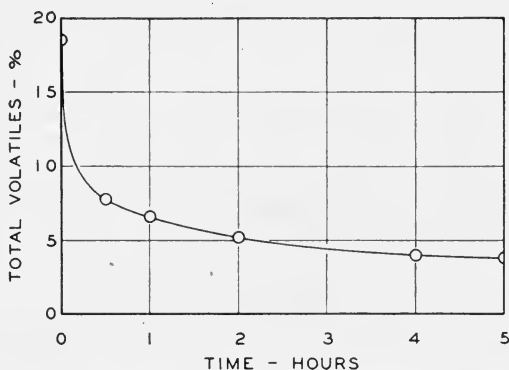


FIG. 1. The rate of curing of a green cellulose acetate film base at 200 F.

graphic films display many physical characteristics which differ considerably from those of flexible metal films. Therefore, a brief description of the manufacture of photographic film base at this point should assist in the discussion to follow.

In the manufacture of both nitrate and safety film base, a viscous honey-like solution or dope of the cellulose derivative in suitable organic solvents, generally containing plasticizers, is first cast upon a smooth metal wheel or roll. Enough solvent evaporates as the wheel revolves so that before one complete revolution, the film skin

\* Safety film base made by the Eastman Kodak Company may be either cellulose acetate or a mixed cellulose ester such as cellulose acetate propionate or cellulose acetate butyrate. Throughout this paper "cellulose acetate" is used as a general term to include these mixed esters as well as cellulose acetate itself.

has sufficient strength to be stripped from the metal surface. It is then passed through a complex series of heated chambers to drive out the remaining solvent.

Unfortunately, in practice it is not possible to remove every trace of solvent from the film base. Fig. 1 illustrates the shape of a typical curing curve for green film base and shows that the rate of solvent removal decreases rapidly as curing proceeds. The last traces of solvent are held very tenaciously by the base. In commercial production it is obviously impossible to increase the curing time beyond a certain limit. Therefore, in spite of the improvements made in recent years, there is always some residual solvent in the film base which, with small amounts of plasticizer, gradually diffuses out of the film throughout its life, resulting in a certain amount of shrinkage and related troubles.

A word concerning the structure of film base may be helpful at this point. Cellulose nitrate and acetate molecules are generally considered to be long chains which may or may not be grouped together in clusters or bundles called micelles.<sup>2</sup> The exact dimensions of the molecules or micelles probably vary even within the same sample, but it is their approximate shape which is of interest here. McNally and Sheppard,<sup>3</sup> following a study of the optical properties of cellulose nitrate and acetate films, concluded that whatever the nature of the particles involved "—it appears that they must be unsymmetrical in shape, rod- or lath-like, having one axis considerably longer than the others." All of the available evidence obtained from studies of the physical properties and dimensional behavior of film base confirms this view.

Since the film base is pulled rather than pushed through the curing chambers, it is unavoidably stretched and strained to some extent in the machine direction (lengthwise). If the base is sufficiently warm and soft when stretched, the molecules (or micelles) tend to become partially oriented in the direction of stretch. This produces a slight "grain" in the film base which affects the strength, tear resistance, shrinkage, and other physical properties of the film which will be described later. If the base is not sufficiently warm and soft when stretched, the deformation produces a mechanical strain in the film.<sup>4</sup> When the base is cooled rapidly, the deformation remains—a phenomenon referred to as the "freezing-in of strain."<sup>5</sup> This deformation or strain may be released sometime during the life of the film with a consequent lengthwise shrinkage.

## MOISTURE RELATIONSHIPS IN PHOTOGRAPHIC FILMS

One of the most important physical characteristics of a photographic film is its susceptibility to moisture. A film which is too moist is weaker, is more easily stretched and distorted, and may be tacky. A film which is too dry may be brittle and more easily cracked or torn. Moisture has a pronounced effect on shrinkage, curl, and virtually every physical property of a photographic film. Therefore, it is important that the influence of moisture on film be clearly understood.

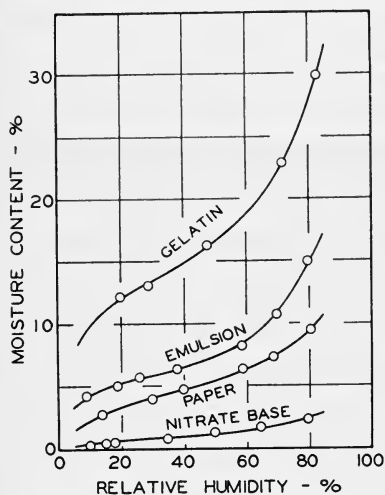


FIG. 2. The equilibrium moisture content of gelatin, stripped positive emulsion, paper and nitrate film base at various relative humidities at 70 F.

We frequently find that the amateur photographer, and sometimes even the professional, believes that a photographic film is either wet or dry and that there is no intermediate state. As long as the emulsion does not actually stick to the fingers, the film is often considered dry and this is responsible for some of the difficulties with green film. In actual fact, cellulose nitrate and acetate, as well as gelatin, in common with many other materials, exchange moisture vapor with their environment at every opportunity. Film in contact with dry air or wrapped in dry paper loses moisture; film

in contact with damp air gains moisture.

The physical chemical mechanism involved in this interchange of moisture is rather complex and need not be discussed here. It is only necessary to say that from a practical point of view, the moisture content of film is determined almost solely by the relative humidity of the air with which it is in equilibrium. Theoretically, the equilibrium relative humidity is the relative humidity of an atmosphere in which the material in question may be exposed for an infinite period of time without any change in moisture content. A knowledge of the rate of attainment of moisture equilibrium in a photographic film is of practical importance in many ways.

It is worth while to emphasize that the most important controlling



factor in determining the moisture content of photographic film as well as paper, gelatin, and related materials, is the *relative* humidity of the air and not the *absolute* humidity. This means that at 50 F and 60 per cent RH, for example, film will hold more moisture than at 80 F and 40 per cent RH even though the actual moisture content of the air (absolute humidity) is approximately 32 grains per lb of dry air in the first case, and 62 grains in the second case. However, the moisture content of cellulosic materials is not entirely independent of the dry bulb temperature at constant relative humidity. Various investigations have shown that cotton,<sup>6</sup>

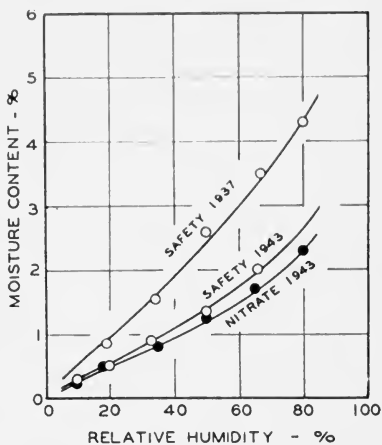


FIG. 3. The equilibrium moisture content of Eastman Safety and Nitrate Motion Picture Positive film base at various relative humidities at 70 F.

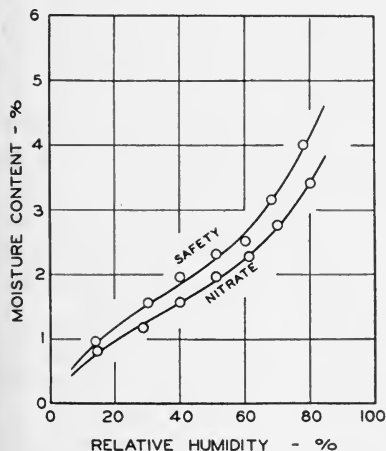


FIG. 4. The equilibrium moisture content of Eastman Safety and Nitrate Motion Picture Positive emulsion coated film (1943) at various relative humidities at 70 F.

paper,<sup>7</sup> and cellulose acetate film<sup>8</sup> hold slightly more moisture at lower temperatures when the relative humidity is constant. Nevertheless, in practice, the effect of a change in the dry bulb temperature at constant relative humidity on the equilibrium moisture content of photographic film is negligible, compared with the effect of a change in relative humidity at constant temperature.

**The Equilibrium Moisture Content of Film.**—Fig. 2 illustrates the relation between equilibrium moisture content and relative humidity for several common photographic materials—gelatin, positive emulsion, paper, and nitrate film base. The difference in the mois-

ture content of these materials at any given relative humidity is due to the differences in their chemical constitution and physical structure. It will be observed that the cellulose nitrate film base contains much less moisture than paper which is a form of natural cellulose. Positive emulsion, on the other hand, holds somewhat more moisture than paper at any given relative humidity, while gelatin generally contains a still higher concentration. It should also be noted that all the curves are similar in shape, and each has 3 distinct parts. Below 20 per cent RH and above 70 per cent RH, the curves are relatively steep and small changes in relative

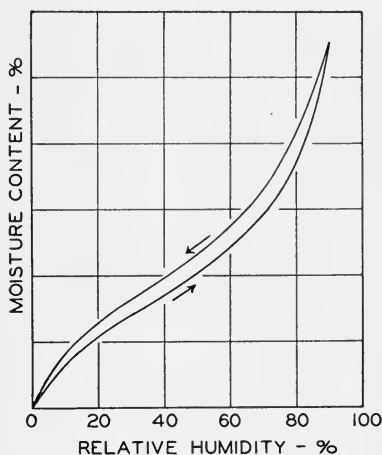


FIG. 5. Typical moisture hysteresis curves for cellulosic materials and gelatin.

plotted on a larger scale, are shown in Fig. 3. One of the problems in the development of a suitable safety base is to reduce its moisture susceptibility to a level comparable with that of nitrate base. It may be noted here that safety motion picture film base which contains very little more moisture than nitrate film base can now be made. This is a marked improvement over the safety motion picture film base made by the Eastman Kodak Company in 1937. In Fig. 4 is shown the equilibrium moisture content of nitrate and safety motion picture positive emulsion coated film at various relative humidities.

A comparison between the moisture content of Eastman Fine-Grain and Regular Motion Picture Positive emulsion, and between nitrate

humidity result in large changes in moisture content. Between 20 per cent and 70 per cent RH the curves are almost straight and the change in moisture content for a given change in relative humidity is less. As mentioned above, this relationship between equilibrium moisture content and relative humidity may be considered to be independent of the dry bulb temperature for all practical purposes.

Equilibrium moisture content versus relative humidity curves for both nitrate and safety motion picture positive film base,

and safety base, both at 50 per cent RH and after soaking in water, is given in Table 1. The ratio of the *concentration* of moisture in the emulsion to that in the base is much larger than the ratio of the *quantity* of moisture in the emulsion to that in the base. This, of course, is due to the approximately ten-fold greater thickness of the base and the difference in density. It may be seen that there is little difference in the moisture content of the regular and fine-grain emulsions at 50 per cent RH, but after soaking in water the regular emulsion absorbs more moisture than the fine-grain emulsion. The safety base has a higher concentration of moisture than the nitrate base at 50 per cent RH, although the quantity of moisture per unit area is about the same because of the difference in density of the 2

TABLE 1

*The Approximate Moisture Content of Eastman Motion Picture Positive Emulsion and Film Base*

Material	Equilibrium Moisture Content at 50 per cent RH at 70 F		Moisture Content After Soaking in Water at 70 F (approximate equilibrium)	
	Concentration of Moisture, per cent	Quantity of Moisture, gm per ft <sup>2</sup>	Concentration of Moisture, per cent	Quantity of Moisture, gm per ft <sup>2</sup>
Regular Emulsion (Stripped) (Type 1301)	8.0	0.16	290.0	5.8
Fine-Grain Emulsion (Stripped) (Type 1302)	9.0	0.18	180.0	3.6
Nitrate Base 1943	1.25	0.25	2.7	0.55
Safety Base 1943	1.40	0.25	6.0	1.00

types of base. After soaking in water the difference between the safety and nitrate base is much more marked. The last column of Table 1 is of particular interest in the drying of the developed film since the figures indicate the relative amounts of moisture which must be removed from the particular type of emulsion or base in question.

Brief mention should be made here of a phenomenon known as moisture hysteresis which has been found to exist in many materials such as paper,<sup>7</sup> gelatin,<sup>9</sup> and cellulose derivatives.<sup>10</sup> The curves, in Figs. 2, 3, and 4 are moisture adsorption curves, that is, curves obtained by allowing very dry materials to gain moisture. However, if a moist material is dried, a desorption curve is obtained similar to that shown in Fig. 5. Hysteresis is essentially a lag in the attainment of equilibrium, so that a higher moisture content is found if a

given relative humidity is approached from above rather than from below.

**The Rate of Swell of Film in Water.**—When a photographic film is immersed in water, both the base and emulsion absorb moisture

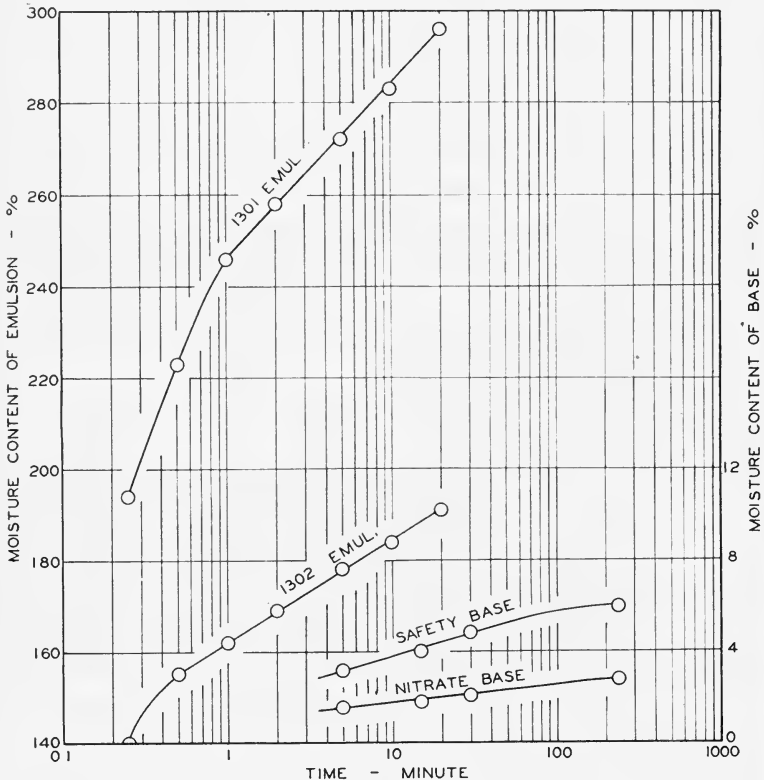


FIG. 6. The rate of moisture absorption of Eastman Motion Picture Positive emulsion (1301, Regular; 1302, Fine-Grain emulsion stripped from the base), and film base in water at 70 F, starting from equilibrium at 50 per cent RH for the emulsion and oven-dry for the base.

and begin to swell. The base swells in all 3 dimensions, but the emulsion swells principally in a direction at right angles to the plane of the film. This is due to the fact that the emulsion is firmly attached to the base and, therefore, its swelling is largely restricted to the vertical direction.

Fig. 6 shows that emulsions not only absorb more moisture than

film base when immersed in water but do so more rapidly. In 5 min, for example, the emulsion absorbs 2 to 3 times its weight of moisture, whereas the base absorbs only a few per cent of its weight of moisture. This means that if a film is immersed in water and then removed before the base is completely swollen, moisture may diffuse from the wet emulsion into the base causing the latter to

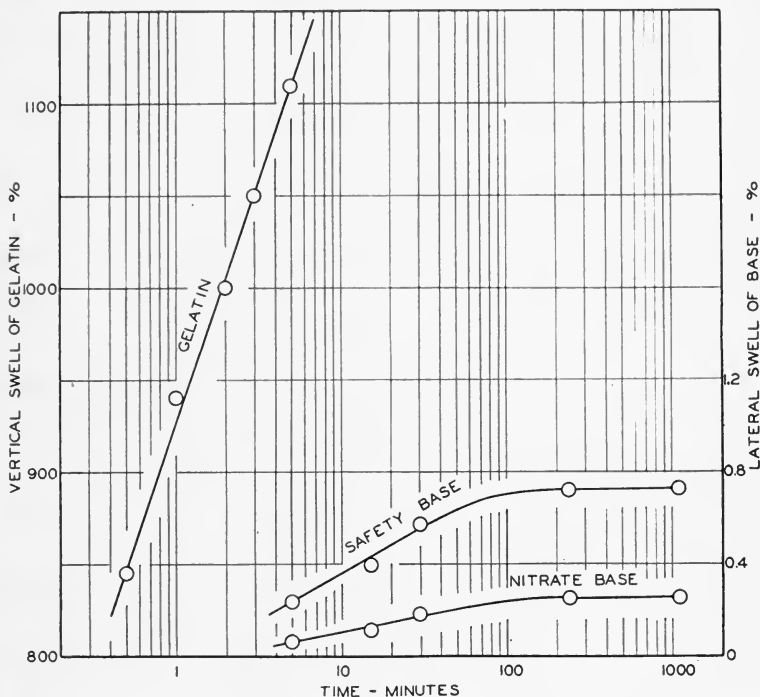


FIG. 7. The rate of swell of gelatin (attached to film support) and Eastman Motion Picture Positive film base in water at 70 F, starting from equilibrium at 50 per cent RH.

continue swelling. Fig. 6 also shows that Eastman Fine-Grain Positive emulsion (Type 1302) absorbs less moisture when immersed in water than the Regular emulsion (Type 1301), and that it does so more slowly. A comparison of safety and nitrate film base in turn shows that the safety base not only picks up more moisture than the nitrate base, but does so more rapidly.

Fig. 7 gives the rate of vertical swell of gelatin (coated on film support) and the rate of lateral swell of nitrate and safety film base

in water starting from 50 per cent RH. The change in dimension, in general, parallels the change in moisture content. The extremely rapid swelling of the gelatin compared to the film base is apparent. In 5 min the gelatin swells more than ten-fold in thickness, whereas the film base swells only a small fraction of 1 per cent in length. The safety base swells to a greater extent than the nitrate base and does so more rapidly, as would be expected from the difference in their rates of moisture absorption. It is conceivable that 2 different films might show the same degree of expansion when fully swollen in water, and yet have different swelling rates. This would be important in processing where the immersion time is relatively short, and the faster swelling film would reach a greater extension.

**The Rate of Drying of Film.**—The rate of drying of wet film after development is very important to the motion picture laboratory. When the film surface is wet, the rate of evaporation of moisture from the film is essentially the same as the rate of evaporation from a free water surface. In the absence of radiant heat, the rate of drying of film by air flowing parallel to the surface is constant as long as the film surface is wet. Under these conditions, the rate of drying may be expressed by the following equation, which is merely a modification of the standard evaporation formula<sup>11</sup>

$$T = k \frac{W}{(P_s - P_a)V^{0.8}} \quad (1)$$

where  $T$  = drying time, min

$W$  = weight of water in film, gms per ft<sup>2</sup>

$P_s$  = vapor pressure of water at the surface temperature (wet bulb),  
mm Hg

$P_a$  = vapor pressure of water in the air (dew point), mm Hg

$V$  = air velocity parallel to the surface, ft per sec

$k$  = a constant

This equation shows that the time to sensible dryness is reduced by:

(1) Decreasing the water content of the wet film by hardening or by the use of a squeegee.

(2) Increasing the difference between the wet bulb temperature and the dew point of the air.

(3) Increasing the air velocity.

This formula has been found to apply very well to the drying of film within the limitations specified. However, there are a number of practical considerations in the drying of developed film which limit the conditions which may be selected. For example, the dry

bulb temperature must not be too high while the film is still wet or the emulsion may be softened undesirably. Very rapid drying under extreme conditions may lead to various film troubles, which are discussed in a later section.

**The Rate of Conditioning of Film.**—The rate at which a film attains moisture equilibrium, or the rate of conditioning, is an entirely different problem from the rate of drying of a wet film. In Fig. 8 we have plotted the change in moisture content by weight (expressed as a per cent of the total change) for motion picture positive film initially in equilibrium with air at 78 per cent RH against the time exposed to an atmosphere at 21 per cent RH. It will be observed that the change in moisture content is very rapid at first, the rate of change decreasing as equilibrium is approached. This graph also shows the relative rates of conditioning of stripped emulsion and uncoated nitrate base which are particularly interesting. The stripped emulsion conditions much more rapidly than the base, reaching 90 per cent of equilibrium in a minute or two as compared with about 40 min for the base under the conditions of the experiment. This difference is due to the greater thickness of the base as well as to the differences in chemical constitution and physical structure between the 2 materials.

A number of extrinsic factors affect the rate of conditioning of film—the air velocity, the manner of air application, the temperature, the relative humidity difference, and so forth. Attempts have been made to develop an empirical formula which would relate these variables and enable one to compute the rate of conditioning of film under various circumstances. However, no simple way of doing this has yet been found so that it is necessary to determine by trial the optimum manner for conditioning film with a given piece of equipment.

**The Processing of Motion Picture Film.**—The application of some of the principles just described may be illustrated in the processing of motion picture film. In the continuous machine the film is generally immersed in the developer, fixing bath, and wash water for a total of 20 to 35 min, depending on the type of film and the processing conditions employed. By the time the film leaves the wash water, the emulsion is completely swollen, but the base only partly swollen. This is due to the difference in rates of swelling between the base and emulsion (*cf.* Figs. 6 and 7). Surface water is then removed from both sides of the film by a squeegee.

In the first stages of drying, moisture from the wet emulsion

diffuses into the base, which may even continue to swell slightly. This retards the drying of the base. The rate of drying of the emulsion is greater than that of the base, because moisture diffuses more easily from the interior to the surface in the case of the former. Therefore, in spite of the larger quantity of moisture originally present, the emulsion will generally dry sooner than the base. Once the emulsion is sensibly dry it will condition more rapidly than the base to the relative humidity of the drying air. Some of the diffi-

TABLE 2

*The Approximate Moisture Content of Various Eastman Nitrate Motion Picture Films in the Drying Cabinet of a Processing Machine*

Film	Type No.	Time to Sensible Dryness, min	Moisture Content After Squeegee		Moisture Content When Reeled	
			per cent	gm per ft	per cent	gm per ft
Background X Panchromatic Negative	1230	18.2	29.0	0.96	3.34	0.069
Plus X Panchromatic Negative	1231	20.9	33.0	1.00	3.44	0.070
Super XX Panchromatic Negative	1232	25.6	33.0	1.14	3.66	0.088
Fine-Grain Panchromatic Duplicating Negative	1203	9.5	16.8	0.45	2.58	0.058
Release Positive	1301	8.1	17.3	0.47	2.68	0.061
Fine-Grain Release Positive	1302	5.4	12.2	0.31	2.76	0.064
Fine-Grain Duplicating Positive	1365	5.4	11.0	0.27	2.34	0.057

Temperature of wash water, 68 F.

Squeegee nozzle pressure, 30 lb per in.<sup>2</sup>

Drying air, 70 F, 55 per cent RH.

culties which may be encountered if film is reeled while the emulsion is dry, but the base still moist, are discussed by Talbot.<sup>1</sup>

In Table 2 the time to sensible dryness is given for various Eastman nitrate motion picture films developed in a typical commercial processing machine. The regular negative type films require longer to dry than the positive films, because the negative emulsion is thicker and, therefore, holds more moisture ( $W$  in Eq (1) is larger). The moisture content of the film in per cent, and in grams per linear foot of 35-mm film, just after the squeegee, and at the point of reeling, is also given in Table 2. However, it should be remembered that



these data apply only to a particular case, and will vary with the type of film, the nature of the processing machine, and the drying conditions employed.

Motion picture film after processing should be neither overdried nor underdried. Film which is overdried may have too high a curl, and give a "spoky" roll when wound.<sup>12</sup> Film which is insufficiently dried may be tacky, which (in the case of release prints) aggravates the various troubles characteristic of green film.<sup>13</sup> Under certain conditions, moist film also has a greater tendency to go "in-and-out of focus" when projected.<sup>14</sup>

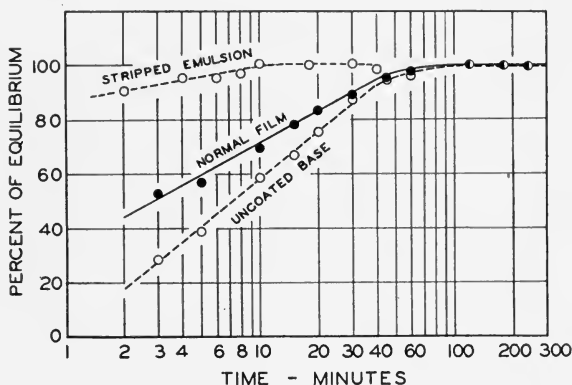


FIG. 8. The rate of conditioning of Eastman Nitrate Motion Picture Positive film from 78 per cent RH to 21 per cent RH at 70 F. Unknown low air velocity, probably under 1 ft per sec.

In the light of information available at the present time, it is generally recommended that motion picture film be dried in air having the relative humidity desired at equilibrium. It is preferable to dry negatives in air at about 60 per cent RH, because of the danger of producing static marks on the positive in printing if the negative is too dry. Positives, on the other hand, should be dried in air at about 40 per cent RH to minimize tackiness and reduce the tendency of the film to go "in-and-out of focus" when projected. *In either case, sufficient time should be allowed to bring the base as well as the emulsion to approximate equilibrium with the drying air.* In laboratories where it is impractical to have 2 different sets of drying conditions, a choice of about 50 per cent RH is probably the best

compromise. Where possible, the drying temperature should not be allowed to exceed 85 F.

#### THE MECHANICAL PROPERTIES OF FILM

The mechanical properties of motion picture film, such as tensile strength, elongation, folding endurance, tearing resistance, and brittleness are important because of the severe wear that the film

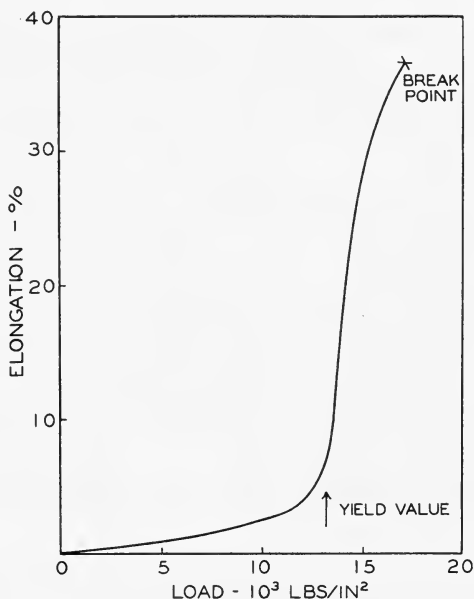


FIG. 9. Typical load-elongation diagram for cellulose derivative films.

must withstand, particularly in the case of release positives subjected to repeated projections. The elastic and plastic properties of the film, such as modulus of elasticity and cold flow, are equally important, not only from the point of view of wearing quality, but also as they affect the dimensional stability of the film and its susceptibility to curl and various other film distortions.

**Theoretical.**—It is necessary here to describe briefly the mechanical behavior of plastic materials, of which film base is typical. If any material under load (either tension or compression) undergoes a deformation which is independent of the rate of loading and dis-

appears rapidly and completely when the load is removed, the deformation is said to be *elastic*. When recovery after removal of the load is not complete, the nonrecoverable deformation is said to be *plastic*. In cases where the deformation is directly proportional to the load and is recoverable, the following relation (Hooke's Law) holds:

$$F = E \frac{\Delta L}{L} \quad (2)$$

where  $F$  = the load applied per unit area

$L$  = the length of the sample

$E$  = a constant (the modulus of elasticity)

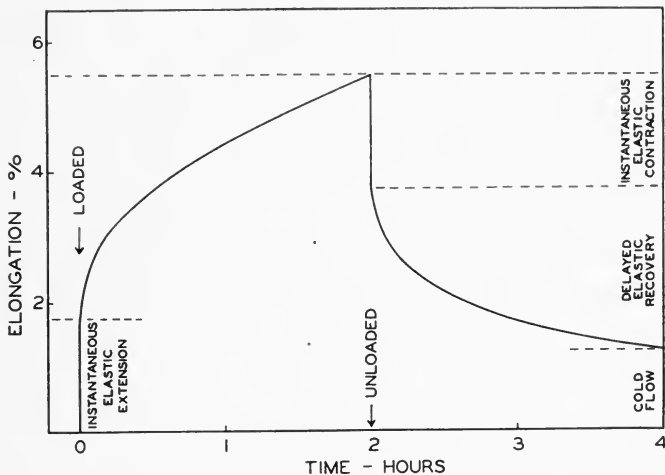


FIG 10. Typical flow (or creep) and recovery diagram for cellulose derivative films under constant tension.

The modulus of elasticity (or Young's Modulus for a material under tension) is the slope of the straight line portion of the load-elongation curve (Fig. 9) for small loads, and is important as a measure of the resistance the material offers to deformation under stress.

In the case of plastic materials such as cellulose nitrate and acetate film base, the load-elongation curve is a function of the rate of loading, since plastic as well as elastic deformations occur even at very small loads. The point at which the elongation increases rapidly for a small increase in load is called the *yield value* and is of considerable practical importance in motion picture film, since it is the point at which the material begins to give way.

If a small constant tension is applied to a strip of film and the elongation measured against time, a complicated series of phenomena occur as illustrated in Fig. 10. Following the first instantaneous elastic extension, elongation does not cease, but continues at a gradually decreasing rate. This is due to a combination of delayed elasticity and plastic deformation, and the material appears to flow or creep. If the load is removed at the end of a given time, there is first an instantaneous elastic contraction corresponding to the original instantaneous elastic extension. The film then continues to contract, a behavior called *creep recovery*. However, the film may not regain its original size or form, even in a very long time. The portion of the creep which is recoverable has been termed *delayed elasticity* or *primary creep*, and the portion which is not recoverable has been termed *plastic flow*, *secondary creep*, or more commonly, *cold flow*.<sup>\*</sup> A material which has undergone cold flow is said to have taken a permanent set.

Plastic behavior of the type described above is important in motion picture film, because of the permanent deformations or distortions which may result from the application of stress during storage, handling, processing, or projection. The magnitude of the cold flow which may occur in a given film increases with increase in the load applied, the time during which it acts, the temperature, and the moisture content of the film. If the temperature of a piece of film under tension is reduced before the load is removed, creep recovery is retarded or prevented. This phenomenon has already been referred to as the "freezing-in of strain." If the film is reheated at some later time after removal of the load, recovery of primary creep will occur and produce a shrinkage. For a more detailed description of the elastic and plastic behavior of materials of this type, the reader is referred elsewhere.<sup>2, 5, 15, 16</sup>

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\* There is some lack of uniformity in the literature concerning the terminology employed for the various types of deformation which plastic materials exhibit under load. Both the recoverable and nonrecoverable portions of creep are sometimes included in the term, *plastic flow*. This may be due to the fact that an analogy is sometimes drawn between recoverable creep and the behavior of a model consisting of both elastic and viscous elements connected in parallel.<sup>2, 15</sup> However, recoverable creep is more logically considered as an elastic deformation in the sense that it is eventually recovered, although it is a delayed, or imperfect elasticity. We prefer to reserve the terms *plastic flow* and *cold flow* for the nonrecoverable creep. Leaderman<sup>5</sup> overcomes this difficulty by the use of the terms *primary creep* (recoverable) and *secondary creep* (nonrecoverable).

**The Strength, Elongation, Modulus of Elasticity, and Cold Flow of Film.**—In Table 3 are recorded some of the mechanical properties of nitrate and safety motion picture positive film base compared with metals and rubber. The tensile strength and elongation measurements on the film base were made with a Schopper dynamometer operating at a speed of 100 mm per min. The values obtained are not absolute values, but depend somewhat on the rate of testing because of the tendency of the material to exhibit plastic flow. Young's modulus for the film base was determined by quickly measuring the elongation produced by the application of a small tension below the yield value. The cold flow or permanent set was determined by measuring the residual extension remaining after the load and recovery cycle specified.

The data show that both nitrate and safety film base lie between steel and rubber in tensile strength, elongation at break, and Young's modulus. The nitrate base has a higher tensile strength, lower elongation at break, higher Young's modulus, and lower cold flow than the safety base. The differences between the lengthwise and widthwise properties are due to the partly oriented structure of the film base produced by slight stretching during manufacture. The film is slightly stronger in the direction of orientation (lengthwise) and is more easily stretched widthwise. For this reason, Young's modulus is highest lengthwise and cold flow is highest widthwise.

The effect of relative humidity and temperature on the mechanical properties of motion picture film is very important in practice. Fig. 11 demonstrates that an increase in the moisture content of film reduces the tensile strength and increases the elongation at break. Fig. 12 shows that an increase in moisture content reduces Young's modulus and increases the degree of cold flow. These

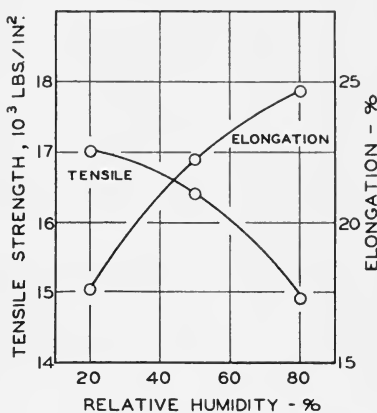


FIG. 11. The effect of relative humidity on the ultimate tensile strength and elongation at break of Eastman Nitrate Motion Picture Positive film in the lengthwise direction at 70 F.

effects are apparently due to a plasticizing action of the moisture between the molecules of the base, and demonstrate that a moist film is weaker and is more easily stretched or distorted than a dry film. This should be borne in mind in the handling of film in processing machines.

The effect of temperature at constant relative humidity on the mechanical properties of film is, in general, in the same direction as the effect of an increase in relative humidity at constant temperature. Heat, like moisture, makes the film base softer and more

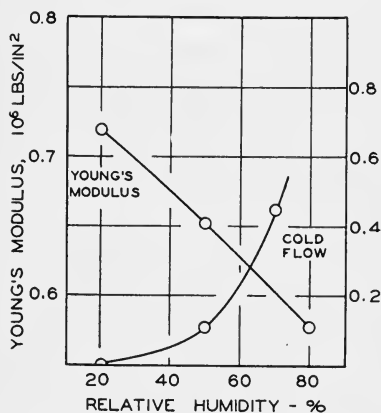


FIG. 12. The effect of relative humidity on the Young's modulus and cold flow of Eastman Nitrate Motion Picture Positive film in the lengthwise direction at 70 F. Load for cold flow test, 1900 lb per in.<sup>2</sup>; time loaded, 7 days; recovery time, 24 hr.

pliant. This reduces the tensile strength and modulus of elasticity, and increases the tendency to plastic flow. Therefore, film is particularly susceptible to various distortions at elevated temperatures. However, it should be remembered that an increase in temperature is generally accompanied by a decrease in relative humidity and vice versa, so that the effect of reduced moisture may partially compensate for the effect of heat.

#### The Folding Endurance and Tearing Resistance of Film.—

The folding endurance and tearing resistance of nitrate and safety motion picture film base are also recorded in Table 3. The folding endurance (number of folds) was determined with the Schopper fold testing machine, which folds the sample sharply back and forth until it breaks. The tearing resistance was measured with the Elmendorf tear tester. A tear is first started by hand, then a weighted disk revolves which continues the tear, and an indicator measures the tearing resistance. It may be seen that the nitrate film base has a higher folding endurance and a higher tearing resistance than the safety base. The tearing resistance of film base is lowest in the lengthwise direction owing to its partially oriented structure (that is, the film tears more easily along the "grain"). The increased

TABLE 3  
*Approximate Mechanical Properties of Eastman Motion Picture Positive Film Base Compared with Other Materials*  
 (All tests on film base made at 70 F, 50 per cent RH.)

Material	Machine Direction	Tensile Strength, 10 <sup>3</sup> lb per in. <sup>2</sup>	Elongation at Break, per cent	Young's Modulus, 10 <sup>6</sup> lb per in. <sup>2</sup>	Cold Flow,* per cent	Number of Folds	Tearing Resistance, Relative
Safety Base 1937	Length	11	35			7	50
	Width	11	40			7	54
Safety Base 1943	Length	12	45	0.45	0.55	16	58
	Width	10.5	60	0.38	0.65	14	67
Nitrate Base 1943	Length	17	30	0.65	0.40	20	64
	Width	15	40	0.55	0.50	19	71
Aluminum, pure metal		9	60	10			
Steel rod, cold drawn, 0.20 per cent C		80	18	30			
Rubber, raw		0.35	1200	0.0005			

\* Load = 3000 lb per in.<sup>2</sup>; time loaded, 7 days; recovery time, 24 hr.

folding endurance and tearing resistance of the film at high relative humidities are illustrated in Fig. 13. This is apparently due to the fact that the film base is softer and more limp when moist, and it tends to "give" rather than rupture.

The mechanical properties described in the above sections affect the performance of film on continued projection, and indicate some of the reasons for the supremacy of nitrate base in the motion picture field. Nevertheless, safety film has made rapid strides in recent years, and its physical properties now approach more closely to those

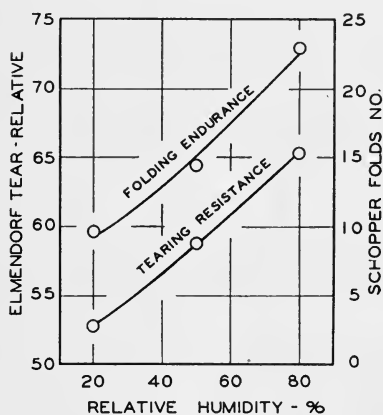


FIG. 13. The effect of relative humidity on the folding endurance and tearing-resistance of Eastman Nitrate Motion Picture Positive film in the lengthwise direction at 70 F.

of nitrate than was formerly the case. This is illustrated in Table 3 with the comparison between Eastman Safety Motion Picture film base manufactured in 1937 and that manufactured in 1943. The improvement in the safety base is particularly marked in the case of folding endurance. Mechanical tests of this nature give an indication of what may be expected from a given film in use, although they are not a direct measure of practical performance. These laboratory tests also help to give a clearer understanding of the behavior of the film, and are useful in manufacturing control to make sure that the highest possible quality is maintained.

**Brittleness.**—Brittleness is another important physical property of a photographic film. Difficulty from brittleness is generally encountered only at low relative humidities or at very low temperatures. When a piece of film is sharply flexed or bent, the surface on the inside of the bend is compressed, while that on the outside is stretched. Therefore, a crack generally starts on the outside of the bend. Emulsion coated film is more brittle than the base alone, partly because the emulsion itself is more brittle which increases the chance of a break starting. Film is more likely to break if bent with the emulsion side out than if bent with the emulsion side in because in the first case the emulsion is under tension, whereas in



the second case it is under compression. When the film is bent with the emulsion side out, the emulsion adhering tightly to the base tends to prevent the outer surface of the latter from stretching. Once the emulsion cracks the stress is localized and the base is much more likely to rupture.

If a film is bent slowly there is less chance of a break than if it is bent rapidly, because there is more time for elastic or plastic deformations to occur, which help to dissipate the stress. For this reason, film breaks due to brittleness under adverse conditions are more likely to occur in high-speed equipment. The design of motion

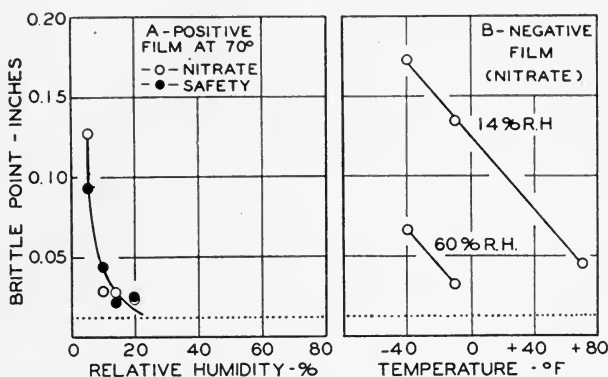


FIG. 14. The effect of relative humidity and temperature on the vise brittleness of undeveloped Eastman Motion Picture film in the lengthwise direction. (Dotted line indicates double film thickness corresponding to minimum brittle point.)

picture equipment should exclude sharp bends in the film travel, particularly with the emulsion side out, whenever possible.

The film brittleness test we have used consists of breaking a loop of film, emulsion side out, between the jaws of a vise closed at a uniform speed. The distance between the jaws of the vise at the instant the film cracks is a measure of the brittleness of the film. Fig. 14 illustrates the effect of relative humidity and temperature on the "vise brittleness" of nitrate and safety motion picture film. The measurements at 70 F were made in air-conditioned rooms. For the subzero temperatures, it was necessary to precondition the film samples to the desired relative humidity at 70 F, seal them in small individual metal containers, and then cool to the desired temperature. The tests were then made quickly (in less than a minute) in a cold room where the humidity was not controlled.

It may be seen in Fig. 14A that the brittleness of motion picture film at 70 F is virtually negligible above 20 per cent RH, but increases rapidly as the relative humidity is reduced below 20 per cent. There is very little difference in brittleness between the present Eastman nitrate and safety motion picture film although the safety film made a number of years ago was considerably more brittle than the nitrate.

Fig. 14B shows that the brittleness of motion picture film increases as the temperature is lowered. At about  $-25$  F and 60 per cent RH the film has the same degree of brittleness as at 70 F and 14 per cent RH. The effect of subzero temperatures on the brittleness of film is of interest where motion pictures must be taken in arctic regions or at high altitudes. Attention is drawn to the fact that relative humidity has an important bearing on the brittleness of film even at temperatures below the freezing point of water. Apparently the moisture in the film does not crystallize at these temperatures, but remains in an amorphous or supercooled liquid state, and continues to plasticize the emulsion and film base. This is probably the reason that more trouble from brittleness is not encountered in the arctic, where the outside relative humidity is generally high. Nevertheless, precautions should be taken to prevent film from drying out prior to use at low temperatures. Additional care should be given to the handling of film and the proper operation of equipment at either low relative humidities or low temperatures.

**Tackiness.**—Although tackiness is not a mechanical property of film it is discussed in this section for convenience. The tendency of film to stick to itself, or to metal parts of cameras or projectors, seldom occurs except at very high humidities, particularly when warm. Under these conditions the emulsion may become somewhat soft and spongy and in extreme cases plasticizer may diffuse out of the base and cause tackiness. The most difficulty from tackiness in practice occurs with green prints which have been insufficiently dried. The emulsion tends to stick in the projector gate, especially if the latter is warm. This builds up tension on the film and may cause a tear or break. Particles of emulsion may also pile up in the gate as a hard, horny deposit and cause trouble. Adequate drying after processing tends to reduce this difficulty, but in any case new prints should be waxed or lubricated in some way before the first projection.

## DIMENSIONAL CHANGES IN FILM

The dimensional changes which occur in motion picture film with changes in humidity, temperature, and age are important because they affect the distance between perforations (perforation pitch). Camera, printer, and projector sprockets are designed to accommodate film having a definite longitudinal and transverse perforation pitch and any marked change in the dimensions of the film causes more or less serious trouble. In the past only lengthwise shrinkage of motion picture film has been considered of importance, but of late certain photogrammetric applications have aroused interest in widthwise shrinkage which is not necessarily the same. Therefore, in the discussion that follows some attention will be given to differences between lengthwise and widthwise shrinkage.

In any discussion of film shrinkage it is important to distinguish between the different types of dimensional change which may occur. Dimensional changes in film are of 2 types—*temporary* or reversible, and *permanent* or irreversible. Temporary dimensional changes are caused by thermal expansion or contraction resulting from change in temperature, and humidity expansion or contraction resulting from change in moisture content. Permanent dimensional changes are due to a variety of causes. The magnitude of the dimensional changes which take place in a given film depends largely on the composition of the base, the treatment it received during manufacture, and the type and thickness of emulsion employed. Both temporary and permanent dimensional changes may occur simultaneously, and both may be complicated by hysteresis and related phenomena. The size of a piece of film at any instant is the resultant of all these effects.

The shrinkage measurements described in this paper were made in air-conditioned laboratories at accurately controlled temperature and relative humidity, using the pin-gage method described in the Bureau of Standards Research Paper No. 1051.<sup>17</sup> The humidity coefficient of linear expansion (sometimes called humidity amplitude) was determined by first measuring samples conditioned at 20 per cent RH at 70 F approached from above, and then remeasuring after conditioning at 70 per cent RH at 70 F approached from below. The change in length was then calculated for a 10 per cent relative humidity interval. This procedure does not exclude errors due to hysteresis which amount to approximately 0.005 per cent of the dimension for every 10 per cent change in relative humidity.

This means that the values reported in this paper for the humidity coefficient of linear expansion of film are too small by about 0.005 per cent of the dimension per 10 per cent RH. Permanent shrinkage was determined by making the initial and final measurements at the same conditions of relative humidity and temperature, generally 50 per cent RH at 70 F.

**Temporary Expansion and Contraction.**—Photographic film expands when heated and contracts when cooled at constant relative humidity. The thermal coefficient of linear expansion of most films is approximately  $5 \times 10^{-5}$  in. per in. per degree F (0.05 per cent per 10 F) at normal temperatures. However, in practice when the temperature increases the relative humidity generally drops, and since moisture has a greater effect than heat, the net result may be a contraction rather than an expansion.

The humidity expansion or contraction of film is much more important than purely thermal expansion from a practical point of view. When the film base takes up moisture it swells, and when it loses moisture it contracts. The magnitude of this effect is greater with emulsion coated film than with uncoated base because the emulsion has a greater tendency to contract than the base as the relative humidity is lowered (*cf.* Table 5). The base is compressed slightly by the emulsion under these conditions, thus increasing the contraction of the film at low relative humidities. The humidity expansion or contraction of film follows the change in moisture content, so that the dimensions at any given instant vary with the relative humidity of the atmosphere and the rate of conditioning of the film.

The magnitude of the humidity coefficient of linear expansion of common motion picture films varies from 0.04 per cent to 0.12 per cent of the dimension per 10 per cent change in relative humidity at 70 F. The change in dimension with change in equilibrium relative humidity is very nearly linear between 20 per cent and 70 per cent RH, but is somewhat greater below 20 per cent and above 70 per cent RH. As already mentioned, hysteresis plays a part in humidity dimensional changes, the film being slightly shorter if equilibrium at a given relative humidity is approached from below than if it is approached from above (*cf.* Fig. 5).

The thermal expansion and humidity expansion of photographic films manufactured in the manner we have described, are generally from 10 per cent to 40 per cent greater in the widthwise direction than in the lengthwise direction. This is caused by the partial orien-

tation of the cellulose nitrate or acetate molecules in the base in the machine direction. When the molecules are aligned it is evidently easier to increase the distance between them (by thermal agitation or by the introduction of moisture) in a direction perpendicular to the alignment. In practice this means that changes in temperature and humidity will have a slightly greater effect on transverse pitch than on longitudinal pitch.

**Permanent Dimensional Changes.**—Photographic film undergoes a gradual but continuous permanent shrinkage throughout its life, at a rate which depends on the type of film and the conditions under which it is used or stored. The permanent shrinkage of a photographic film is due principally to the following causes:

(1) *Loss of residual solvent or volatile material other than moisture.* Shrinkage due to this cause is increased by heat and moisture and reduced by preventing free access to the air. The effect of moisture is two-fold—it accelerates diffusion of solvents from the interior of the base and also renders the emulsion more permeable. (Dry gelatin is an effective barrier to many solvents.) Shrinkage resulting from the loss of volatile material from the base is greatest in the widthwise direction because of the orientation of the cellulose nitrate or acetate molecules.

(2) *Plastic flow of the base.* The compressive force of the emulsion upon the base results in a certain amount of plastic flow or permanent shrinkage. Dimensional changes of this type are increased by heat because the base is softer and more plastic at higher temperatures. Moisture also increases the plasticity of the base, but it reduces the contraction of the emulsion, and the latter has the greater effect. Consequently, an increase in relative humidity at constant temperature generally decreases this type of shrinkage. Plastic flow of the base may also be produced by stretching in handling or processing which, of course, will result in an extension rather than shrinkage. Dimensional changes of this type are increased by heat, moisture, the tension applied, and the time during which it acts. Shrinkage or stretch caused by plastic flow of the base is slightly greater in the widthwise direction (*cf.* Table 3).

(3) *Release of strain or recovery from deformation.* If film base is stretched during manufacture under conditions which do not permit reorientation of the cellulose nitrate or acetate molecules, deformation or creep occurs resulting in a lengthwise extension and a widthwise contraction. Rapid cooling retards recovery of the deformation (primary creep) due to "freezing-in of strain." This strain may be released at some time during the life of the film with a consequent lengthwise shrinkage and widthwise expansion. Where such a strain exists, the rate of recovery is increased by both heat and moisture.

It will be seen from the above that the shrinkage of photographic film is extremely complex. Several different processes are going on simultaneously, and each is affected in a different manner by heat, moisture, and other factors. It is not always easy to predict how a

given film will shrink when subjected to unknown conditions of storage and handling.

The largest portion of the permanent shrinkage of most motion picture films results from the first of the above causes, that is, loss of volatile material from the base. The exact magnitude of the dimensional changes produced by compression by the emulsion, and release of strain in the base are difficult to determine because they are generally masked by the larger effects of solvent loss. With some low-shrink films, the shrinkage of the base alone may be compared with the shrinkage of the emulsion coated film to obtain an estimate of the plastic compression in the latter. This is not possible with ordinary motion picture films because the emulsion influences the rate of solvent loss which masks the effect of plastic flow of the base. Compression by the emulsion and release of strain in the base are generally of secondary importance in the shrinkage of motion picture film, except in special cases where a high degree of dimensional stability is required, or where extremely severe storage conditions are encountered.

Although temporary dimensional changes in a motion picture film are always greatest in the widthwise direction, permanent shrinkage may be greatest in either the lengthwise or widthwise direction, depending on which of the 3 causes described above predominates. In cases where the release of strain is large, the permanent shrinkage is greatest in the lengthwise direction. However, since loss of volatile material predominates in most motion picture films, permanent shrinkage is generally greatest in the widthwise direction (*cf.* Table 4).

**The Shrinkage of Raw Stock.**—The shrinkage of motion picture film prior to exposure is generally small, where the film is kept in tight rolls in closed metal containers which retard the loss of both solvents and moisture. In the case of unexposed nitrate motion picture film in 1000-ft rolls in taped cans which have not been opened, the actual shrinkage (temporary and permanent) seldom reaches 0.1 per cent in 6 months at 70 F. However, where cardboard boxes were temporarily substituted for cans during the war a somewhat higher shrinkage was encountered. The necessity of using rubber substitutes in adhesive tape during the war has also resulted in slightly greater shrinkage.

Film in 16-mm  $\times$  100-ft rolls wound on cores shrinks more rapidly than the same film in 35-mm  $\times$  1000-ft rolls, because there is a

TABLE 4  
*Approximate Shrinkage Characteristics of Various Eastman Motion Picture Films*  
*(Tests made on 15-in. X 35-mm strips of film processed by tray.)*

No.	Type	Kind	Base	Date of Manufacture	Humidity Coefficient of Linear Expansion per 10 per cent RH, per cent		Processing Shrinkage, per cent		Accelerated Aging Shrinkage,* per cent	
					Length	Width	Length	Width	Length	Width
1	1231, 1232, ...	Negative	Nitrate	1943	0.055	0.070	0.10	0.15	0.40	0.55
2	5240, 5242, ...	Negative	Safety	1942	0.090	0.105	0.15	0.20	0.75	0.90
3	5240, 5242, ...	Negative	Safety	1944	0.090	0.100	0.08	0.10	0.35	0.40
4	5261, 5263, ...	Reversal	Safety	1942	0.090	0.105	0.17	0.20	0.80	0.95
5	5201, 5203, ...	Reversal	Safety	1944	0.080	0.095	0.10	0.12	0.45	0.55
6	1301, 1302, ...	Positive	Nitrate	1943	0.050	0.065	0.06	0.08	0.35	0.45
	1357, 1370, ...	Sound								
	1203	Dup. Neg.								
7	1301, 1302, ...	Positive	Nitrate	1944	0.040	0.055	0.05	0.06	0.25	0.35
8	5301, 5302, ...	Positive	Safety	1942	0.070	0.080	0.18	0.20	0.65	0.70
9	5301, 5302, ...	Positive	Safety	1944	0.070	0.080	0.08	0.08	0.25	0.30
	5203	Dup. Neg.								

\* Permanent shrinkage during processing and subsequent aging for 7 days at 120 F, 20 per cent RH.

smaller distance for the moisture and solvents to travel from the interior of the roll. For the same reason, 16-mm film wound on cores will shrink more rapidly than the same film wound on flanged metal spools. Some of the older Eastman 16-mm safety reversal films on 100-ft spools in taped cans shrink approximately 0.25 per cent in 6 months at 70 F, but the present safety reversal films shrink somewhat less under the same conditions. In cases where the storage conditions are more severe, a higher shrinkage will be encountered.

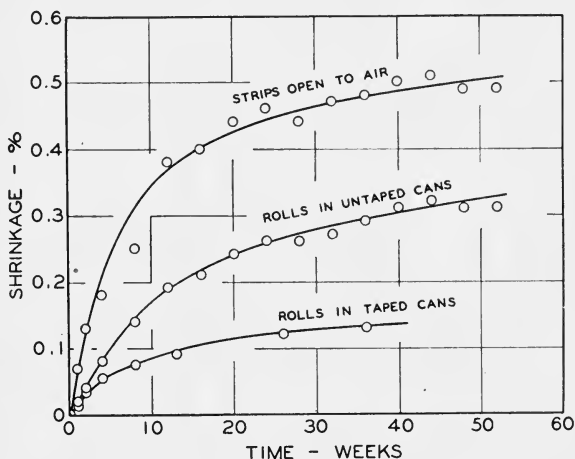


FIG. 15. The effect of free access to the air on the rate of shrinkage of processed Eastman Nitrate Motion Picture Positive film in the lengthwise direction at 50-65 per cent RH at 70 F. (The rolls in taped cans were opened for each measurement which slightly increases the rate of shrinkage.)

Once a can of film is opened 2 things happen—the film starts to approach equilibrium with the relative humidity of the air, and shrinkage due to the loss of solvents is accelerated. Consequently, film which has been opened for a few days, especially in a dry atmosphere, may have a somewhat shorter pitch than expected. The use of film under these conditions for the design of 16-mm camera sprockets has sometimes led to errors, particularly in the case of special cameras for which pitch is unusually critical. The sprocket pitch should be such that film stored under normal conditions will mesh properly when fresh from the can.

**Processing Shrinkage.**—Both nitrate and safety base films swell



during development and shrink back again during drying. Most films also undergo a small permanent shrinkage during processing. However, if the film is not brought to equilibrium with air at the same relative humidity after development as it was before, the permanent processing shrinkage may be completely masked by the temporary expansion or contraction due to change in relative humidity. This frequently happens in the case of motion picture film, which at the time of perforating may have a moisture content equivalent to that at equilibrium with air between 50 per cent and

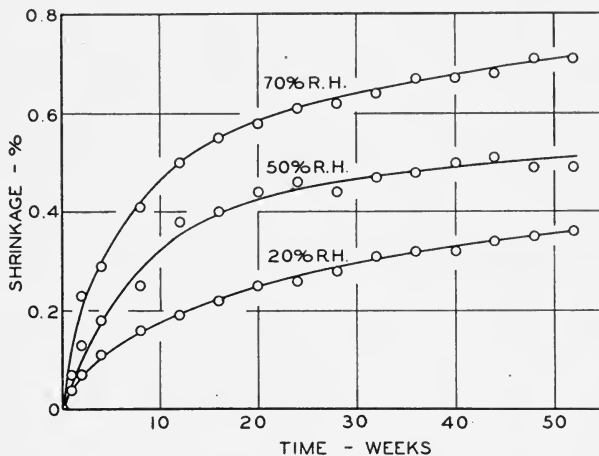


FIG. 16. The effect of relative humidity on the rate of shrinkage of processed Eastman Nitrate Motion Picture Positive film in the lengthwise direction at 70 F. (Film in strips having free access to air.)

60 per cent RH. If the film is removed from the drying cabinet after processing with a moisture content equivalent to that at equilibrium with air between 70 per cent and 80 per cent RH, the permanent shrinkage of the raw stock plus the processing shrinkage will be masked by the humidity expansion, so that the pitch of the film may even be slightly longer than the standard.

**The Effect of Storage Conditions on the Shrinkage of Film.**—After development, photographic film continues to shrink at a decreasing rate throughout the remainder of its life. The degree of permanent shrinkage which occurs depends on the type of film and the treatment it receives. The effect of several extrinsic variables

on the permanent shrinkage of film during aging after development is illustrated in Figs. 15, 16, and 17. A comparison of the permanent shrinkage of strips of film suspended freely in circulating air, and film wound in tight rolls in untaped, and in taped cans is shown in Fig. 15. Free access to the air enables solvents and other volatile material to diffuse out of the film more easily and, therefore, accelerates shrinkage. Fig. 16 shows the effect of relative humidity at constant temperature, on the rate of shrinkage of strips of nitrate

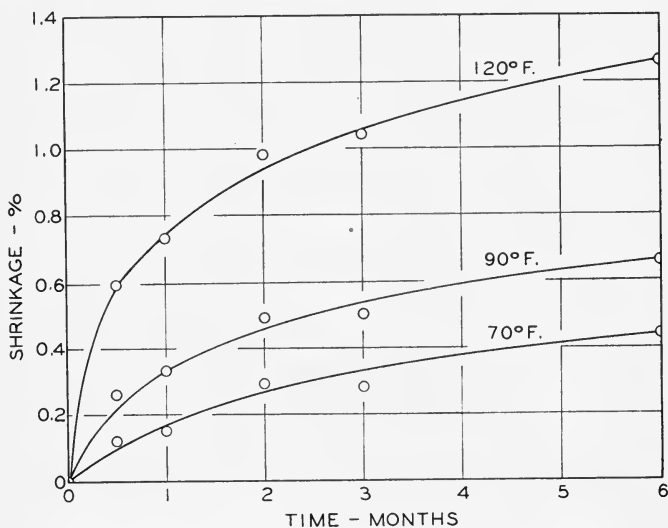


FIG. 17. The effect of temperature on the rate of shrinkage of processed Eastman Safety 16-mm Reversal film (Type No. 4, Table 4) in the lengthwise direction at 20 per cent RH. (Film in strips having free access to air.)

motion picture positive film hung in circulating air. As mentioned previously, moisture aids the diffusion of solvents through both the base and the emulsion, so that the film shrinks more rapidly at higher relative humidities. Fig. 17 illustrates the effect of temperature at constant relative humidity on the rate of shrinkage of Eastman Safety 16-mm Reversal Film. Heat drives out some of the residual volatile material from the film base, thus accelerating shrinkage.

The influence of the various storage variables on the rate of shrinkage described above applies qualitatively to the majority of motion

picture films. Consequently, where low shrinkage is desired over a period of time, the film should be stored in tight rolls in well-taped cans at low temperatures (50 F, for example) and at moderate relative humidities (40 per cent to 50 per cent RH).

Although a storage relative humidity below 40 per cent would be preferable from the point of view of reducing permanent shrinkage, this is not recommended for several reasons. Film tends to become brittle, and curl becomes excessive at low relative humidities. Although negatives may be stored safely at a relative humidity around 40 per cent, they should be brought to equilibrium with air at a relative humidity of 60 per cent to 70 per cent at the time of printing to prevent static discharges on the raw positive. If developed rolls must be stored in untaped cans or cardboard boxes, it is more important that the film at the time of winding be in equilibrium with the relative humidity most likely to be encountered in the storage atmosphere. This is necessary to prevent differential moisture changes from the edges of the rolls, which cause various film distortions such as flute and buckle.<sup>12</sup>

**The Shrinkage Characteristics of Various Eastman Motion Picture Films.**—In Table 4 are recorded the approximate shrinkage characteristics of a variety of Eastman motion picture films including both nitrate and safety base, and negative and positive emulsions. The accelerated aging test employed consists of heating short strips of developed film for 7 days at 120 F and 20 per cent RH, and is useful for comparing films of different potential shrinkage. This aging treatment is very roughly equivalent to about a year under normal conditions for strips of film freely suspended in moving air. The figures given for aging shrinkage should not be interpreted as indicating the actual shrinkage to be expected in practice. Film in tight rolls or in containers of any kind will shrink considerably less, while under severe storage conditions the shrinkage may be greater.

All the safety films in Table 4 have a higher humidity expansion or contraction than the corresponding nitrate films. This is due to the fact that safety base holds more moisture than nitrate base (*cf.* Fig. 3). However, the humidity expansion of these safety base films approaches more closely to that of the nitrate film than was the case 6 or 7 years ago. The permanent shrinkage of the older safety films (Nos. 2, 4, and 8), as indicated by the processing shrinkage and accelerated aging tests in Table 4, is considerably higher than that of the nitrate films. The newer safety films (Nos. 3, 5, and 9), on

the other hand, are quite comparable in this respect to the nitrate films.

**Shrinkage of Release Prints in the Trade.**—The actual shrinkage of positive motion picture film encountered in the trade is of interest, because laboratory tests can never duplicate precisely the variety of conditions of storage and projection found in practice. Shrinkage measurements (deviations from standard pitch) have been made in a number of theaters and film libraries in the northeast

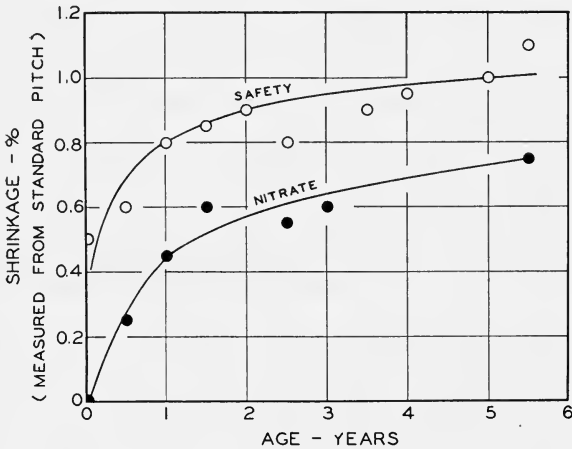


FIG. 18. The rate of shrinkage of Eastman Motion Picture Release Positives under average trade conditions in the northeast United States. Film manufactured between 1937 and 1943 (Nitrate, Type No. 6, Table 4; Safety 16-mm, Type No. 8, Table 4). Number of projections unknown and measurements made at unknown equilibrium relative humidity.

United States. These measurements, of course, could not be made at constant relative humidity, so that the values obtained are very rough. New prints may be in equilibrium with an atmosphere of 70 per cent RH, whereas after several bookings the film may be in equilibrium with air having a relative humidity of 30 per cent. Measurements of this nature, therefore, include permanent shrinkage of the raw stock, processing shrinkage, and shrinkage produced by subsequent storage and projection, together with an unknown degree of reversible humidity expansion or contraction.

The average deviation from standard pitch for both Eastman Nitrate 35-mm and Safety 16-mm commercial prints obtained in the

above manner, is plotted against the approximate age of the film in Fig. 18. The initial shrinkage on each curve was obtained from new prints, which in the case of nitrate is practically zero due to the moist condition of the film at the time of measurement. The number of projections on the balance of the samples is not known, but probably increases with the average age of the different samples tested. It may be seen that the nitrate prints released to the trade for a year have a shrinkage of about 0.4 per cent. This agrees reasonably well with the curve for rolls in untaped cans (Fig. 15), determined in the laboratory under controlled conditions. The safety 16-mm film released to the trade for a year shows a shrinkage of about 0.8 per cent. However, this safety positive film is the older, higher-shrink type (No. 8, Table 4) and the present film (No. 9, Table 4) will shrink much less under the same conditions.

The shrinkage encountered in the trade in individual cases may vary considerably from that shown in Fig. 18, depending on the actual projection and storage conditions in different parts of the country. Nevertheless, it is apparent that the deviation from standard pitch of present-day motion picture films is much less than that for which the projector sprockets were originally designed.

#### FILM CURL

The tendency of a photographic film to curl is well known. Curl is usually most pronounced at low relative humidities owing to the contraction of the gelatin emulsion. For convenience we have called the curl *positive* when the film is bent toward the emulsion side, and *negative* when the film is bent away from the emulsion side. In the case of motion picture film a slight positive curl is generally preferred. This is believed to reduce scratching of the emulsion in handling. The curl of the film should not be too high at any relative humidity likely to be encountered in practice and should not change too much with age. Film with excessive curl is difficult to handle, is more susceptible to the distortion called "spokiness,"<sup>12</sup> and may not focus sharply when projected. On the other hand, film which is flat is sometimes regarded as too limp, although this may not be a serious objection.

The cause of curl and the effect of relative humidity on curl are illustrated in Table 5. It may be seen that when the relative humidity is reduced from 70 per cent to 20 per cent, stripped emulsion contracts approximately 7 times as much as uncoated nitrate base.

In normal film the emulsion is firmly attached to the base so that it cannot contract as much as it would otherwise. Therefore, when the moisture content of film is reduced the film bends or curls toward the emulsion side to reduce the strain. In addition, the base is compressed slightly (*cf.* Table 5) and the emulsion stretched (compared with the dimensions it would assume if unattached). An analogy is sometimes drawn between this behavior and that of a bimetallic strip which consists of 2 elements, each having a different thermal coefficient of linear expansion.

The curl measurements in Table 5 give the average altitude of the arc (that is, the maximum distance between the arc and the chord) formed by 35-mm film in the widthwise direction. If the film base itself were perfectly flat, the emulsion coated film would be nearly flat

TABLE 5

*The Effect of Relative Humidity on the Curl of Fresh Undeveloped Eastman Nitrate Motion Picture Fine-Grain Positive Film*

Relative Humidity, per cent	Widthwise Humidity Contraction from 70 per cent RH, per cent				Curl of 35-mm Film, in.
	Stripped Emulsion	Uncoated Base	Normal Film		
70	0	0	0		-0.03
50	0.8	0.10	0.15		+0.05
20	1.8	0.25	0.35		+0.20

at high relative humidities and become more positive in curl as the moisture content is reduced. However, in most motion picture films the base is treated so that it will have a small negative curl to counteract the pull of the emulsion. The film, therefore, has a slight negative curl at 70 per cent RH, a small positive curl at 50 per cent RH, and a curl at 20 per cent RH which is not as large as it would be if the base itself were flat. It is desirable that the curl amplitude, that is, the difference between the curl at low and at high relative humidities, be as small as possible.

**Curl in Processing.**—When film is immersed in the processing solutions, both the base and emulsion swell. The curl generally disappears and the film is essentially flat as it enters the drying cabinet. Here the back of the film base begins to dry while the face is kept moist by contact with the wet emulsion. This causes the film to curl in a negative direction. As the emulsion dries, it contracts more than the base and finally pulls the latter until the curl

changes from negative to positive. This change in the direction of curl does not occur gradually as a rule. The film base appears to resist the pull of the emulsion as long as possible and may even buckle slightly. Finally, the contraction of the emulsion becomes sufficiently great, and the curl of the film changes suddenly from negative to positive, often within the length of a single strand in the drying cabinet.

As mentioned in an earlier section, the emulsion dries more rapidly

TABLE 6

*The Effect of Storage Conditions on the Curl of Processed Eastman Nitrate Motion Picture Fine-Grain Positive Film*  
(Original curl, +0.03 in.)

Storage Relative Humidity, per cent	Curl in Inches After 2 Months' Storage (Storage Temperature, degrees F)			
	55	70	90	110
<i>Film Wound Emulsion-In</i>				
20	+0.02	+0.01	-0.03	-0.05
35	+0.03	+0.04	+0.01	-0.05
50	+0.02	+0.04	+0.02	-0.02
65	+0.02	+0.04	+0.04	+0.01
80	+0.05	+0.06	+0.06	+0.03
<i>Film Wound Emulsion-Out</i>				
20	-0.04	-0.07	-0.11	-0.13
35	+0.01	-0.03	-0.08	-0.15
50	0.00	-0.02	-0.06	-0.11
65	0.00	-0.01	-0.04	-0.09
80	+0.01	0.00	-0.04	-0.06

NOTE: Film conditioned to storage relative humidity before winding and re-conditioned to 50 per cent RH at 70 F for measurement.

than the base, because moisture diffuses more easily from the interior to the surface in the case of the former. In many commercial machines the base is still somewhat moist at the end of the drying cabinet, and since it is softer and weaker in this condition, it offers less resistance to the pull of the emulsion. Consequently, the curl of the film at the point of reeling may be higher than normal for the relative humidity of the drying air. Drying at high temperatures and low relative humidities should be avoided to prevent excessive curl in the drying cabinet.

**The Effect of Storage Conditions on Curl.**—The curl characteris-

tics of film tend to change on storage even where the moisture content of the film remains the same. Table 6 illustrates the effect of several storage variables on the curl level (at 50 per cent RH) of developed Eastman Nitrate Motion Picture Fine-Grain Positive film over a period of 2 months. It will be observed that the curl of the film becomes more positive under some conditions and more negative under others. The film wound emulsion-in behaves differently from the film wound emulsion-out. The changes in curl are greater at high storage temperatures and low storage relative humidities.

It may help to clarify some of the peculiarities in film behavior if we attempt an explanation of the curl changes which occur during storage. The following are believed to be the more important factors responsible for the effects observed in Table 6:

(1) *Shrinkage of the base.* Shrinkage of the base in the widthwise direction tends to counteract the pull of the emulsion and, therefore, makes the curl less positive or more negative. The influence of storage conditions on the shrinkage of film has already been described in detail. An increase in either storage relative humidity or storage temperature increases shrinkage of the base and, we believe, accelerates curl changes due to this cause.

(2) *Plastic flow of the base and emulsion during storage in roll form—(a) Transverse flattening of the film.* The effects of plastic flow on curl are rather complex. If a strip of film having moderate curl is held flat under a weight, one of the 2 elements (emulsion and base) will be stretched and the other compressed. Since neither the base nor emulsion is perfectly elastic, a plastic flow takes place which reduces the strain. This tends to make the film flatter regardless of whether the curl was previously negative or positive in direction.

Motion picture film wound in tight rolls is somewhat analogous to the strip of film under a weight, since the tension in the roll prevents the film from curling in the widthwise direction. The magnitude of this effect is directly related to the degree of curl at the time of winding which determines the widthwise stress applied in the roll and, therefore, the amount of permanent set. In other words, the more curly the film at the time of winding, the greater will be the change in curl.

Curl changes caused by transverse flattening of the film are increased by heat during storage because plastic flow is greater at higher temperatures. Relative humidity (or rather the equilibrium moisture content of the film at the time of winding) has the opposite effect to that expected. Although film undergoes greater cold flow at high relative humidities under a given load (*cf.* Fig. 12), the curl at the time of winding is usually highest at low relative humidities. Since this latter factor determines the magnitude of the stress applied in the roll, curl changes due to this cause are greatest when the film is wound when in equilibrium with air at low relative humidities.

(b) *Longitudinal winding of the film.* The film in roll form is flat only in cross section and is wound or curled in the lengthwise direction. This has a compli-



cated effect on the subsequent widthwise curl of the film when unwound, which we will attempt to analyze. It is common practice to wind raw stock emulsion-in and processed film emulsion-out. When film is rolled emulsion-in, the emulsion is compressed and the base stretched in the lengthwise direction. Plastic flow takes place to relieve the stress and, under suitable conditions, the film takes a certain degree of permanent set. Then, when the film is unrolled the emulsion is stretched lengthwise and the base compressed. This compresses the emulsion and stretches the base in the widthwise direction which tends to make the widthwise curl more positive.

When film is rolled emulsion-out, the effect is the opposite to that described above. Unwinding film having a permanent set stretches the base and compresses the emulsion in the lengthwise direction. This compresses the base and stretches the emulsion widthwise, which tends to make the widthwise curl more negative.\*

The smaller the diameter of the roll the greater is the deformation of the film and, therefore, the greater will be the change in curl from this cause. (We have found somewhat larger curl changes at the core end than at the outside end of 1000-ft rolls.) An increase in either relative humidity or temperature increases curl changes of this type because of the increased plastic flow and permanent set.

The above discussion illustrates a few of the complexities in the behavior of motion picture film. In addition to the factors described, there are undoubtedly others, even more obscure, which influence curl. The curl of the film at any given time will be determined by all these effects, some of which act in opposite directions, and each of which may be influenced in a different way by heat, moisture, and other factors. For these reasons it is not always possible to predict what the curl of motion picture film will be at any given point in its history.

In the data in Table 6, the effects of shrinkage on curl are difficult to distinguish from the effects of plastic flow. However, in the case of film wound emulsion-in, plastic flow produced by transverse flattening would tend to give a zero curl, while plastic flow produced by longitudinal winding would tend to give a more positive curl. The fact that the curl actually becomes increasingly negative at low relative humidities as the temperature increases, must be attributed to shrinkage of the base. At higher relative humidities the effects of shrinkage are masked by other factors.

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\* It is assumed that at least several feet of film are involved, so that the weight of the film itself when unrolled and stretched out will prevent lengthwise curl. If a strip of film only a few inches in length is taken from a roll, it will frequently curl lengthwise rather than widthwise, particularly if previously wound to a small diameter. This behavior is sometimes referred to as "clockspring" from the obvious analogy.

The greater change in curl observed in Table 6 at the lower relative humidities is believed to be due to plastic flow produced by transverse flattening of the film. At the low relative humidities the film has a higher curl at the time of winding which increases the widthwise stress on the film. The rather surprising fact that the film wound emulsion-in at the higher relative humidities actually becomes more positive in curl can be explained by plastic flow produced by the longitudinal winding. It may be noted that the effects of shrinkage of the base and plastic flow due to longitudinal winding operate in opposite directions when the film is wound emulsion-in, but in the same direction when the film is wound emulsion-out. This explains the much larger negative drift in curl when film is wound emulsion-out.

From a practical point of view Table 6 demonstrates that where it is desired to retain a small positive curl, film should be wound emulsion-in at moderate relative humidities (preferably 40 per cent to 60 per cent); and stored at low temperatures (50 F to 60 F) in taped cans. These conditions are more easily fulfilled in the case of raw stock. Processed film which is normally wound emulsion-out is in a somewhat less favorable condition from the point of view of curl changes, although these are generally not serious except where the film is reeled when very dry and then stored at high temperatures. A film having too high a positive curl may be improved by winding emulsion-out, while film having too negative a curl may be improved by winding emulsion-in.

#### CONCLUSION

The proper performance of motion picture film in practice depends to a marked degree on the physical properties of the film, and on how these properties are affected by relative humidity, temperature, and other factors. The importance of proper protection of film against moisture changes during storage, and the exercise of a certain amount of control over relative humidity in most operations in the motion picture laboratory cannot be overemphasized.

Safety base motion picture film is now substantially improved in its physical properties compared with that manufactured 6 or 7 years ago, although it is still inferior to nitrate film in some respects.

It is our hope that this discussion of the physical properties of motion picture film will clarify some of the peculiarities in film behavior, and prove of practical value to the motion picture industry.

**Acknowledgment.**—The experimental work and the theories described in this paper have resulted from the accumulated efforts of numerous members of the Department of Manufacturing Experiments and the Research Laboratories of the Eastman Kodak Company over a period of many years. The writer wishes to express his sincere appreciation to Dr. E. K. Carver for his many helpful suggestions and for continued guidance in the preparation of the paper. Thanks are also due to those who assisted in the collection of data and in the preparation of graphs.

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## AIDS FOR PICTORIALLY ANALYZING HIGH-SPEED ACTION\*

E. M. WATSON\*\*

*Summary.*—Many of the objects that concern us are of use only when they are in motion. While we can watch mechanisms that move slowly to determine whether or not their actions confirm performance predictions, the unaided eye is useless to observe high-speed mechanisms.

To find out what is going on some method of visual aid must be employed. While this paper does not cover the entire field of activity in high-speed photography, the more important methods are classified, equipment is described, and various applications are discussed.

Many of the objects that concern us are of use only when they are in motion. While we can watch mechanisms that move slowly to determine if their actions confirm performance predictions based on blueprints and slide-rule calculations, the unaided eye is useless to observe the behavior of mechanisms that move at high speed.

Rapid motions cannot be adequately analyzed by the unaided eye for several reasons. Because of persistence of vision, images are retained by the eye for a short period of time and any motion of the image during the period of retentivity will cause the image to appear indistinct. Even though there may be momentary periods of repose, as a high-speed crosshead at the end of its travel, or when by external means it is made to appear motionless, it may not be possible to determine by these glimpses what is taking place because the rate at which the brain can comprehend the performance is exceeded.

To find out what is going on, some method of visual aid must be employed. Just what is practicable to use depends upon many different conditions. Of all the different methods available, it is necessary to choose the one which will reveal the conditions for which a question has been raised. This method must be one for which the necessary apparatus can be practically constructed or obtained. If

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the phenomenon to be considered is repetitive, some device for direct visual observation can be considered, but if not, it is necessary to store the records of events photographically or otherwise until such time as they can be developed and studied.

In making estimates as to how a mechanism will perform, it is not always possible to forecast all of the effects of motion and, therefore, until the mechanism is tried, there is no way of telling how it will perform. In some instances it will be found that the best way to go about perfecting a machine is to build a model. When this model is put into operation it will likely be found that at low speeds the performance corresponds to that desired, but as the operating speed is increased effects of inertia, slipping, and other conditions many introduce deviations from performance at low speeds.

Since it is usually desired to have the machine operate at the highest practical speed in order to get adequate output to justify conditions, as investment, *etc.*, some method must be employed that will assure acceptable operation at the desired speeds. Many times when using the trial and error method a number of changes will have to be made. Further operation and subsequent examination will probably determine the extent of the improvement and offer a clue as to what to do next.

When progress is difficult or impossible by this procedure, *seeing* what happens while the erroneous action is taking place will often show what to do to obtain the desired performance.

Choices of apparatus necessarily depend on what is to be accomplished. Versatility of application is of considerable importance when the apparatus represents considerable outlay. A knowledge of methods of examination of phenomenon too fast for unaided visual observation is essential in making a proper choice of equipment.

In general, the available methods are of value only where there is an appreciable movement to be shown. Dimensions of a few mils can be shown under special conditions. Variations of hundredths and tenths of inches are within the normal range of equipment of this kind; but the field area should be so selected that the motions looked for exceed one per cent of the diameter of the field area.

On account of these limitations it is best to try to study only one condition at a time, but it is well to make some general views to locate the areas where the detail can best be studied.

Colored photographs at high speed will often show some things which cannot be adequately studied with the use of black-and-white

TABLE 1  
Principal Methods for Pictorially Studying Phenomena That Are Too Fast for Unaided Visual Observation

CLASSIFICATION

<p>1. Direct visual observation.....</p>	<p>SHUTTER METHOD (Used where subjects radiate light of themselves or reflect utility light not used to determine exposure time. Exposure time is determined by shutter.)</p> <p>Visually observing through a shutter the action of devices that perform repetitive cycles.</p>	<p>STROBOSCOPIC METHOD (Used where other light does not materially interfere with stroboscopic light. Exposure time is determined by stroboscopic flash.)</p> <p>Visually observing without optical apparatus the action of devices that perform repetitive cycles.</p>
<p>2. Still Cameras:</p>	<p>(a). Single-image.....</p> <p>Camera with shutter which will give a single exposure of adequate shortness of time.</p>	<p>Camera with its shutter open during a single stroboscopic flash.</p>
<p>(b). Multiple-image.....</p>	<p>Camera with continuously open shutter, and exposure repeated at short intervals by means of moving perforated disk or other special light-interrupting device.</p>	<p>Camera with its shutter continuously open during several stroboscopic flashes.</p>
<p>3. Motion picture cameras:</p>	<p>(a). Cameras with intermittent motion which allows film to remain stationary during exposure. Speed limited by strength of intermittent mechanism and film.</p>	<p>Ordinary motion picture camera fitted with stroboscope which may be operated in synchronism with film.</p>
<p>(b). Cameras in which the film is transferred from spool to spool at continuous speed. Speed limited by strength of film.</p>	<p>Special cameras in which exposures are controlled by a shutter, and images are moved with the film by means of optical devices, such as prisms or mirrors that are used in addition to the objective lens. Most common operating speed, 1000 frames per sec. Maximum speed about 6000 to 7000 frames per sec.</p>	<p>Special cameras in which the film is moved past the objective lens, and synchronized stroboscopic flashes are used to produce exposures that are so short that no appreciable motion of the image on the film can be detected.</p>
<p>(c). Cameras which operate at such high speed that the film is not strong enough to run unsupported. This difficulty is overcome either by supporting the film while in motion or by allowing it to remain stationary and optically moving the image.</p>	<p>Special cameras of various types of construction where exposures are controlled by shutters. Maximum speed thus far attained about 120,000 exposures per sec for 1000 exposures.</p>	<p>Special cameras for taking pictures of phenomena such as lightning, etc., which are somewhat stroboscopic of themselves.</p>

films. For example, colors of flames in gas can give added insight to what is taking place. Solid or liquid materials such as those used in silver soldering may be identified readily by color, whereas their identification will be difficult or impossible by the use of black-and-white film. Various ferrous and nonferrous metals can be made to show distinctive photographic color and shade.

Often accessories to the available devices are required. Much of the success in getting data difficult to obtain will be found proportional to the extent to which accessories can be constructed.



FIG. 1. Ashdown Rotoscope for making observations under conditions where light from subject being observed prevents the use of ordinary stroboscopic methods.

The classification of means for pictorially analyzing motions that are too rapid for unaided visual observation is included as Table 1. The column at the left lists various general types and arrangements of apparatus; the middle column outlines the manner in which investigations are made when the subject is continuously lighted; and the column at the right applies to methods employing intermittent light on the subject.

In almost every setup the following points must be considered:

- (1) Means must be devised for placing the image (with necessary sharpness and steadiness) on the medium where the exposure is to take place.
- (2) Arrangements must be made for starting and stopping the exposure.



(3) Means must be devised for placing the subsequent exposures on recording material at the proper time and location to obtain the desired results.

Recognition of these requirements gives some idea of the method of accomplishment in each case.



FIG. 2. Stroboscopic equipment used for demonstration purposes. In the normal operating position, the tube and reflector are turned toward the wheel. The useful light from the stroboscopic tubes originates either in mercury vapor or rare gases.

#### VISUAL OBSERVATION

Item 1 of Table 1 refers to the visual observation of repetitive phenomena, such as take place in the action of engines or of other devices where a specific motion is continually repeated.

When continuous light of sufficient intensity is reflected from or radiated by the subject that is to be observed, some type of shutter must be employed to pass light from the subject to the observer only at times when similar images will be seen.

Such a shutter control of the light that reaches the eye is provided in the Ashdown Rotoscope (London), shown in Fig. 1. The observations are made through 2 slots in a tube which is revolved on its axis by a spring motor. These slots are fitted with vanes which further restrict the passage of light to only a very short interval out of each half revolution. By means of an adjusting knob, the observer can control the speed of the rotating tube and hence can view the performance of the subject at any one point in its operating cycle (by adjusting the rotoscope to synchronism with the subject) or

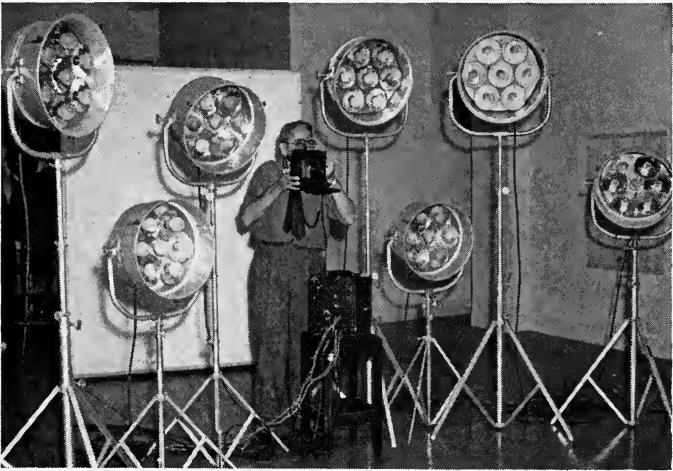


FIG. 3. Camera and lights with synchronizing equipment for obtaining single exposures at high shutter speeds.

throughout its cycle (by adjusting the rotoscope to a slightly different speed). Included also are speed-change gears which provide for a choice of any one of 4 basic speeds and thus give the device a considerable speed range of application.

Under conditions where existing continuous light reflected or radiated from the subject is not so bright as to overcome the contrasts introduced by an addition of intermittent light, the stroboscopic method of examination can be used to advantage.

Fig. 2 shows the stroboscope that was used in the House of Magic demonstrations at the New York World's Fair. The tube mounted in the reflector is filled with neon. The power to operate the tube is taken from a condenser which quickly discharges during each flash,

causing the light to be of very short duration. The necessary circuit is provided for recharging the condenser at sufficient speed to allow the flashes to take place at the rate of once for each revolution of the wheel, which is driven by a synchronous motor. The circuits used depend on how the equipment is to be employed.

When a particular point of an operating cycle is being studied, the flashes of light should be made to coincide with that point of the operating cycle, though the timing of the light may also be varied somewhat to bring other points of the cycle into view. Apparatus



FIG. 4. An example of high-speed photography accomplished with the type of equipment illustrated in Fig. 3.

for this work can sometimes be constructed from equipment that is at hand, but in most cases it is more economical to purchase apparatus designed for the purpose.

#### STILL CAMERAS

Whenever the subject being investigated does not repeat its motion at all or not often enough to use a stroboscopic device, it is necessary to use some form of photography for quickly recording the action for later study. When complications are not great, still cameras can be used.

**Single Images.**—When it is not necessary to know what happens before and after a given instant, a single exposure on a stationary

film may suffice. In Table 1, this condition is listed as 2(a). For many applications much can be accomplished with still cameras, particularly if the camera's shutter is capable of a speed of the order of  $1/1000$  of a sec.

Fig. 3 shows a setup used by Jack Price in taking single shots at very high shutter speeds. Attached to the camera is a synchronizer



FIG. 5. Photograph of a 0.30-caliber bullet (velocity 2700 ft per sec) striking an electric lamp bulb. Note that the cracks in the glass travel faster than the bullet. An exposure of less than  $2 \times 10^{-6}$  sec is required to "stop" the bullet without blur as shown in this picture.

which makes possible the electrical signal that the opening in the curtain shutter is approaching the film. This signal is in advance of the uncovering of the film by an amount which will allow the Photo-flash lamps to reach the desired plateau of light intensity by the time the exposure is started. The synchronizer reduces the voltage on the grid of a thyratron tube to a point where the tube is made conducting, thus causing the lamps to be set off. The lamps in each cluster are connected in series. The leads from the clusters are plugged into the

box containing the thyratron tube, *etc.*, and the usual arrangement is to have them in parallel. Fig. 4 shows a picture of two dancers taken by this method.

Single-shot exposures may also be taken by stroboscopic light, examples of which are shown in Figs. 5 and 6. These stroboscopic pic-



FIG. 6. A microsecond silhouette photograph taken with stroboscopic polarized light to show the stress pattern during the growth of the cracks in a glass plate when violently broken. The crack velocity is 5000 ft per sec. It is measured by taking 2 photographs spaced in time by 15 microseconds.

tures, and those in Figs. 9 and 13, were obtained from Dr. Harold E. Edgerton, K. J. Germeshausen and H. E. Grier, who have very ably used the technique of flash photography at the Massachusetts Institute of Technology. The apparatus and methods have been widely described.<sup>1</sup>

Even with a still film or plate and no camera, instructive silhouette photographs can often be taken by interposing the moving object be-

tween the stroboscopic light source and the sensitized material. For example, in the study of the flight of projectiles fired from a gun, the compression and rarefaction of the air due to the sound wave will refract the light, causing it to show in a photograph. Fig. 7 shows a 0.50-caliber projectile traveling about 2400 ft per sec, as photographed by Dr. A. C. Charters of The Aberdeen Proving Ground (Md.). The sound wave from the bow and stern may be seen, as well as the wave from the grooves caused by the rifling. The turbulence of the air in the path just traversed by the projectile can also be seen.

**Multiple Images.**—When the action to be studied moves across the field of view, multiple exposures on a single plate can be used

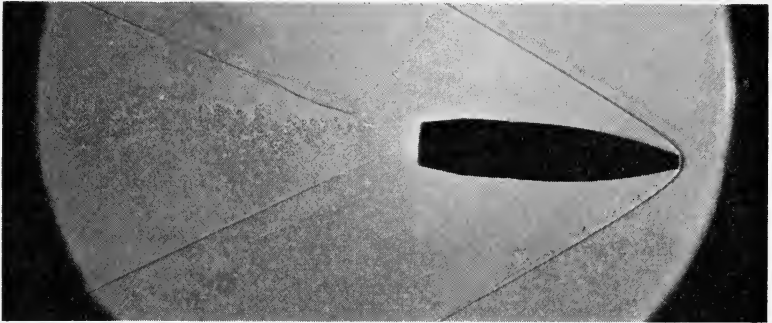


FIG. 7. A single-flash silhouette picture of a 0.50-caliber projectile in flight.

to record what takes place. In Table 1 this condition is listed as 2(b). The photograph in Fig. 8, taken by Otto Schurig, of an arc in a contactor,<sup>2</sup> is an example of an action recorded by multiple-image photography. A disk with a series of radial slots near its periphery was revolved before the still camera lens during the time the arc took place. The various positions of the arc were recorded when the slots in the disk successively uncovered the lens. The difference in brightness of the various images of the arc is caused by their being taken at various points on the a-c cycle.

The stroboscopic images of the golf club in Fig. 9 show its relative speed before and after striking the ball and also the distortion of the staff as a result of the impact. The ball is compressed when struck, some of the kinetic energy supplied by the club being taken up as potential energy by the rubber of the ball. As the ball decompresses,

much of this potential energy goes into the kinetic energy of motion of the ball. It is the addition of this energy to that of the push of the club which accounts for the ball's flight at a speed higher than that of the club by which it was struck. The flash frequency was 600 per sec, which allows the speed of the club and ball to be calculated on the basis of the distance between individual images.



FIG. 8. High-speed multiple-exposure photograph of arc interruption, showing successive stages of the arc at intervals of about  $1/300$  of a sec.

#### MOTION PICTURE CAMERAS

When a single picture is insufficient and the motion occupies approximately the same area, causing multiple images to overlap and to be confused, one must resort to motion pictures. Motion pictures taken at speeds in excess of the regular projection speed will, when projected, show the action in slow motion. In Table 1 motion pictures are listed as 3.

**Intermittent Film Movement.**—If the difference between taking speed and projecting speed need not be very great, an intermittent camera 3(a) would be suitable. In this type of camera the film is

drawn from the supply reel and wound on the take-up reel at constant speed. However, film is stationary adjacent to the aperture when each exposure is made. It is advanced intermittently past the aperture for the exposure of each successive frame, and the light through the optical system is interrupted during the motion of the film. Fig. 10 shows a Bell and Howell super-speed 16-mm camera



Photo Courtesy A. G. Spalding & Bros.

FIG. 9. Multiple-image study of impact and reactions of golf club and ball.

which will operate at about 128 frames per sec or 8 times the normal projecting speed. Most of the slow-motion pictures of athletic events, *etc.*, shown in theaters are taken at about this number of frames per sec.

The Eastman Ciné-Kodak Special fitted with a stroboscope has been used to study the operation of looms, *etc.*, by the Bigelow Sanford Carpet Company, Inc., as shown in Fig. 11. A commutator is attached to the shaft on the camera which would otherwise accommo-



date a crank. This commutator, extending to the right of the camera operator, is connected to the stroboscope control apparatus that is in the black box. The stroboscope lamp is caused to operate at the time the camera shutter has completely uncovered the film.

**Continuous Film Movement.**—When it is desired to operate at a picture frequency in excess of that attained with an intermittent



FIG. 10. Bell and Howell super-speed camera in which the film moves intermittently. This camera is sometimes called the golf-stroke-analysis camera.

camera, a camera in which the film moves continuously without stopping must be employed. In the class of cameras designated as 3(b) in Table 1, the film is passed from one spool to another at a constant speed, once the desired speed has been attained. The images are either placed on the film almost instantaneously by means of stroboscopic light or allowed to travel with the film for a short distance by means of an optical system.

The stroboscopic camera of this type is very simple in construction, because its optical system consists of only an ordinary lens which is

arranged to focus the image on the film as it passes. The stroboscopic exposures are usually so short that the motion of the image on the film is less than the dimensions of the optical errors of the lens (circles of confusion), and therefore the motion of the image is not noticed. This method has the advantage of stopping very fast motion which would blur the image on the film if continuous light and a camera which allowed a longer period of exposure were used. An-



FIG. 11. Eastman Ciné-Kodak Special fitted with a stroboscope and set up to make a high-speed record of an action in the operation of a loom.

other advantage of this type of camera is that the light is on the subject only while a picture is being taken and, therefore, has less heating effect than if it were left on continuously.

Cameras that employ an optical system to move the image with the film can be used to advantage in photographing subjects which radiate continuous illumination. Various methods have been used in constructing cameras of this type. The Jenkins camera displayed in the Smithsonian Institution at Washington (D. C.) employs a ring of lenses which move with the film. The Eastman high-speed cam-

eras employ a revolving glass plate which moves the image along with the film. The same effect is accomplished in the Zeiss camera by means of mirrors. The top speed of all these cameras which use spooled film is limited by the rate at which the camera can pass film from one spool to another without serious damage to the film.

At the present time, the practical upper limit of film speed seems to be about 100 miles per hr. Using full frames of 16-mm film, this

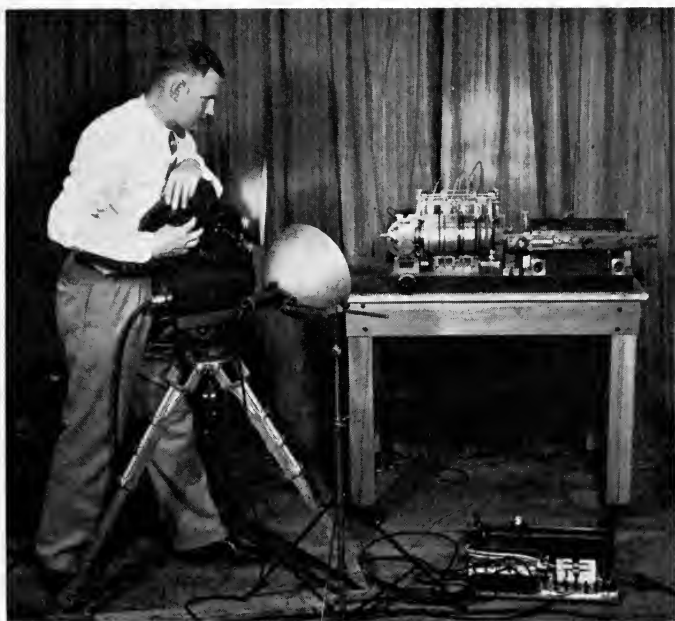


FIG. 12. Eastman Type II High-Speed Camera and accessories set up for recording the performance of a contact mechanism.

speed would correspond to a picture frequency of 6000 to 7000 frames per sec. When several pictures are placed in the area regularly occupied by one picture, it is possible to increase further the picture frequency. This usually cannot be done, without major alterations, in a camera having an optical system that moves the image with the film, but it is not difficult to accomplish in a stroboscopic camera. To make the change in the latter camera, about all that is necessary is a mask to limit the field on the film and a means of producing the stroboscopic flashes at the desired increased frequency. Pictures

taken under these conditions and intended to be projected as motion pictures should be rephotographed with an animation camera, enlarging to full-frame size the section of the film on which the desired action took place.

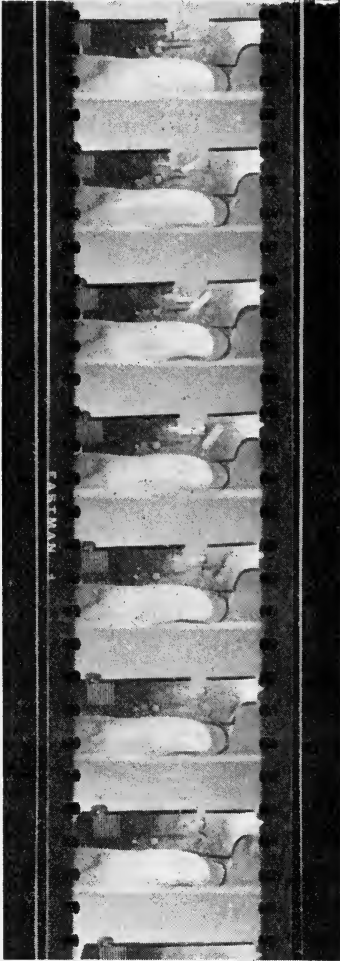


FIG. 13. Motion picture of the action of a .22-caliber automatic pistol. This is a sequence from a high-speed 35-mm film taken at approximately 500 frames per sec.

Fig. 12 shows a view of the Eastman Type II High-Speed Camera, which uses 16-mm film, set up for operation. Projection-type incandescent lamps in reflectors are placed at each side of the camera to illuminate the subject being photographed. In the box on the floor in the left background is a 200-cycle tuning-fork frequency generator which provides energy for operating a clock. This clock is located in the lower part of the camera. Its image is photographed at the right-hand edge of each frame and enables the time to be read to 1000ths of a sec.

Fig. 13 shows an enlargement from a strip of film taken at approximately 600 frames per sec with a stroboscopic camera. The sequence shows the action of an automatic 0.22-caliber pistol. This is a subject which can be taken with either the special-shutter type or stroboscopic type of camera that utilizes continuously moving film, a fact that is true in most instances of practical high-speed photography.

**Mechanically Supported Rotating Film.**—When there is required a picture frequency greater than that which can be obtained with the types of cameras in which the film is passed from one spool to another, it is necessary to mount the film on a drum for support.

When there is required a picture frequency greater than that which can be obtained with the types of cameras in which the film is passed from one spool to another, it is necessary to mount the film on a drum for support.

This arrangement is listed as 3(c) in Table 1. The greatest speed so far known is that attained by D. C. Prince and W. K. Rankin who constructed a camera that will take 1000 pictures at rates up to 120,000 pictures per sec.<sup>3</sup> A front view of this camera is shown in Fig. 14 and the rotor in Fig. 15. The film used is  $4\frac{1}{2}$  in. wide by 40 in. long and contains space for 10 rows of images, each row consisting of 100 individual pictures. At maximum rotational speed, the length of the film is sufficient to record an event lasting  $\frac{1}{120}$  of a sec, which is equal to one alternation of 60-cycle alternating current.



FIG. 14. Front view of high-speed pinhole camera that can take pictures at the rate of 120,000 per sec.

Cameras of this type are limited to the photography of phenomena which are complete in one revolution of the rotor, unless special precautions are taken to prevent interference from multiple exposures on the film, or unless a high-speed shutter is used to block out the light except during the one revolution. Because of the very short exposure the subjects should be of very great brightness. Either black-and-white or color film can be used.

This camera was built to study the performance of high-speed switchgear, and when operated at the highest speed it is especially valuable in photographing arcs which are extinguished after one al-

ternation. The film is held, by centrifugal force, on the inside of the rim of the rotor, with the emulsion away from the main shaft. The rotor is so constructed that it consists essentially of 1000 very small cameras having pinhole lenses. These pinholes correspond to the first zones of zone plates, and are of such size as to give the best image under the conditions in which they are used. The images are exposed progressively from one row to the next, until the tenth row is reached. This is followed by repetitions, beginning each time with

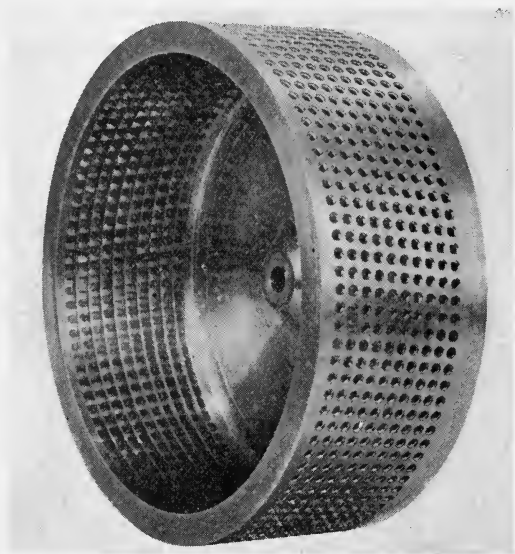


FIG. 15. Rotor with pinhole lenses which supports the film in the camera shown in Fig. 14.

the first row. The pictures may be printed on paper for examination in the same manner as is done in still photography. If it is desired to show them as a motion picture, it is necessary to photograph individual views with an animation camera in order to locate each picture properly in the desired frame area.

**Mechanically Supported Stationary Film.**—Instead of causing the film to rotate, it may be placed in a stationary drum and the light caused to sweep over it if the objects to be photographed give off light sufficiently stroboscopic to permit intelligible images to be obtained. Such devices have been used by Dr. K. B. McEachron,

J. H. Hagenguth, and C. J. Kettler for studying lightning discharges.<sup>4, 5, 6</sup>

In addition to facilitating the study of the formation and history of lightning strokes, cameras of this Boys type may be used to study the phenomena associated with the start of sparks and arcs and also the entire history of a spark or arc. Two such designs of cameras have been built, known as the low-speed and high-speed types. A record made with the high-speed camera is shown in Fig. 16. Fig. 17 shows the end of the camera in which the film cylinder is located. The housings for the 2 objective lenses and the 2 prisms may also be seen. The rotation of these causes the light to sweep along the film.

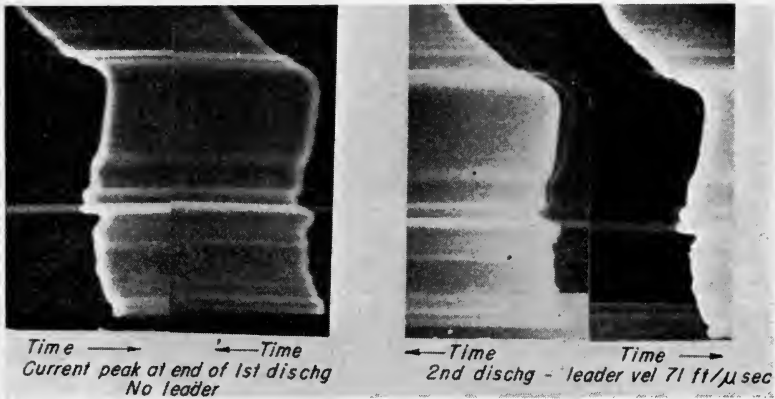


FIG. 16. High-speed Boys camera photographs of multiple-stroke lightning to the Empire State Building tower.

This type of camera will give a continuous record of the propagation of a spark during its formation and the change in intensity after it is formed. The maximum power of resolution so far obtained is  $11/1,000,000$  of a sec, or  $11 \mu\text{s}$  per mm of the film. By enlarging the pictures obtained, shorter times can be investigated. Speeds of propagation of lightning strokes as high as 65,000 miles per sec have been measured.

#### CONCLUSIONS

In any kind of high-speed photography, all the limitations of ordinary photography are encountered plus some special restrictions imposed by the high speed. As types of cameras are changed to obtain increased speed, compromises in image quality and in exposure

must be made. In the operation of an intermittent camera of the type mentioned as 3(a) in Table 1, the film is stationary while the exposures are made. This allows the best quality of image to be obtained from the lenses, a variety of which may be used. Only a moderate amount of light is needed, and both black-and-white and color film can be used.

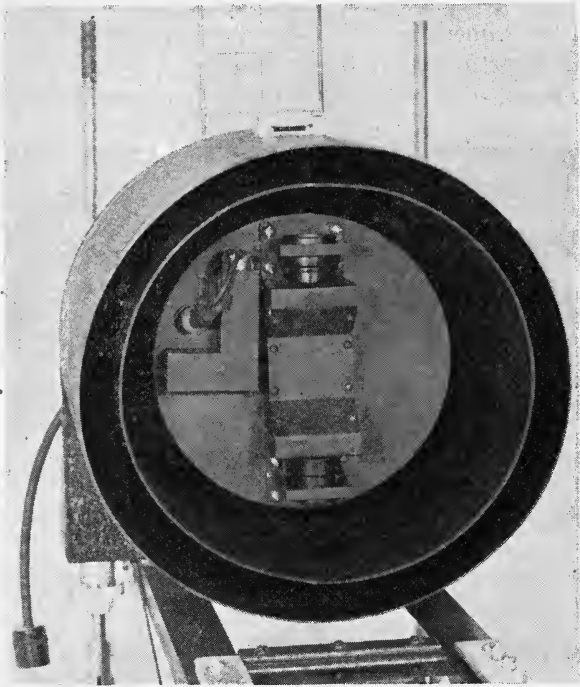


FIG. 17. Interior of the high-speed Boys camera, showing the stationary film cylinder and rotating lenses and prisms.

At high speeds where a camera of the type designated as 3(b) in Table 1 is used, in which the film is passed from one spool to another without intermittent motion, it is necessary to increase the intensity of the illumination because the time of exposure is shortened. It is fortunate, however, that, owing to the deviation from the reciprocity law, the intensity of illumination does not have to be increased quite in proportion to the reduction in exposure time. Focal length and



width of aperture of objective lenses are often limited for cameras which require an optical device for moving the image with the film.

Of the 2 general types of cameras, the stroboscopic type will usually give the better quality of image. With it there is no restriction on the focal length of the lens or the wideness of the aperture. When the camera is run at regular speed, there are only minor variations—such as vibration, *etc.*—which might cause the film to take a slightly different position than was intended. The lighting requires the most attention, since it must be of extremely short flashes for which special electrical equipment is required. The stroboscopic light thus produced is usually quite actinic, which simplifies the film requirements for black-and-white photography. If color photographs are to be made, attention must be paid also to having proper color balance.

For cameras in which the images are moved optically with the films, the lighting is simple but the lens and other camera requirements are more complicated. For most purposes, the light from incandescent lamps, the sun, or the subject itself will be adequate.

Among the optical systems of these cameras are some in which the motion of the image does not follow the film exactly, and in which the optical distance through the system varies slightly during exposure. These 2 factors contribute to the conditions that prevent high-speed pictures being as good as those obtained with the same lenses when no optical system for moving the image is employed. The loss in quality in most cases is about the same as that occasioned in changing from 16-mm film to 8-mm film when running at normal speed. The part of the optical system for moving the image limits the use of lenses to those of the longer focal lengths, restricts the amount of light that can be passed by increasing the lens apertures, and causes some loss of light enroute.

The speed range of high-speed photography is continuous. At one extreme there is the example of the telephone companies' photographing of call counters. Here the visual observation period can be very long but the detail is necessarily great. By these pictures, errors can be checked. The other extreme is the camera for studying lightning flashes. Here the detail to be observed may not be great but the visual observation period is very short.

There is opportunity in high-speed photography for anyone having only modest equipment, but many of the applications require very expensive equipment which has little versatility.

## REFERENCES

<sup>1</sup> An extensive bibliography on high-speed photography is included in the recent book "Flash" by H. E. Edgerton and J. R. Killian, Jr.

<sup>2</sup> JONES, B. W., AND SCHURIG, O. R.: "The Performance of Contactors as Circuit Interrupting Devices," *General Electric Review*, **39** (Feb., 1936), p. 78.

<sup>3</sup> PRINCE, D. C., AND RANKIN, W. K.: "A 120,000-Exposure-Per-Second Camera," *General Electric Review*, **42** (Sept., 1939), p. 391.

<sup>4</sup> MCEACHRON, K. B.: "Lightning to Empire State Building," *J. Franklin Inst.*, **227** (Feb., 1939), p. 156.

<sup>5</sup> HAGENGUTH, J. H.: "Lightning Recording Instruments—Part II," *General Electric Review*, **43** (June, 1940), p. 248.

<sup>6</sup> KETTLER, C. J.: "Cameras for Lightning Studies," *Phototechnique*, **2** (May, 1940), p. 38.

## FAST MOTION ANALYSIS AS AN AID TO ORGANIZED INVENTION\*

E. M. WATSON\*\*

*Summary.*—In getting any device ready for a test it is necessary to consider what is to be found out about it, the complete equipment to be used in the test, and the preparation needed to put the device into proper condition for conducting the test. This paper describes the various ways of recording the performance of fast-moving mechanisms, and includes a discussion of how to analyze and apply the data to practical development of apparatus.

During a war fear of the consequences, if it should be lost, causes the greatest possible efforts to be put forth in the attempt to win it. Just as mechanical devices are used to increase production in peacetime, they are likewise employed in times of war to make the efforts of the soldiers more effective. Of these mechanical devices, many operate too fast for their performance to be observed by the unaided eye. In some instances in the development of these devices or in their adaptation to new uses, the various aids for analyzing fast motion can be utilized to advantage in determining any appreciable variation from the desired performance. In the past it was necessary to do this work entirely by trial and error, examining as evidence after operation scarred, worn, misplaced, deformed or broken parts. When conditions permit the use of these analysis aids, usually less time is used in discovering the deviation from the wanted operation than would otherwise be used.

The procedure for this accomplishment is shown in Table 1 with the following comments conforming to the sequence of items given.

In getting any device ready for a test it is necessary to consider what is to be found out about it, the complete equipment to be used in the test, and the preparation (such as cutting windows, *etc.*) needed to put the device into the proper condition for running the test in mind. Listed in "Taking of test data" are various devices which may be used.

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\*\* Cleveland, Ohio.

If performance in a single area, showing motion in 2 dimensions, and to some extent in a third, as a function of time is desired, pictorial equipment may be used. This includes means for stopping motion for visual examination, such as by a stroboscope or by a shutter, as well as by photographically recording the image for later leisure examination. The advantage of this lies in the fact that there is no change in the performance from loading of the parts by the recording

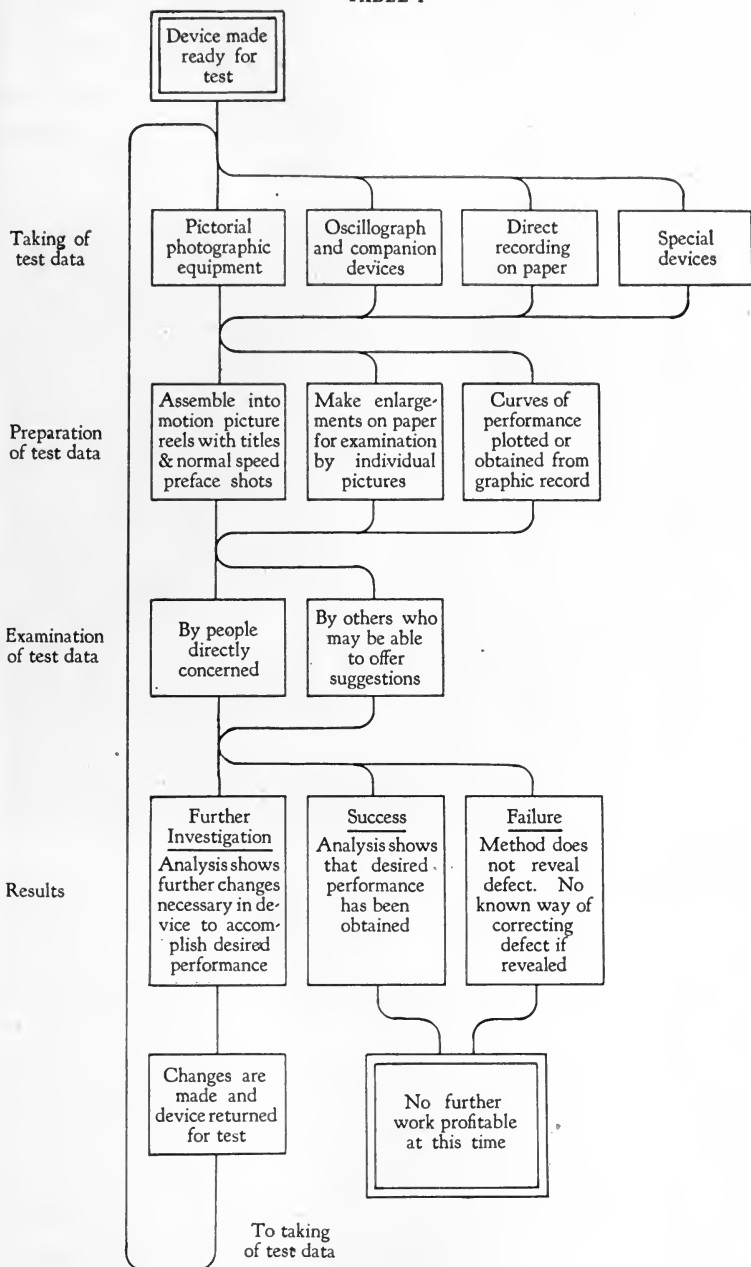


FIG. 1. Film on which recording is made being placed on camera attached to oscillograph. These with the amplifiers, power units, *etc.*, mounted on the wall are part of a travel and strain gauge setup.

instruments. The various devices that may be used for this are described in a previous paper.<sup>1</sup>

If a record of motions in several directions and from different locations is desired, an oscillograph and companion equipment may be used (Fig. 1). For relatively large motions covering whole or ordinary fractions of inches, the electrical values to be recorded by the oscillograph may be produced by the use of equipment employing a travel gauge or a slide wire resistance. For smaller motions, in the range of thousandths of inches, equipment employing a strain gauge or a piezoelectric pickup may be used. These devices may be constructed so as to read very small changes in dimensions, and when

TABLE 1



mounted on various parts that are to be stressed, they are sufficiently sensitive to permit, in most cases, the determination of instantaneous stresses from the record of the resultant strain. Each individual application of these gauges must be calibrated on the part used. Also in some instances a photoelectric cell may be employed to advantage in a pickup. Through the use of the oscillograph, electrical conditions

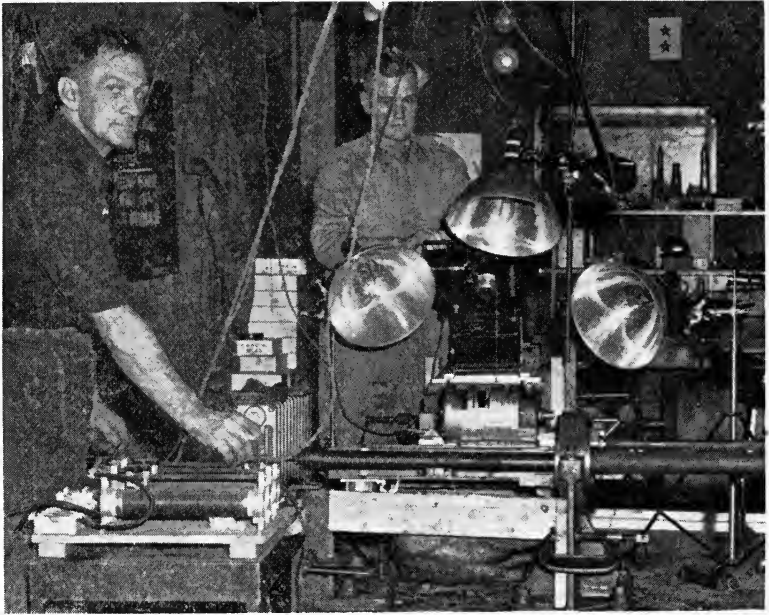


FIG. 2. High-speed camera and accessories set up for photographing the operation of an ammunition feeder for a 20-mm aircraft cannon. A drum for the use of waxed paper may be seen directly behind the lower end of the vise handle.

present in the device under test may also be recorded simultaneously with the motion.

When the motions are in one direction and in a limited area, direct recording on paper may be employed. This can be done either with a pencil or a pen on ordinary paper, or with a stylus on waxed paper, or paper otherwise coated to show the path of the stylus (Fig. 2).

Under the heading "Special devices" comes such apparatus as may have to be constructed specially to do the particular job in question. If there is considerable testing of a certain type to be done, these

special devices may facilitate much saving of time. However, since to some extent tests may be conducted with more than one of the devices listed, it is preferable, if possible, to use what is at hand rather than to construct special devices.

Under the heading "Preparation of test data" the processing of the results varies with the purpose for which these results are to be used. Motion picture film which has been examined for performance of the subject as soon as ready may be made into reels with normal speed



Fig. 3. Cardboards to which description and enlargements from individual motion picture frames are attached and which are joined by tape hinges. The action of locking of the 20-mm aircraft cannon may be studied picture by picture.

preface shots and titles for later showing to people who may be interested in the particular subjects involved. The individual frames of the movie may be copied and enlarged on paper (Fig. 3). These enlargements, when mounted 5 to a page, with typed description of what happened adjacent, may be made into a stack with tape hinges so folded that 2 pages at a time may be brought into view or, if a longer sequence of action is to be examined, as much as is required may be completely unfolded with all the views being in the proper relation as in the original motion picture film.

In some instances it is desirable to plot performance curves showing the position of the various parts being studied as a function of time.

This may be done either by projecting the film as individual pictures on the screen and measuring the positions of parts (Fig. 4), or by measuring the silver prints made for the stack as described above.

By the use of the physics formulas  $F = MA$  and  $E = \frac{1}{2} MV^2$ , it is sometimes possible to estimate the energy in the various moving parts and the forces incident to the transfer of energy to and from them. Sometimes it is found that several unknowns which cannot be evaluated are involved. For example, a force may be pushing an object which is being impeded by friction. Any acceleration or de-



FIG. 4. The special projector for examination of motion picture film. Horizontal and vertical scales with movable transparent rulers permit measurements of positions of the subject to be made.

celeration of the object is the result of the difference between the rates at which energy is being added and subtracted. The friction involved is often difficult to evaluate, because the coefficients of friction and pressures normal to the travel of the object are not easily determined. This is particularly true when explosions are involved during the operation of apparatus when there are very violent shock waves in the materials themselves causing almost incredible conditions to be revealed.

With reference to "Examination of test data," the people who are only occasionally in a position to make use of these data are often only slightly familiar with the methods by which they were obtained. To have the data as nearly as possible in the form with which they are



familiar will considerably expedite the progress that can be made in this kind of activity.

When trials are made of a device in the development stage, there are usually a number of details involved in the setup which are of interest only to the men who have asked for the test to be run, and there would be little value in any general showing. There is some advantage, however, in building up a library in which different kinds of devices are shown. Thus when there is a situation needing attention, a record of a similar situation will be available which can be reviewed to form an estimate of what can be accomplished in the current situation.

Most of the progress in mechanical devices has been by the trial and error method and, although these devices may operate very satisfactorily, it may not be known just what does take place or how much margin there is before unsatisfactory operation will result. It may be found that a device in question does work satisfactorily for the original purpose, but does not work satisfactorily when it becomes a part of a new combination.

It is when the first construction of a device which a designer has originated is complete and is being given its initial trials that these methods of analyzing fast motions are of most value. The designer has proposed certain operations when the apparatus was laid down on the drafting board, but he may not have chosen the best way to attain these, since there may not have been sufficient experience on the subject to permit the best decision to be made. When the completed device is given its initial trials, certain variations from the desired performance may be found, at this time there is more improvement to be made than there will ever be at any other time, as later some of the discrepancies will have been eliminated by whatever means there is available.

Since mechanical development has preceded by considerable time the development of methods of fast motion analysis, and so many things which have not been analyzed are already in use, there appears to be more opportunities for work on existing devices, particularly with regard to new applications, than for pioneer work at the time of origination of new devices. It is most essential that all attention be given to possible improved designs before decisions on specifications for quantity production of a device are arrived at. Information that is acquired later might have been of use if it had been known before the decision for quantity production was made, but

once made the benefits to be derived from any improvements may be more than offset by the disadvantages involved in trying to incorporate them into already finished production. In the war period, when time is at a premium, it is necessary to make decisions quickly and compromise any possible future improvement with the advantage of having what is now on hand available in quantity at an earlier date. It is imperative that what is done in the field of fast motion analysis be completely accomplished in the minimum time while it can still be used.

As contrasted with the difficulties encountered in current development, there is value to be obtained through the studying by many people of regular operation of standard equipment. Since the standard equipment may be used as component parts in many different assemblies, general knowledge of what happens during its regular functioning may facilitate the origination of better methods of employing such equipment by those who are to use it as units in their designs of larger assemblies.

There is now a question of how a fast motion analysis activity may be fitted into an already existing organization. Much depends on finding personnel who may be interested in, and adapted to, doing the kind of work needed. It is noted that with the limited experience up to the present no conclusive answer can be given, but it is believed that in general the purchase of a high-speed motion picture camera for use in the photographic department of an establishment is not the best way to go about it. Instead of making the fast motion analysis activity an appendix to an existing activity of still and ordinary speed motion pictures, the point of view should be more that of a development project, since considerable original thought and pioneer construction are involved in devising and reducing to practical methods the means for best obtaining the different kinds of data needed. Reasons for not just simply adding this activity to the work of the photographic section are mentioned more fully in the following paragraph.

In order to record extremely fast motions adequately and to interpret the data therefrom, it may be necessary to construct special apparatus and to use complicated processes which are as involved as determining the interface distances of crystals from the photographic record made on an X-ray diffraction camera, or the weights of molecules from the photographic record made on a mass spectrograph. Photography may not even be necessary for making records of certain

kinds of performance, and of course, it does not enter into the interpretation, which may be found to require a longer time than performing the experiment. It appears that the best arrangement for carrying on such an activity is to have it done by people experienced in developmental engineering, so that the evidence, when revealed, will be quickly evaluated with regard to the project, and that adjustment of subsequent procedure may be made with a view to further development of the technique employed.

Furthermore, there are other factors to be considered with regard to the introduction of a high-speed photographic activity. The ac-

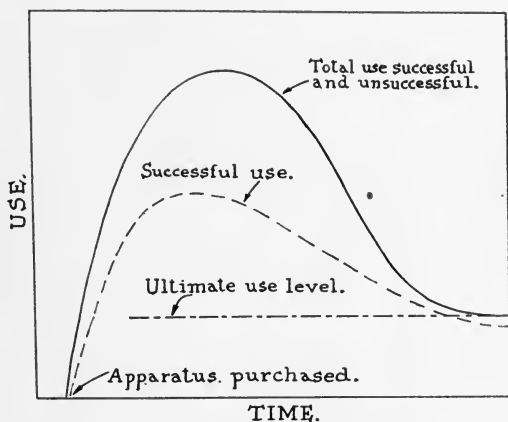


FIG. 5.

tual amount of use expected to be given to the photographic device employed in this activity can be gathered from the curves of Fig. 5. At first, the novelty of the device and the fact that some applications may be long-standing will provoke a high level of use, represented by the solid line. Then it will be used many times where useful results will not be obtained, represented by the space between the solid and dotted lines. Finally, the ultimate use of the camera, after the novelty has worn off and the long-standing applications have been tried, will settle down to the level of the dot-and-dash line. Thus, in starting a high-speed photographic activity, one must not expect the device used to maintain the high level of its initial employment.

Returning again to Table 1, there is portrayed opposite "Results" the condition where further changes in the device are necessary to get

the desired performance. As may be seen, this is the conclusion to be drawn after the data have been taken, prepared, and analyzed. The next step is to try to make the changes necessary in the device to accomplish the desired action. It is not always easy to decide just what to do in every instance, because sometimes inventive ability is not adequate for the occasion. However, it is necessary to do what-

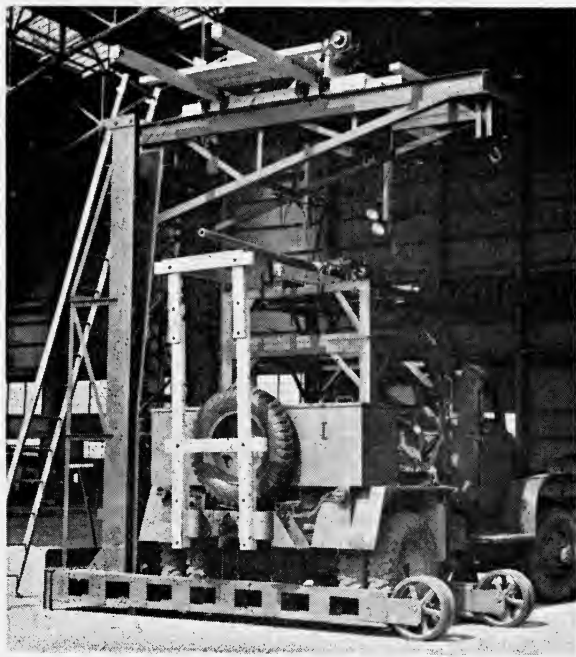


FIG. 6. 37-Mm gun mounted on turret truck for test firing. The elevator on which the camera is placed is adjustable in height for various picture sizes.

ever seems most desirable to accomplish what is needed. When these changes have been made, the device is again ready for more data to be taken and for the test cycle to be followed through again. It may be necessary to do this several times before arriving at a conclusion of success or failure. If the changes accomplish the desired results, then it can be said that the job is complete so far as the present requirements are concerned, and success has been attained. On the other hand, it may be found that what is desired has not been

accomplished, and it appears for the present there is little prospect of its being done.

In order to make the most progress in the development of apparatus, things to be done should include not only the obvious items but also those where the method of doing them can be found only by many trials, or may not even be possible until some subsequent development or invention provides the methods or material needed. Briefly, this means that not only the easy but the difficult things should be tried. Failure to get results by fast motion analysis may come from a number of things such as the fact that (1) methods used in the analysis are not suitable for the kind of investigation at hand, (2) conditions believed to be present are found to be non-existent, and the discrepancy is due to some other cause, and (3) con-

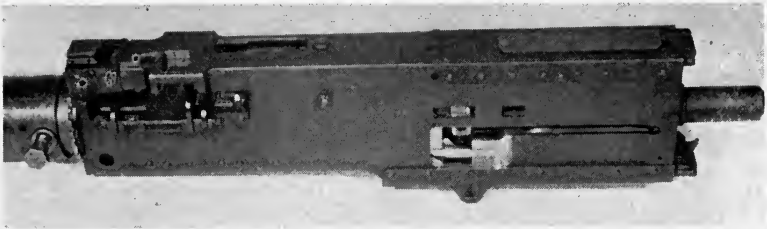


FIG. 7. 50-Caliber gun with window cut in side for viewing operation.

ditions are found to exist for which no remedy can be immediately devised.

High-speed pictures are best when the undesired motions looked for are fairly large and take up more than 5 per cent of the diameter of the picture area. There is considerable leeway, as there is a wide choice of picture area. In general, this method of analysis is best for reciprocating motions, where motions of parts are irregular and do not follow any well-defined path, or where articles are grasped, transported and released.

With reference to the analysis of fast motions, we find not only a problem in the technique of obtaining data but also a problem in the psychology of the minds of the people who are to use it. The latter perhaps is the more important, because it involves individuals as separate units, whereas technique once developed is usually universally applicable. People vary in their background of experience and reaction to ideas. Getting various people together in a discussion

might bring out some ideas which would never be thought of by these people individually.

The data should be used in such a way that not only the individuals who are primarily interested have an opportunity to study them in order to utilize their abilities for the purpose of making improvements, but others who might possibly contribute ideas for the successful completion of the problem should also review the data. Under conditions of this kind it is very difficult to draw the line where diminishing returns in useful suggestions make attention from others, not primarily interested in the problem, unprofitable.

In general, the data may be divided into 2 classes of special modifications during the steps of apparatus development and regular operations of standard apparatus. In the case of apparatus development,

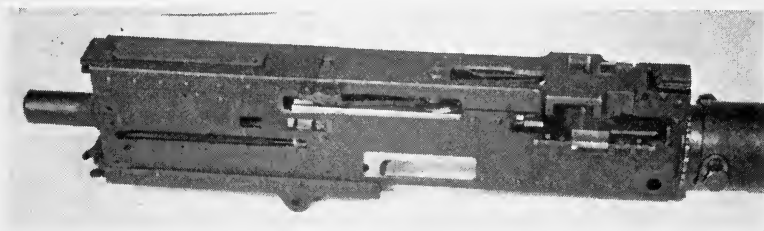


FIG. 8. Other side of same gun, showing viewing window.

perhaps only a few people known to have worked on similar problems could profitably take working time to review the data. It must be recognized that with respect to the working time available, a choice of spending this time reviewing data and advising others materially handicaps one's own activity.

In the case of regular operation of standard apparatus, it is of greater importance that people who are involved in the improvement and adaptation of this apparatus to specific jobs should study its operation. This interest may be not only in the establishment where the pictures are taken but at many other establishments where design work is done, where the devices are manufactured, and where they are fitted as component units in the assembly of larger pieces of apparatus in which they will have their ultimate use.

It often happens that at establishments other than those where the pictures or data were taken few people have any idea of the conditions under which they were taken. It is always well to have adequate

general views, in addition to those showing the data, in order that people unfamiliar with surroundings will have the preface necessary to a fuller understanding of the fast motion analysis to follow. When the data are in the form of still pictures or curves, stills might be used to show the surroundings. When the data are in the form of high-speed motion pictures, there is an excellent opportunity to use, with little trouble and expense, the old silent picture technique of explaining, by means of titles and normal speed views, the important items to observe in the high-speed motion pictures to follow.

A condition to be avoided is the disturbing of the peace of mind of those in charge of projects being studied by others who may attempt to improve their standing at the expense of those in charge of the projects. In showing pictures to others, there should never be the thought that the necessity for taking the pictures indicated inability of the people for whom they were taken to solve their problem without aid. There should be no appearance of change in the responsibility as to who decides what should be done in the program of trying various modifications thought profitable. All suggestions and interpretations of things seen should clear through the people who are directly responsible for carrying out the program of improvement.

Conditions here are different from those usually encountered. Ordinarily the person in charge knows what is to be done by reason of having previous experience in less responsible positions and can direct the work accordingly. Where inventive work is done, the person looking after it can only try to encourage excursions of the minds of those in his group into fields which are entirely strange to him. A person's efficiency in routine jobs may not be greatly affected when he is annoyed by conditions about him, but creative work is inestimably handicapped when the minds of the people involved are disturbed.

High-speed motion pictures have a unique application in training films. For the most part in training films normal-speed motion pictures are used to show the latest and most advanced procedure in order that the trainees may repeat this procedure when practicing with the actual pieces of equipment previously viewed. Under these conditions there is sufficient time for mental reactions to take place as the trainee adjusts his procedure, using actual equipment, in an effort to follow the approved procedure previously demonstrated.

Action which may require several seconds to show, but which takes place in a fraction of a second, happens too fast for anyone to make a

decision while it is under way. The showing of such fast action may give the viewer a better knowledge of performance of devices he must use, thus increasing his confidence, but unless several situations are shown illustrating the effect of proper and improper preparation before the fast action is caused to take place, there will be little training value derived. In some instances normal-speed views of proper and improper preparation followed by fast action pictures showing the results therefrom will have training value.

Much of this procedure has not been tried sufficiently to be able to say that final conclusions can be drawn. It is to some extent a case where the methods of performing the experiment are still experimental, and constructive criticism on the part of those involved may be very helpful in determining further refinements in methods.

#### REFERENCE

- <sup>1</sup> WATSON, E. M.: "Aids for Pictorially Analyzing High-Speed Action," *J. Soc. Mot. Pict. Eng.*, **43**, 4 (Oct., 1944), p. 267.



## TECHNICAL NEWS

The items appearing in this section were submitted August 22, 1944, by members of the Technical News Committee, who welcome and will consider items of current technical interest from any member of the Society.

Additional information concerning these items, or the equipment and processes discussed, may be obtained by communicating with the General Office of the Society, Hotel Pennsylvania, New York 1, N. Y.

### COLOR

Extensive tests are being carried on in Hollywood with Ansco color process, even to the point of building special printers and other equipment.

### SOUND

**Warner Bros. Pictures, Inc.**—When sound tracks are recorded for playback or cuing only, no prints are made and the negative is played back through the film playback equipment.

**Sound Services, Inc.**—A vocal booth, which can be folded against the stage wall when not in use, is a feature of Sound Services scoring stage. A number of large panels capable of being arranged to form various enclosures are suspended from the roof trusses on rails so they may be easily moved. The possibility of simulating a number of acoustic conditions has proved of value in post-synchronizing work.

**Eastman Kodak Co.**—A new Eastman 35-mm variable-area sound recording negative film, code 1372, was placed on sale in Hollywood and New York during the month of August, 1944. This is a fine-grain, high resolving power emulsion of characteristics normally desired by variable-area sound recordists.

### TELEVISION

A large number of television station applications have been received by the Federal Communications Commission from Southern California. Eight commercial applications are on file, with the possibility of a few more. The newest entry into the field is Warner Brothers. The Broadcasting Corporation of America of Riverside

is also a newcomer. The National Broadcasting Company, as well as Warner Brothers, and Broadcasting Corporation of America all seek Channel 3. The Howard Hughes organization is in line for Channel 2. The Earl Anthony application is for Channel 6. Television Productions, the Paramount affiliate, is in operation on Channel 4, while the Don Lee Broadcasting System is operating on Channel 1. The Consolidated Broadcasting Corporation, Ltd., has applied in Los Angeles for Channel 7.

#### CAMERA EQUIPMENT

**Republic Pictures Corp.**—A combination line and buckle switch for camera motors, which performs both functions, has been developed at Republic Studios. The new switch has a positive action when the trigger is released by a rod actuated when abnormal conditions of the film loop occur in the camera.

**Warner Bros. Pictures, Inc.**—Warner Brothers have purchased the Camera Division of the California Telephone and Electric Company. This subsidiary is known as the American Camera Company and is now manufacturing the Cunningham Combat Cameras for the Armed Forces. Col. Nathan Levinson is president of the new company.

#### CINEMATOGRAPHY

Owing to the present technique in most studios of shooting many scenes, especially close-ups, with extremely wide-angle lenses and with actors in close proximity to the camera, some of the latest cameras are not sufficiently quiet to permit recording low-level dialogue. When these same cameras are used for average shots with 40-, 50- or 75-mm lenses, they are satisfactory. Now with the use of 24-, 25- and 28-mm lenses for close angles, the microphone must be used too close to the camera for good sound. One major studio is considering the possibility of "blimping" their latest model cameras.

In the production of *Wilson* certain old newsreel shots were used showing President Wilson riding through the streets of Paris and London. Since no close-ups were available, it was necessary for the producers to "shoot" black-and-white "close-ups" for inter-cutting in this old footage. This was done very successfully by flat-lighting the subject and using an old model Pathe camera for the photography.

## COMMITTEES OF THE SOCIETY

(Correct to September 15)

The Board of Governors voted recently to publish in the JOURNAL regularly the personnel and scope of all standing committees of the Society. It is believed these data will be of value not only to committee chairmen and members in having an up-to-date list of committee membership, but will be of interest to others who may be unfamiliar with the general nature of activities engaged in by the various technical and nontechnical committees of the Society.

« »

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# JOURNAL OF THE SOCIETY OF MOTION PICTURE ENGINEERS

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*Industrial Arts Index* available in public libraries.

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# JOURNAL OF THE SOCIETY OF MOTION PICTURE ENGINEERS

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## NOISE-REDUCTION ANTICIPATION CIRCUITS\*

JOHN G. FRAYNE\*\*

*Summary.*—The use of an additional microphone to provide an anticipation signal to operate noise-reduction circuits is described, the anticipation microphone being placed ahead of the signal microphone by sufficient distance so that the noise-reduction element in a modulator is fully opened to permit recording of the maximum signal amplitude. In rerecording a special hill-and-dale record is made of the last rehearsal. This record is then played back during the take, the output being fed to the noise-reduction circuit and anticipation being accomplished by moving the needle ahead on the disk by an appropriate distance.

The clipping of the initial waves in a sound sequence in recording systems employing noise-reduction circuits is well known, and several concrete suggestions have been put forth by various writers with a view to eliminating this effect. Attention was first called to this effect by Silent and Frayne<sup>1</sup> who suggested the use of a delay circuit in the signal channel. The difficulties involved in designing such a delay circuit, and the expense involved in applying it to production recording, have been discussed in some detail by Kellogg.<sup>2</sup> So far as is known, no actual attempt has been made to use a delay circuit in the sound channel, chiefly because all of the devices proposed, whether artificial line, acoustic tube, magnetic tape recorder and playback, add some distortion to the sounds being recorded.

The most successful attack on the problem of clipping is the scheme described by Dimmick and Blaney<sup>3</sup> in their method of so-called "direct-positive recording." The noise reduction is attained by an auxiliary light beam which operates on the film after it has passed the recording light beam. Since this track resembles a positive made from a negative to which noise reduction had been applied, no further prints can be made without resorting to photographic duplication

\* Presented Apr. 18, 1944, at the Technical Conference in New York.

\*\* Electrical Research Products Division, Western Electric Company, Hollywood.

Kellogg<sup>2</sup> points out that this method is not applicable to variable density by any known methods.

For variable-density records anticipation can be accomplished in 2 ways, either by incorporating the signal delay circuit referred to above, or providing means for impressing the input signal on the noise-reduction circuit ahead of the signal being applied to the light valve by a time interval equal to that required for the operation of the noise-reduction circuit. The latter can be accomplished by using 2 microphones in line with the sound source, the microphone nearest the sound being used to supply the input to the noise-reduction circuit, while the other microphone supplies the signal in the normal manner to the modulating device. The use of 2 microphones was suggested by Fletcher<sup>4</sup> in connection with the operation of the compandor circuits used in making the stereophonic recordings. In this case the advance microphone supplied an input to the compressor, in order to reduce the gain of the signal channel in sufficient time to accommodate the incoming signal of increased amplitude. So far as is known to the author, the use of a separate microphone to actuate a channel employing noise reduction was not employed previous to its recent use by the Electrical Research Products Division of Western Electric Company, Inc., in connection with the recording of steep wave front sounds.

While the over-all improvement obtained by employment of anticipation is similar, whether applied to a compandor or to a noise-reduction circuit, the mechanism of obtaining the improvement is totally different in the 2 cases. In the compandor the gain of a recording channel is controlled in advance, while in the noise-reduction case the capacity of the modulating device, or light valve, is increased in advance of the incoming signal. In the compandor no change is made in the mean transmission changes in advance in accordance with the envelope of the sound being recorded.

A simplified schematic of this noise-reduction anticipation recording channel is shown in Fig. 1. The 2 microphones are shown at the left followed by 2 similar *120-B* preamplifiers. A special ganged mixer position is supplied which enables the mixer to control equally the gain of both speech and anticipation channel by the rotation of one single dial, the output of each potentiometer in the gang being fed, respectively, into the appropriate signal and control channels.

In operation the signal microphone is first placed at the position dictated by the requirements of the pickup, that is, close-up, me-

dium, or distant, the control microphone being placed about 10 ft in front of the signal microphone and in line with the source of sound. The 10-ft distance was determined by multiplying the speed of sound of approximately 1100 ft per sec and the operating time of 0.009 sec of the noise-reduction circuit. Having placed the microphones in their proper relation to the source of sound, the calibration of the 2 channels was made by setting up a loudspeaker at the sound source to which was fed a 400-cycle tone. The output of the 124 amplifier in the signal channel was first measured on the volume indicator. The output of the 120 amplifier in the control channel after passing through the high pass filter was then patched into the input of the

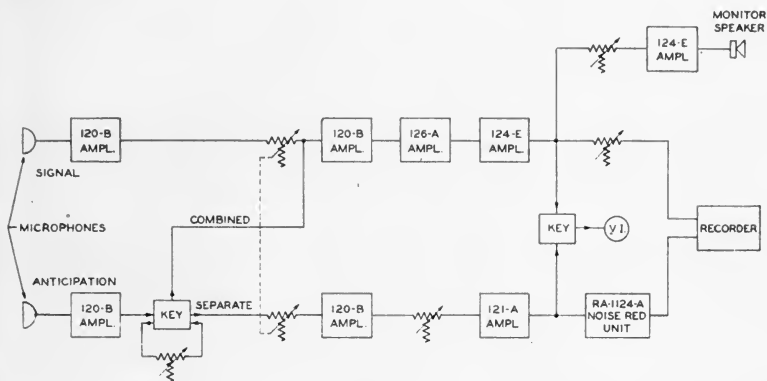


FIG. 1.

limiting amplifier in the signal channel, thus lifting off the tone from the signal circuit. The volume indicator was then read again and the gain of the anticipation channel varied by the 30 db potentiometer immediately in front of the 120-B amplifier until the 2 readings on the volume indicator were identical. Since the 120 amplifiers in the signal and control channels had previously been checked for equal gain, equal readings on the volume indicator for the 2 conditions mentioned showed equal sensitivity for the 2 circuits from their respective microphone positions. Under some pickup conditions, especially when the sound source was not well localized, "margin" of one or 2 db was used in the noise-reduction channel.

Recordings made in this manner of steep wave front sounds showed a degree of sharpness not usually associated with recordings of this nature. An unexpected improvement was a complete absence of

"hush-hush" which normally is associated with recordings of this type. Results of the initial recordings showed such an improvement in these respects that this technique was continued throughout the project.

#### ANTICIPATION IN RERECORDING

It was considered desirable to retain in the rerecording process as much as possible of the sharpness achieved in recording the original steep wave front sounds. It was conceded that the ideal method of obtaining anticipation in a rerecording channel would be to employ an

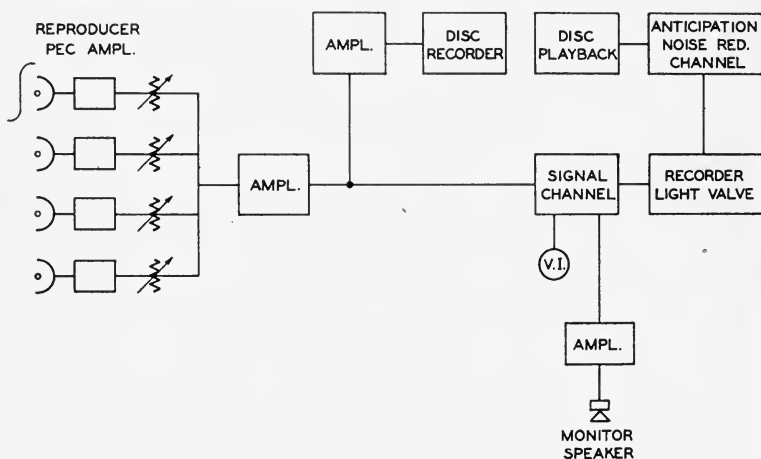


FIG. 2.

advance scanning slit in each rerecording dummy, the spacing between this slit and the customary translation point being determined by the operating time of the noise-reduction circuit used in making the rerecorded negative. This method was disclosed in U. S. Patent 2,096,811 issued in 1937 to E. W. Kellogg. Since the rerecording operation involves a great many dummies, the provision of extra slits with their associated amplifiers and mixing controls would add considerable complexity to an operation which is already highly involved.

An alternative of this scheme was employed in making the rerecordings, the circuit schematic being shown in Fig. 2, which is a simplified form of the rerecording setup. Here, the output of the individual dummies is combined in the usual manner and may be fed into



either a disk recorder, or a film recorder, or both. After rehearsing the operation a sufficient number of times to insure correct synchronization and balance of the individual sounds, a hill-and-dale wax playback was recorded. Following the making of the wax record, the output of the latter was patched into the input of the anticipation channel in a manner similar to the output of the anticipation microphone used in making the original sound tracks. The anticipation was provided by moving the reproducing needle along the groove by a distance from the starting point so that the corresponding time interval equaled the operating time of the noise-reduction circuit. A push-pull recording was then made on film, the output of the playback being applied to supply signal to the noise-reduction circuit.

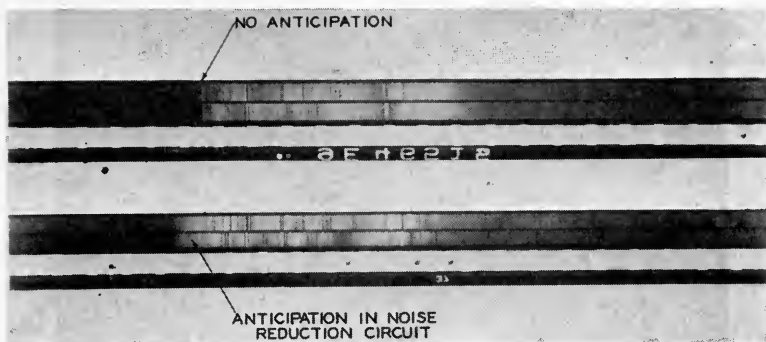


FIG. 3.

To insure that the playback level was correct for operating the noise reduction, a recording from a 400-cycle push-pull film loop had first been made on the disk. The film output from this loop and the output from the wax playback made from it were then fed, respectively, into the signal and anticipation channels and the gain adjusted until equal sensitivity was attained.

For completely correct operation of this anticipation technique it would be necessary that the signal amplitudes on the recorded take be very close at all times to those used in previously making the playback. With manual operation of the mixing dials this is, of course, difficult to achieve, but the levels in the 2 cases were apparently close enough at all times so that no apparent trouble was encountered from operating the noise reduction in this manner. Listening tests proved that rerecordings made thus preserved the sharpness of attack sounds

of the original records and were far superior to a push-pull rerecording track made employing noise reduction in the customary manner.

The photographic reproduction of 2 rerecorded tracks shown in Fig. 3 illustrates very clearly the opening of the noise-reduction circuit in advance of the signal. It will be seen that when anticipation

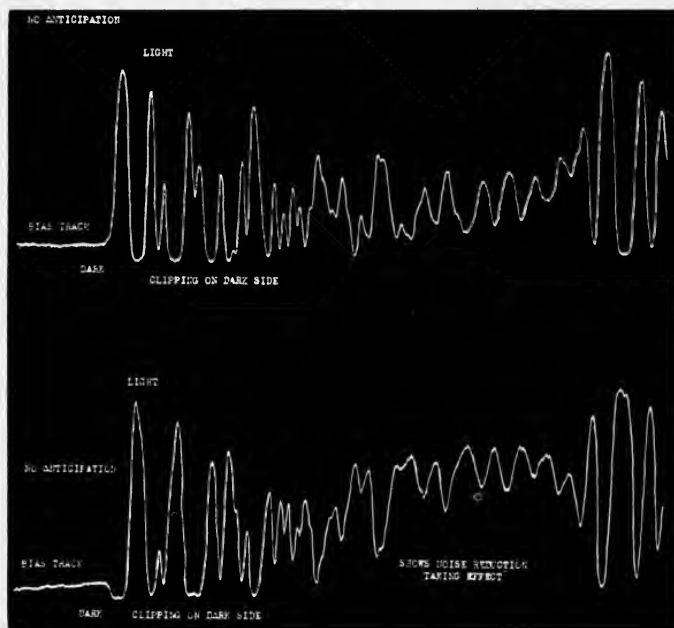


FIG. 4.

is used the transmission of the print begins to increase about one sprocket hole in advance of the first pulse, whereas in the standard condition the track remains dark up to the initial pulse. The photomicrographs, Figs. 4 and 5, show, respectively, the nature of the modulation without and with anticipation. In the first case the positive phase of the increasing signal is recorded normally by one of the component push-pull valves, while the negative phase is clipped. It will be noticed that the light valve has failed to open until the first main part of the signal has been recorded. The initial sounds recorded in this manner have the appearance of a class *B* push-pull recording.

An examination of Fig. 5 (in which anticipation is employed) shows that the bias has now been removed before the first signal pulse arrives and both phases of the initial sounds are now recorded with a high degree of fidelity.

Since the completion of this project U. S. Patent 2,341,303 was issued as of February 8, 1944, to W. V. Wolfe, which discloses the use

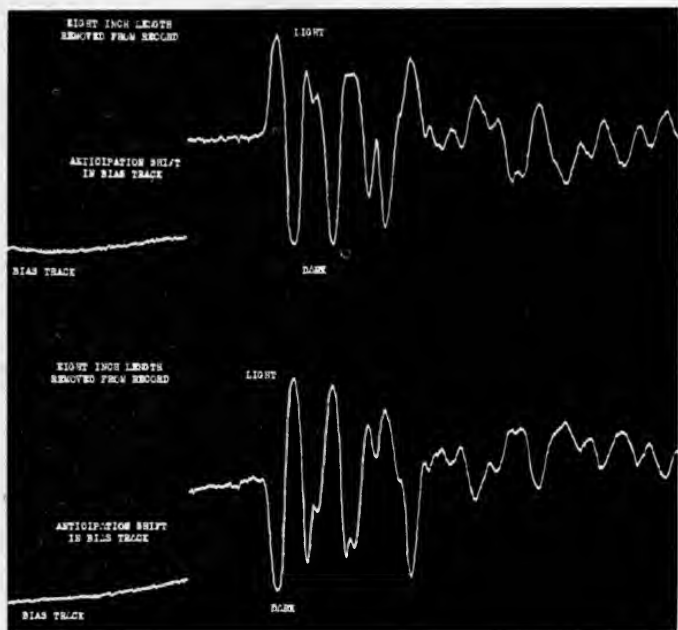


FIG. 5.

of a playback record to accomplish results comparable to those described in this paper.

The success in recording steep wave front sounds when anticipation is employed leads inevitably to the conclusion that the recording of all manner of sound effects and certain types of musical instruments would be greatly improved if the anticipation technique could be made available to the motion picture industry. However, the use of 2 microphones placed about 10 ft apart presents an almost insurmountable difficulty on recording stages owing to the limited space requirements. This condition can be alleviated, however, if a

quicker operating time of the noise-reduction circuit were made possible. For example, an operating time of one millisecond would permit the microphones to be placed about one foot apart, thus making it possible to mount both of them from a single suspension and make possible simultaneous movement of both microphones by the microphone boom operator. Alternately, the reduction of operate time to around one millisecond might make a delay circuit of the artificial line type more feasible from the economic point of view.

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<sup>2</sup> KELLOGG, E. W.: "Ground Noise-Reduction Systems," *J. Soc. Mot. Pict. Eng.*, **XXXVI** (Feb., 1941), p. 137.

<sup>3</sup> DIMMICK, G. L., AND BLANEY, A. C.: "A Direct-Positive System of Sound Recording," *J. Soc. Mot. Pict. Eng.*, **XXXIII** (Nov., 1939), p. 479.

<sup>4</sup> FLETCHER, H.: "The Stereophonic Sound-Film System," *J. Soc. Mot. Pict. Eng.*, **XXXVII** (Oct., 1941), p. 331.

## THE EASTMAN HIGH-SPEED CAMERA, TYPE III

J. L. BOON\*

*Summary.*—In the following article the Eastman Type III High-Speed Camera is briefly described, and particular emphasis is given to the improvements of this model over the Type II Camera in design and operation.

The Eastman Type III High-Speed Camera is basically like its predecessor, the Type II Camera, in design and operation, but a number of changes and improvements have been made for the benefit of the user.

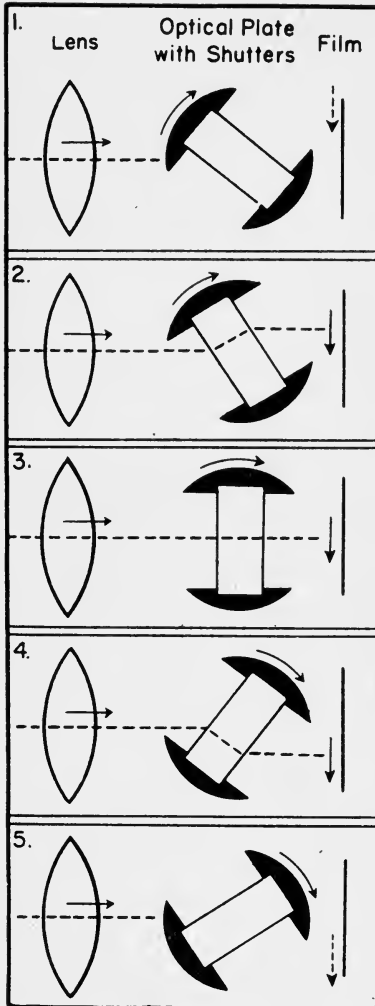
The optical compensation principle has already been described in a paper published by Tuttle and Reid,<sup>1</sup> and a description of the Type II Camera has been published by Tuttle in the JOURNAL of December, 1933.<sup>2</sup>

In the new model a universal type of motor has been continued, but the windings have been changed so that it is now possible to attain maximum speeds on 110 v without resorting to transformers. Lower voltages may be used, but slower maximum speeds will result. A dynamically balanced motor was chosen to reduce vibrations which might come from this source. Although definite evidence was lacking, it was believed that vibrations or deflections of the shaft would occur if the motor were coupled directly to the rotating compensator plate shaft. Consequently, it was decided to interpose an intermediate shaft between them, which also made it possible to separate the bearings on the rotating plate shaft so that a bearing could be placed at either end. With these improvements, the maximum camera speed was increased to 3000 pictures per sec, giving a time magnification of approximately 200 when the film is viewed with a motion picture projector running at normal speed.

As a result of considerable tests and studies, the thin rotating flat of glass used as a compensator for the film motion was retained, along with the barrel-type shutter for limiting the angle of exposure (see Fig. 1). A new type of mounting was designed in which the glass

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\* Eastman Kodak Company, Rochester, N. Y.



1. Light coming from the lens is prevented from reaching the film by the shutter.

2. After further rotation of the shutter and compensator unit, light rays from the lens are permitted to pass through to the film and are refracted upward.

3 and 4. Continuation of the rotation during the exposure period.

5. The light is again prevented from passing through to the film. The small arrows at the right illustrate the various displacements of the image formed by the lens; through the use of gears between the compensator shaft and the film sprockets, the film is advanced continuously at a rate which approximates the image displacement very closely.

For the sake of clarity, only one light ray is shown in these illustrations.

FIG. 1. Schematic drawing showing the rotating optical compensator and barrel-type shutter.

plate housing, the pinion for driving the film sprockets, and the shaft are machined from a single piece of steel.

The same general plan of film path is retained in the Type III Camera (see Fig. 2). The film travels from the supply spool over the upper sprocket, past the film gate where the exposure is made, over the lower sprocket, and then to the take-up spool. The film gate is reversed, however, so that it now touches the film backing instead of the emulsion, a change which retains a substantially flat focal plane at the exposure area. For ease of threading, the spring-mounted up-

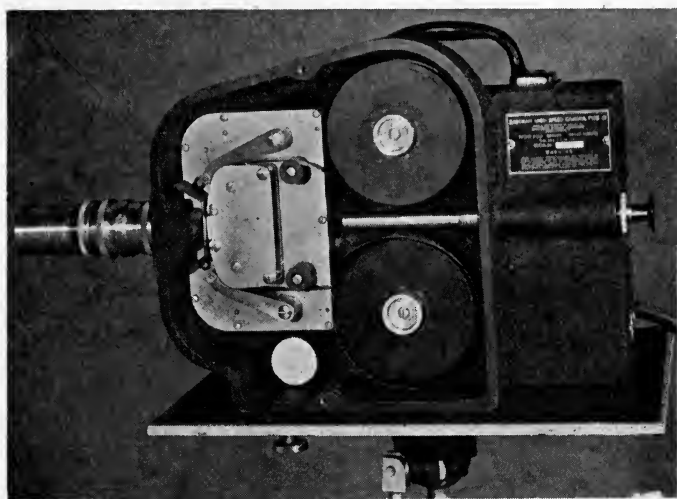


FIG. 2. Interior of Eastman Type III High-Speed Camera.

per sprocket was improved so that its toothed portion is now limited in its motion relative to the directly driven inner portion. In this way possible damage to the spring is eliminated, as well as uncertainty regarding the exact amount of tension in the film across its gate.

Excessive unwinding of the film on the supply spool is prevented by a friction brake on its shaft, and compensation for the varying diameter of the film on the take-up spool is obtained by means of a friction clutch driven by the motor through a vee-belt. A circular housing around the take-up spool has been devised to reduce the possibility of flaying of the trailer end of the film. Both film spools are fastened to their respective spindles when the film is run through the camera, making it possible to operate the camera in any position.

This construction also prevents unwanted vibration from the loose fit of the spools on the spindles.

All types of 16-mm film (up to 100-ft lengths) may be used in the camera although care must be taken to see that it is wound on aluminum spools which do not have separable film clips on the core. By eliminating the timing-clock image from the main picture area, standard 16-mm pictures are now recorded on the film.

From our past experience, we have learned that it is difficult to

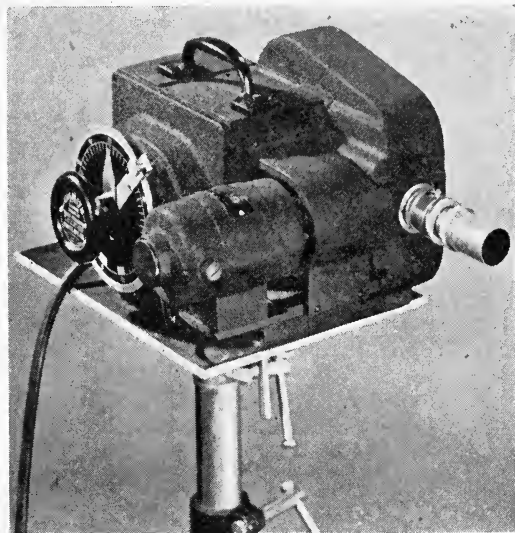


FIG. 3. Side view of Eastman Type III High-Speed Camera, showing the motor and speed control rheostat.

perform control operations during the run of the film through the camera—a period of time which may be less than 2 or 3 sec. We, therefore, make use of a mechanically driven cut-off switch which, when pre-set for the length of film being run, automatically cuts off the current to the motor at the correct time, thereby decreasing the chance of damage to the camera from excessive acceleration. Approximate picture-taking rate is controlled by pre-setting a rheostat limiting stop to the desired position (see Fig. 3). This rheostat also performs the function of bringing the camera up to speed by decreas-



ing automatically the resistance in series with the motor up to the position of the limiting stop, which fixes the amount of resistance remaining in series until the end of the run.

A second switch operated by the camera motor, which has nothing to do with its electrical circuit, is incorporated in the camera and may be used to start the operation being photographed after any predetermined length of film has gone through the film gate. For instance, it may be desirable to fire a Photoflash lamp or trip a relay after 30 ft of film have run through the camera. This can be done without resorting to personal effort by plugging the second switch in series with the lamp or relay and its initiating current and setting the switch dial to the desired footage mark.

To facilitate focus adjustments of the camera lens and to see the area being photographed, a telescopic magnifier has been built into the camera. The objective of this magnifier is slidable, and when in its forward position, high magnification is obtained for setting the focus accurately; in its back position, the entire area being photographed can be studied to determine the composition of the subject.

Although the camera is equipped with an  $f/2.7$ ,  $2\frac{1}{2}$ -in. focus lens, other lenses of the Kodak interchangeable-mount type (2-in. or greater focal length) can be adapted readily for use. The Kodak  $f/1.6$ , 2-in. lens, however, may be used only at near distances since it does not have sufficient back focus clearance. The standard camera lens is coated on all glass-air surfaces to increase the light transmission and picture contrast.

Subject lighting, except for self-luminous subjects, must be continuous during the run of the camera. Direct sunlight may be used at the slower speeds. Photoflood lamps and strong spotlights have been used with complete success for artificial illumination. Even Photoflash lamps have been used where lighting is required for only a short time. Self-luminous subjects can be photographed readily, and Kodachrome pictures made of this class of subjects are particularly interesting.

Owing to the shortage of some materials, changes have had to be made in order to manufacture these cameras, and in some instances manufacturers of purchased parts have also found it necessary to alter their products in a way not entirely satisfactory for our construction. In general, however, the original specifications for operation have been met in spite of the difficulties of manufacture under present conditions.

## REFERENCES

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<sup>2</sup> TUTTLE, F. E.: "A Non-Intermittent High-Speed 16-Mm Camera," *J. Soc. Mot. Pict. Eng.*, **XXI** (Dec., 1933), p. 474.

## AN AAF PORTABLE SOUND RECORDING UNIT\*

F. T. DYKE \*\*

*Summary.*—This paper describes an extremely flexible portable sound recording unit assembled and placed in service by the First Motion Picture Unit of the Army Air Forces, whose Headquarters are located in Culver City, California. It includes a general description of the equipment used, with special attention given to the provision of power supply facilities.

The equipment selected is of such nature that special manufacturing processes are unnecessary, and power supply arrangements are such that use of the channel is not restricted by the fixed conditions of weight and bulk usually associated with the conventional recording channel.

Sound recording, as practiced in motion picture studios today, is considered a field of endeavor which has passed the infancy stage. Equipments and techniques have become more or less standardized throughout the industry, owing to the efforts of the studios themselves, and through the coordinated activities of such organizations as the Society of Motion Picture Engineers, the Academy of Motion Picture Arts and Sciences, the manufacturers, and others. The final product of all has become reasonably uniform—only the methods of obtaining that product vary from one studio to another.

With the activation of the Headquarters of the First Motion Picture Unit of the Army Air Forces, whose basic function is the production of training films for use by the Air Forces, the responsibility has resolved upon those active in the sound section to obtain that same uniformity of product—"GI" style. The nature of the work itself, together with matters of personnel and equipment available, has presented some unusual problems. It has been necessary to abandon the more conventional practices and resort to improvisation and substitution to accomplish many of the varied missions assigned. These missions vary widely in nature and scope. A recording channel with its operating crew may be called upon to

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\* Presented Apr. 18, 1944, at the Technical Conference in New York.

\*\* First Lieutenant, First Motion Picture Unit, Army Air Forces, Culver City, Calif.

record in rapid successive moves on a sound stage, with all its facilities, in an airplane, airborne or aground, in an airfield hangar, out on a remote part of a runway, in an aircraft factory, among a group of mobile repair or radio trucks—from there to an operations tower, and then back to a sound stage for process slots.

Transportation facilities vary widely. The channel may take a 2-mile ride in a jeep, or a cross-country jaunt aboard a fast bomber,

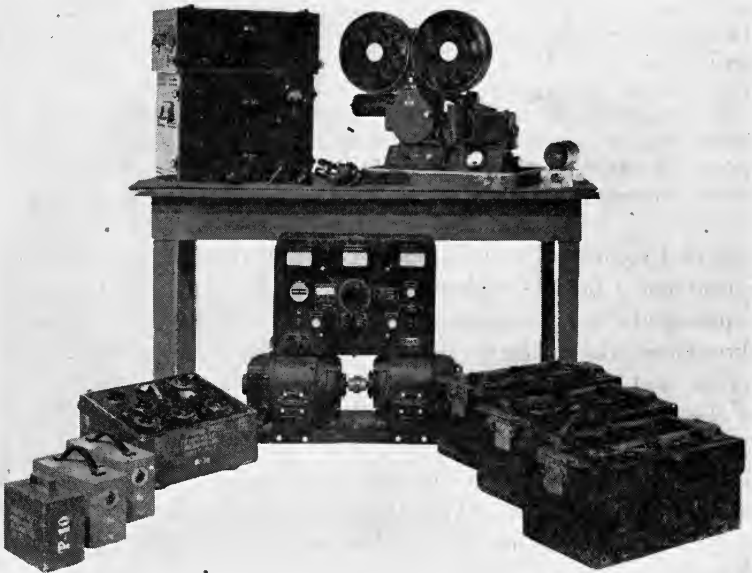


FIG. 1.

or by slow freight. It must be prepared to operate strictly on its own or as a unit in a highly coordinated operation, such as is demanded by process projection scenes.

To fulfill such requirements, an extremely flexible sound recording channel has been assembled and placed in service at this Headquarters as an all-purpose, portable unit, completely adaptable to whatever conditions may be encountered. The component parts were selected for immediate availability rather than for superior results to be obtained, and they were assembled in such a manner so as not to be bound by any fixed condition; and most important, no

pecially manufactured equipment was necessary. The basic channel as it now stands consists of a mixer console capable of handling 3 microphones, an electronic mixer or volume compressor, a power amplifier, a ground noise reduction amplifier, and a variable-area galvanometer-type film recorder, together with the all-important power supply apparatus. (See Fig. 1.)

The use of Western Electric Type 630 ("eight ball") microphones was decided upon for their uniform quality, ability to stand punishment, lightness, and relatively high output level. RCA Type MI-10209 microphone amplifiers are used ahead of the mixer console so that vulnerable low-level lines are avoided. The console, in addition to the microphone volume controls, provides a variable gain monitoring line and an adjustable high-speed volume indicator meter, each of which is bridged directly across the recording galvanometer, so that the mixer at all times monitors on the complete recording channel, a condition doubly necessary when a volume compressor is used. Western Electric Type 705 headphones are employed for high quality and dependability. The console also provides a signal-telephone line to the recorder, with an extension for an auxiliary telephone when necessary.

The compressor, power amplifier, and ground noise-reduction amplifier are of the type manufactured by RCA and listed as part of the *PM-40* Portable Recording Channel. These units are arranged for either a-c or d-c operation. The compressor is mounted in one case, the remaining 2 units combined in a second case. They have been modified only to the extent needed to provide essential cabling and power facilities. The compressor has been provided with a "de-essing" equalizer, an addition found necessary for this type of recording. The gain frequency response of the channel is strictly conventional, in accordance with present studio practices.

A standard RCA Type *PR-22* film recorder is employed without modification. This recorder utilizes the rotary stabilizer to control film motion, a device found to be ideally suited for this type of work; the bilateral aperture and noise-reduction shutters; the ultraviolet filter; it is equipped with a footage counter and tachometer, and is arranged to operate with synchronous, Selsyn, or dc-ac interlock motors. The recorder is provided with a suitable carrying case containing a shock-proof mounting.

Provision for power supply has been so arranged that when storage batteries must be used, a single set providing 36-v d-c is sufficient for

all purposes. Since any type of battery may be used, it is not necessary to carry them when weight and bulk are factors in transportation. The essential units may be secured at the destination. All component parts of the channel are interconnected by means of flexible, rubber-covered, shielded cables equipped, where necessary, with conventional Cannon plugs. The shields and grounds have been so arranged that the speech circuits are isolated from the motor circuits; therefore, pickup troubles originating in the motor lines are eliminated.

When the channel is operated near a source of 110-v a-c supply, the compressor, power amplifier, and ground noise amplifier provide their own heater and plate voltages. A tap has been provided in the compressor plate supply circuit which furnishes plate voltage through the console to the microphone amplifiers. A source of d-c heater voltage is necessary for these amplifiers and is provided by means of cables with clips which may be connected to the storage battery when used, or to a low voltage rectifier. A rheostat and voltmeter are installed in the console for metering the heater voltage. This *A* supply is also used to energize the telephone subsets in the console and at the recorder position, and illuminates a VI meter light.

When a source of 110-v a-c supply is not available, a small, portable, Philco plate supply dynamotor is connected to provide plate voltage to all amplifiers. The dynamotor is driven from an 18-v tap across the common storage battery, and has a manually controlled voltage adjustment. One unique feature employed is the manner in which the plate voltage is supplied to the unit. This voltage is applied directly across the plate-heater circuit of the a-c rectifier tubes, so that the filters provided for a-c operation are used also for the plate generator. This arrangement permits immediate substitution of any suitable plate supply dynamotor, or a set of *B* batteries.

A source of low voltage d-c supply is required for operation of the exciter lamp in the recorder, and for operation of the amplifier heaters when 110-v a-c is not available. The supply leads for this purpose are so arranged that they may be connected to the storage battery, or to a suitable low voltage rectifier, such as the RCA *MI-3528* power supply.

When it is desirable to use synchronous motors for driving cameras and recorder, and a source of 220-v, 60-cycle, 3-phase, a-c supply is available, the motors may be connected directly to the supply line through suitable switches furnished. When the supply is not available, a Robin Stedypower portable a-c supply motor generator set is

utilized. This operates from the common storage battery, and has excellent frequency regulation. If it is necessary to use the recorder as a part of a Selsyn interlock system, such as would be the case while recording with process projection equipment, a simple substitution of the recorder motor and cable is made, and the process distributor is used for interlock and driving motor power.

When weight and bulk limitations impose restrictions, a dc-ac motor system is utilized, in this case the power is furnished by the



FIG. 2.

most readily available source, such as a set of dry batteries, or the output of the d-c generator which is usually carried with a production unit for set lighting purposes.

No trouble has been encountered because of the method of furnishing low voltage d-c supply to the various components from a common storage battery, the grounding and shielding circuits having been so planned that objectionable disturbances can be easily eliminated. Supply leads from the battery are provided with clips, so that voltages may be adjusted in accordance with existing conditions, and a balanced discharge can be maintained.

A battery charger is usually carried, and may be used to keep the batteries completely charged at all times, removing the necessity for night charging. Charging usually can be maintained while the channel is in use. On occasions, when 110-v a-c was not available, batteries have been floated, and even quick-charged by making use of the 110-v, d-c light generator, using the conventional set light dimmer to control the charge rate. Also, throughout the Air Forces, many types of portable generators are available which furnish ideal sources of power.

Once the channel is set up, a minimum amount of time is required to prepare for recording. A small fixed frequency oscillator is provided, so that it can be connected to the console in place of a microphone amplifier. The VI is equipped with a calibrated potentiometer so that accurate checks can be instantly made, such as the amounts of compression or noise-reduction margin used, level at which 100 per cent modulation occurs, *etc.* Provision is made for a monitor for the recordist, either by headphones or loudspeaker. Telephone communication between the mixer and recorder can be augmented by the use of a microphone installed at the console, whereby the mixer may give instructions to the recordist, using the channel amplifiers and monitor system.

Hence, it should be readily seen that once the nature of an assignment is known, the channel may be quickly prepared for it, and only the requisite amount of apparatus need be taken. A GI truck, with the ability to move itself over any terrain, is usually provided for transportation. But the channel may be stripped down and easily carried in a "jeep," an airplane, a small boat, or by rail. (See Fig. 2.)

Thus, we have provided, without resort to special equipment or manufacturing processes, a complete, all-purpose recording channel, capable of producing entirely satisfactory results under all probable conditions that may be encountered in the production of sound motion pictures for use in the training of personnel in the Army Air Forces.

The accompanying schedule will illustrate more clearly how the wiring has been arranged to utilize the various available sources of power supply:

Unit	Power Supply Provision
Preamplifiers and Oscillator (Heaters)	$\left\{ \begin{array}{l} \text{Any source of 8-v, } A \text{ supply.} \\ \text{An 8-v tap from the common storage battery.} \\ \text{A suitable low voltage rectifier.} \end{array} \right.$



Unit	Power Supply Provision
Preamplifiers and Oscillator (Plates)	{ Any source of 110-v, a-c supply. A suitable dynamotor. B batteries. A suitable plate rectifier.
Volume Compressor (Heaters) Power Amplifier GNR Amplifier	{ Any source of 110-v, a-c supply. Any source of 6-v, A supply. A 6-v tap from the common storage battery. A suitable low voltage rectifier.
Volume Compressor (Plates) Power Amplifier GNR Amplifier	{ Any source of 110-v, a-c supply. A suitable dynamotor. B batteries. A suitable plate rectifier.
Recorder (Exciter Lamp)	{ Any source of 18-v, A supply. An 18-v tap from the common storage battery A suitable low voltage rectifier.
Motors (Synchronous)	{ Any source of 60-cycle, 220-v, 3-phase supply. The M-G set driven from the common storage battery.
Motors (Interlock)	{ Any Selsyn or interlock motor and distributor system.
Motors (DC-AC)	{ Any source of 110-v, d-c supply. B batteries.
Telephones	{ Any small 6-v, dry battery. An 8-v tap from the common storage battery.
Battery Charging	{ Any suitable battery charger. Any suitable source of d-c supply.

## THE TRAINING FILM FORMULA\*

ORVILLE GOLDNER\*\*

*Summary.*—To carry on an extensive training film program it is necessary to define terms and procedures in order to eliminate confusion and cut to a minimum the many aspects of the job which are generally considered as unpredictable.

Five factors must be considered in the construction of every training film: the truth about a condition or set of conditions, interpretation of the truth, visualization, verbalization, and emphases. These 5 factors make up the basic training film formula, variations in the application of which result in the pattern of the film. The pattern of any training film is as interesting and effective as the mental, manual, and mechanical skills and equipment used in the development of the formula permit it to be. The pattern of a given training film is established for the purpose of achieving specific predetermined objectives with a specific audience.

The business, *i. e.*, production, distribution, and utilization of training films, as carried on by the Armed Forces, is no longer a fringe activity without status and influence. Its importance in the war effort is being proved repeatedly at shore stations, advance bases, and in the fleet. Service personnel almost everywhere now have some contact with training films.

The motion picture has made its mark in a new field on a large scale—it has moved from the corner theater to the Quonset hut, the hangar deck, and the ward room. Chameleon-like it has taken on a new aspect—changed its gaudy colors for entertainment to mellow tones for training, and the tradition, the force, the holding power of the motion picture have moved into these new spaces easily because movie-mindedness comes easily, as air-mindedness does. When space and time merge as they have today it is as easy and natural to expect motion pictures in Iceland and Bougainville as it is to expect Flying Forts and Liberators.

As the training film business grows and matures, it is necessary to look at the job being done—to check the specifications, the parts, the

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designs, the purposes, to look at the job not from the volume point of view and the maze of mathematics which indicate man-hours, miles of film, and millions of dollars, but from the unit point of view—at that significant item—the training film itself. It is necessary now to check the terms, to eliminate the confusion—in fact, to dissolve the mystery and the unpredictability which characterize the motion picture business as a whole.

At this stage of the training film job with thousands of effective and ineffective specimens at hand, it makes good sense to analyze as scientifically as possible that ephemeral screen experience for training to see “what makes it click.” Only by dissection, analysis, and definition can we hope to get closer to understanding and creating the special film that is to be the sharp and dependable tool for training.

Upon analysis we find that the agglomeration of sight and sound experience which reaches and emanates from the screen is not something formless and indescribable—certainly not esoteric. Whether it is a theatrical motion picture or a training film it is the result of skills and developments which for purposes of clarity we shall refer to as “ingredients.”

Inasmuch as we are concerned here specifically with the training film, we shall separate these ingredients and determine the *formula* of the training film, and how the formula is varied to give us the *pattern*, that is, the total style of presentation. And formula and pattern will be kept separate, for one is the *means* and one the *end*. The pattern must not be confused with the formula because the pattern is a result of a use of the formula, the important points being: first, that this resulting pattern may be either singular and completely effective or prosaic, and partially effective when evaluated for a predetermined objective; and second, that different patterns can result from a use of the training film formula even when the objective remains the same.

Now, perhaps there are some who wonder why it is necessary to go to all the trouble of analyzing and defining the structure of training films when it is so much easier to shoot pictures from an outline or “off the cuff” and then cut and recut, write and rewrite, until you get what you want, or should we say a fair compromise with what you want? It may be easier to make “films” this way and it may be more fun. However, just “films” are not training films, and rolls of celluloid covered with uncorrelated photographic images and meaningless words and sounds seldom meet a training need. Fur-

ther, you cannot carry on an extensive training film production program by using such haphazard, hit-or-miss methods. To qualify this statement a little, let it be said that you can carry on an extensive training film production program along such lines, but not when time, money, and maximum effectiveness must be considered at all times. This is the position of the Training Film Branch of the Navy and this is sufficient justification for analyzing the training film, for separating the predictable elements from the unpredictable, and for studying the mental, manual, and mechanical aspects of the training film production job.

To get an understanding of the difference between the training film formula and the pattern—the resulting style and meaning in total—it is logical to resort to an analogy.

Let us take a mural as an example, the type of mural we find in many post offices—the one which portrays the history of the United States Mail System from the days of the Pony Express to modern air mail. When such a mural is viewed by the thousands of persons who come in contact with it, it means not only many different things, but it means these things with greatly varying degrees of intensity. Many of the individual meanings may be quite different from those the artist had in mind when he painted the mural. Some persons may read into the mural all kinds of meanings that are subsidiary to the main historical story which the mural is designed to tell. Others may read into the mural “extra” meanings which are so important as to make the main theme itself *effectless* as far as they are concerned. There will be some who will find in the mural very personal meanings and much that is sentimental. Still others will find it only “interesting” or meaningless. Inevitably, there will be a few who will enjoy the mural for what it is—a fine art form, a use of skill and imagination expressed in oil paint on canvas. The enjoyment and meanings for this group will be clinical. This group will be far more interested in what the mural is intrinsically than what it attempts to say and mean extrinsically.

So our mural will mean a thousand things to a thousand individuals. Its importance as an effective contributing experience in American history will depend on many factors. Most of all it will depend on the *commonness* of the forms, *i. e.*, the signs and symbols, which are used to interpret the theme—the story of the U. S. Mail System. And the *commonness* of the forms depends entirely on what the audience brings to the mural in the way of mental and emotional experi-

ence and educational background. In other words, there will be much or little meaning in direct proportion to the commonness of the elements of the mural to the existing and potential life history of the total audience, which in turn depends on the age, the heritage, the environment, the education, the vocations and avocations, the habits, desires, and ambitions of every individual.

We can then conclude that to give the most meaning to the visualization of any subject matter it is necessary to ascertain as completely as possible the common denominators of the total life experience of the audience for whom we are "visualizing."

From this analogy we see quite clearly that the *pattern* of the mural and the resulting meanings in their little or great importance and varying intensities depend on the artist's ability to *talk the language* of his audience using only visual signs and symbols. This indicates unequivocally that he must know a lot about his audience—their education, their experience, and their habits and attitudes. More, he has to know how they express themselves and how they learn—that is, what visual forms and qualities in a context of new experience have meaning for them.

It is evident that we can translate directly the requirements of the mural painter to the instructional film maker. But the film maker has one more problem. He has to understand the values of audible forms, the spoken language and sound, when they are used *with* pictures. He has to synthesize carefully, adding just the right kinds and amounts of words and sounds to pictures to guarantee more meaning and more learning. And always, this job, too, must be done in the terms of a given audience. If the film maker does not understand the importance of a harmonious marriage between pictures and sound for a purpose, for *an* audience, only one thing can result—a panorama of innocuous visual images accompanied by a cacophony of sound, an experience which may keep an audience awake but which will be quite without lasting meaning and learning.

It should now be clear that the product of the film maker's art and craft—that experience which reaches the screen—is a cohesive force, a delicate synthesis of design and technique, a total pattern that may be coherent or incoherent, meaningful or meaningless, with or without quality which can be described or *evaluated* only as it affects an audience.

To illustrate further the difference between the formula of a training film and its pattern, and how many individual patterns will result

from a use of the same formula, let us return again to the analogy of the historical mural. Let us assume that we have a post office in a town in the Middle West for which we want such a mural painted. We offer the job of painting on a competitive basis. Five artists are given complete specifications for the project. They are given all the exact dimensions of the space into which the mural is to fit, the quality of the canvas and paint that is to be used, a time for completion of the work and a color scheme, or at least a definite indication of the colors of floors, walls and ceiling with which the mural must harmonize. In addition, they are furnished with a detailed story of the theme.

The 5 artists on receipt of the mural's specifications begin word and picture research. It is entirely possible that they will use the same source materials. *But at this stage something happens.* Each artist draws from the source materials the parts which seem cogent to him and he begins his plans and sketches. The picture and word facts which he gathers are segregated, expanded and combined, over and over again until he achieves a satisfying totality—a complete visualization of a group of ideas which pleases him aesthetically. When he has achieved what is to him a balance between fact and imagination expressed graphically, he is ready for paint, brushes, and canvas. The important point here is that each of the 5 artists will arrive at a different balance between fact and imagination, and each will express his graphic totality in a different style and different colors—yet all 5 artists will be fulfilling the requirements of the mural competition. However, each artist's work, if completed for the given audience passing through the post office of the middle western town, will have a different effect—that is to say, will mean to the audience different things with different intensities. These meanings and their effects in total may be described by the audience in empty sentences without qualifications, such as "I like it"—"It's beautiful"—"I don't understand it," *etc.*, but of one thing we can be sure: one of the murals will mean more and mean it more effectively than all the rest.

Our conclusion must be that: The same specification, research data, tools, equipment, and material used in the development of a given "theme" for a specified objective result in greatly different end products because of 2 factors—the quality of the craftsmanship expressed in the use of tools, equipment, and materials, and the appropriateness of the imagination applied to the interpretation of

research data which we assume to be the truth. And a training film, like a mural, is the result of basic factors or "ingredients," the accumulation of which we shall refer to as the *formula*, and the imaginative result of which we shall refer to as the *pattern*. Further, a training film formula like any other has to be exact and dependable and made up proportionately to accomplish definite predetermined results.

A qualitative analysis of any training film reveals the following ingredients in the order of their application in the training film production process:

- (1) *The truth* about a condition or set of conditions.
- (2) *Interpretation* of the truth as it relates to human behavior.
- (3) *Visualization* of the interpretation of the truth in a way that will permit individual identification with it.
- (4) *Verbalization* of the interpretation of the truth in terms and in a manner that will permit the relatively effortless development of definite behavioral concepts.
- (5) *Emphases*, both visual and audible, which emanate naturally out of the interpretation of the truth (2, 3, 4 above), and which will add to the immediate and retentive value of the whole.

For a better understanding of the 5 ingredients of the training film formula, we shall examine the details of each to determine its characteristics and the skills required for its accomplishment.

**(1) The Truth about a Condition or Set of Conditions.**—Obviously, this is the first thing to be determined in the production of a training film. The truth about any subject can be learned only after all the available sources of information have been tapped. To get at the truth about a condition or set of conditions as the basis for a training film, it may be necessary to do a number of different things—

- (a) Read books, manuals, reports;
- (b) Visit locations where the subject matter may be studied in fact and in operation (as opposed to its presentation in writing and conversation);
- (c) Conduct interviews with persons having an operational knowledge of the subject matter;
- (d) See motion pictures on the same, similar, and allied subject matter.

The nature of the job of determining the truth indicates plainly that it requires a person who knows how to "search out" and appraise existing information on the given subject matter. It requires a person who is not satisfied with surface observation and the easily accessible, but rather one who has the ability to penetrate the common and accepted facts and alleged facts. Frequently, in Navy

work the job of determining the truth for a training film is difficult—more difficult than might be expected—because weapons, in the sense that machine guns and battleships are weapons, tactics and personnel change almost from day to day. This means that doctrine changes rapidly, and that what was true yesterday entirely or in part may not be true today. This means, also, that as the history of a training film is written, over one-third of the time it is *in production* is entered against “research.”

Whatever the difficulties of establishing the truth, it is the first important step in the production of a training film, and if the truth is literally in transition, it must be “frozen” as of a given moment in preparation for the next step. A knowledge of training film methods is not necessary for the work of this first step, but mental acuity and a knowledge of research techniques are a positive requirement.

**(2) Interpretation of the Truth as It Relates to Human Behavior.**—In the process of interpreting the truth as it relates to human behavior, there is implied at once a given audience because human behavior is different at different ages, and it is dependent on many factors including the education, experience, heritage, and environment of the individuals making up the audience. In practice, interpretation of the truth for a Navy training film amounts to a precise but complete statement of the film’s content based on results of the initial research (the truth). The content is delimited, that is, only such segments of the truth are set down for inclusion in the film that are considered important for influencing the behavior of the defined audience. The business of interpreting the truth, and delimiting to establish the required segments for *an* audience demands a thorough knowledge of the objective of the film and the relationship the film will have to a curriculum if it exists. If no curriculum exists and the film is to “stand on its own feet” and be a complete meaningful experience without supplementary assistance, a different interpretation of the truth will have to be made. In all probability the interpretation will have to be more general with some attention given to introducing and summarizing the subject matter. There is a wide variety of unique circumstances and audiences, each of which requires a special interpretation of the truth. In this second step of training film production such special requirements are determined. In this step, though not in the first, a knowledge of the construction of training films is essential.

**(3) Visualization of the Interpretation of the Truth.**—This in-



redient of the training film formula demands "picture mindedness." To accomplish a complete and forceful visualization of the segments of the truth resulting from its interpretation and delimitation, it is necessary to "see" in detail the totality that is to become the screen experience—the training film. This process of seeing "in the mind's eye" all of the correlated details and their interrelationships must be translated into words in a script which can be read and understood by a cameraman, any cameraman—in fact, by anyone concerned in production whether he is conversant or not conversant with the subject matter.

For the visualization of complex material in a script it is often necessary to use drawings and photographs. This is a sure procedure when words alone will not make graphic the obscurities of abstract problems, *e. g.*, Location of Points on the Celestial Sphere (celestial navigation), The Occluded Front (weather), The Chain of Asepsis (surgery). Regardless of the method used to visualize the interpretation of the truth in the script, it must contribute to the production of *moving pictures* which will permit the individual student to identify himself closely with whatever he sees. For he must "feel" the visual experience as a mental-emotional entity. There must be an experiential bond, a kinesthetic response to the actions pictured. Vicariously he must get as close to actual experience in a specific area as is possible. Only if he does, is the visualization of the interpretation of the truth, the pertinent delimitation, adequate and effective for learning. This step in the production of a training film requires (1) the mental and manual skills of writers and artists who can put in a script whatever will assist production technicians in getting to the screen the right "moving pictures;" and (2) the mental and manual skills of technicians who, with equipment and materials, can translate the adequately visualized scripts into specified quality "moving pictures." Cameramen, animators, carpenters, scene painters, laboratory technicians, and many others, including actors, are a part of this job. So this step in training film production depends on 3 factors, mental, manual, and mechanical for its accomplishment. Visualization is the third and, by all measurements, the most important ingredient in the training film formula.

**(4) Verbalization of the Interpretation of the Truth.**—Verbalization as it applies to training films means, simply, the use of words with pictures to explain, interpret, and extend their meanings. However, because words come easily and may be changed and shifted easily,

there is always prevalent the danger of putting into words what should be in pictures. This fact accounts for training films that are packed with words like cars on a busy street—one against the other until none stands out, until any one is like all the rest.

Three conditions are important in the use of words in training films:

(1) The vocabulary must be "geared" to the audience. The words used must not be "over their heads," or have a "talk-down" effect.

(2) Words should be used only where absolutely necessary to an understanding of the picture. Words should not be used for themselves alone.

(3) Voices and voice quality used for narration must give the impression of understanding the subject matter. They must be "voices of experience" talking personally *to* and not impersonally *at* the audience. There must be no "selling" but rather sincere and straightforward "informing."

As has been stated, the interpretation of the truth should be verbalized in a manner that will permit the relatively effortless development of definite behavioral concepts. In other words, the audience should not be conscious of 3 experiences—seeing, hearing, and understanding, or attempting to understand. If words fit pictures and both fit the audience, the whole training film experience will be effortless and without fatigue, and effective learning will take place painlessly. If words fit pictures and both fit the audience, the development of behavioral concepts will be orderly and natural, and understanding expressed in action will be inevitable.

For this step in training film production there are required (1) the skills of "seeing" writers, picture-minded writers, who know that what is *seen* of "Fourth-of-July" fireworks is more important and lasting than what is *heard*; and (2) voices and technical equipment that can put on training films the words which, when released with specific moving pictures, are easily understood and pregnant with meanings.

(5) **Emphases—Visual and Audible.**—This last ingredient in the training film formula is by far the most difficult to explain because it covers many techniques—the gamut of optical effects and screen devices, music and congruous sound, and many others. All of these are used in training films, sometimes well, often badly, but always, purportedly, to increase the effectiveness of the films. And yet how many training films have been unpleasant and irritating experiences because they were full of senseless "opticals," so-called humor in picture and sound, loud ill-fitting music, and other "effects?"

On this ingredient of the training film formula, Emphases, the im-

portant point is that they must "emanate naturally out of the interpretation of the truth—and add to the immediate and retentive value of the whole." The fade-in and -out, lap dissolve, wipe, montage, double exposure, and the wide variety of other screen devices, all may serve useful purposes in the training film. So, too, may music and humor, but only if they add in some direct and natural way to the assimilation and retention of the subject matter being presented. It must be admitted that many of the values of these devices though accepted as genuine and important are yet unproved. It is safe to conclude that straight cuts and restrained use of other effects will add up to better training films if the jobs of *visualization* and *verbalization* are done with incisiveness to interpret delimited truths for given audiences.

The fifth ingredient of the training film formula and its devious techniques requires many skills and much equipment. It requires the special and peculiar training of technicians ranging from cutters to musicians and sound-effects men. Whatever it requires in the way of mental, manual, and mechanical skill and equipment, it requires most of all a profound and discriminating sense of combining, synthesizing, on a continuous piece of film many pictures and words for an experience which will contribute in a tangible way to learning.

These, then, are the 5 *ingredients* of the training film formula, the imaginative and creative use of which results in the training film *pattern*. The ingredients of the formula are for the most part predictable to the extent that (1) the known truth about any subject can be determined at a given time; (2) the truth can be interpreted and delimited for given objectives for a given audience; (3) the interpretation of the truth can be visualized; (4) it can be presented in words; and (5) all this can be combined and blended with a variety of emphases for definite purposes. And the mental and manual skills, the equipment, and materials used in the development of the *ingredients* are reasonably predictable.

To summarize, training films that are predictable as to effectiveness are scientifically constructed when all of these factors are understood and used creatively for their full potential. It is hoped that by presenting the training film formula in positive terms, a fresh approach can be made to the separation of "predictables" from "unpredictables" in training film construction, and further that by imaginative thinking about the *ingredients* of the training film formula, more interesting and effective training film *patterns* will result.

## THE TRAINING FILM—AN INSTRUMENT FOR THE CONTROL OF HUMAN BEHAVIOR\*

HAROLD B. ROBERTS\*\*

*Summary.*—The producer of training films may well combine the discoveries of psychology with the techniques of the motion picture. Such a combination will have as its antecedent the realization that a training film is only as good as it is an effective instrument of behavior control. While changes in the behavior of the trainee provide the final measure of excellence of the picture, standards of excellence must be considered before and during production. A film to be effective must have 4 basic characteristics: it must be built in the form of a narrative, around the successful solution of a problem; it must possess opportunities for directed identification; it must be convincingly logical; and it must be an artistic production.

Training is a process by which a relation is established between human behavior and a given problem. Ordinarily, training is the process by which the behavior of man is established in relation to a social situation or to something man has created. The objectives of training must always be stated in terms of accomplishment, of effective individual action in the solution of a problem.

Training in the Navy is the process by which the behavior of Naval personnel is changed from behavior which has been effective in civilian life to that which will be most effective in the handling of Naval equipment and personnel in combat and combat support. All Navy training points toward the successful operation of the fleet. Some personnel are attached to the fleet, others may be hundreds of miles from any sign of a fleet. But the fleet is the focus of their activity.

The success of the fleet depends upon the behavior of large numbers of Naval personnel in relation to each other and in relation to the technical equipment of the Navy. The problem of training is control of that behavior.

Success in training is in direct proportion to the predictability of behavior. The individual is said to be trained when his behavior in

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relation to his job is predictable beyond a reasonable doubt. A machine gunner is trained when he can assemble and disassemble his gun, when he can load it and fire it, and when one can safely predict that he will do all of these things in the right way at the right time. His total training involves a great many more types of behavior, but in relation to his gun, the predictability of his behavior is the measure of the success of his training.

Strange as it may seem, the behavior which the individual exhibits toward a piece of equipment (or toward personnel, for that matter) may or may not be directly related to his knowledge of it. The machine gunner may have a thorough knowledge of the 20-mm machine gun. He may know its weight and the weight of the projectile, the names of the parts of the gun, the amount of the powder in the shell, and the muzzle velocity of the projectile. But if he cannot disassemble the gun and assemble it under the worst conditions, even though he knows the purposes of the parts, if his shooting is mediocre, even though he knows and can explain proper form in shooting, the contribution which he will make is open to question.

Knowledge cannot be substituted for behavior as a satisfactory measure of success in training. In general education, we may give examinations and measure success by examination grades, we may teach facts and assume behavior, or teach concepts and assume the solution of problems by these concepts. But these are grim days, and inadequate training means the difference between life and death and battles lost or won. The behavior of officers and men in relation to each other and to matériel will prove a deciding factor in the outcome of the war.

The training officer who settles for anything less than predictable behavior misunderstands his assignment, and so does the training film maker who proceeds on the assumption that the imparting of knowledge is a sufficient aim of a training film.

The training film must be produced on the assumption that it will change the behavior of the trainee. The training film is a training instrument, and it has the same type of responsibility as the training officer. It must influence and control behavior. It must also provide information. But more importantly, it must point out the problem, the solution of the problem; it must provide the trainee with the kinesthetic concept of the behavior and provide the motivation for action. The training film must provide the information on which to act, the knowledge of how and when to act. From it the trainee

must gain a concept of the feeling of the action and the desire to act in the right way at the right time.

The training film maker has the responsibility for seeing that these factors are a part of the training film. If the film cannot provide the trainee with behavior patterns, either the film is not a training film, or the behavior patterns must be provided from another source. The film maker must make certain that the behavior patterns which are not a part of the film, are provided elsewhere in the program of the trainee.

Similarly if motivation has no part, or if information is not to be presented in a particular film, then the training film maker must know that they do appear elsewhere in the training program.

Usually the training film is an instrument for the control of overt visible behavior and as such must include basically psychological factors which cover a large area and are too numerous to be covered in a single paper. Four, however, I shall consider and briefly discuss:

(1) A great many years ago, in 1575, there appeared in print a short English comedy in verse. The title of the yarn was "Gammer Gurton's Needle." It was not very good verse, or at least it was not very interesting verse, but some historians in the field of English literature hold it in esteem because it possesses certain characteristics which have been used in the modern short story, making it the most popular form of fiction in the last 4 decades. It may be said to constitute a discovery in the field of psychology. The author revealed, perhaps unconsciously, that human beings react most favorably to a new situation when it is presented in 4 or 5 parts. Experts have named these parts the introduction, the rising action, the climax, the falling action, and the conclusion.

These parts appear also in the novel and the drama. In some instances they are in the order in which they appear here; in many instances that order is disregarded. A narrative may begin with the climax rather than the introduction and may end with almost any of the parts. Any part may be abbreviated or extended as the situation demands.

It is the contention here that the best training films to date follow the structure of the novel, the short story, or the drama. There are several reasons why training films so constructed should prove most effective. In the first place, there is opportunity for the presentation of the problem to be solved. Actually all stories are the presenta-

tion of a problem. In most problems man struggles with man, or with nature, or with machinery, or institutions which he created. In a story, the introduction provides the opportunity for the presentation of the forces, telling *who* and *what* are involved, and the *place* as well as the *time*. The rising action points up the problem, explains *how* the forces are related, and depicts the behavior of the character struggling toward the solution of the problem. The climax describes the convergent action of all factors involved in the successful solution. The falling action and conclusion portray the effects, tragic or successful, of the action on the whole problem.

The second advantage of the story form is the fact that of all the organizations of material for learning, the narrative structure is universally the most interesting. Learning is painful at best. Under conditions in which there is fear or mental conflict owing to new situations or to danger, learning may approach the impossible. In any situation there is no rule against making learning as interesting as possible. The old law, which held that the more unpleasant the learning process the better the result, was disproved long ago even though the announcement may not have reached all alleged teachers.

The narrative, in the third place, gives maximum opportunity for the presentation of a problem in terms of overt behavior.

The narrative is peculiarly suited to the portrayal of activity. Stories can be written portraying man's internal struggle. It is possible to write a drama of mental conflict. But a story of mental operations requires the greatest finesse in comparison with one in which physical action predominates. The framework of the story lends itself particularly to the portrayal of overt behavior, which is the problem of training.

The use of the story form is not free from danger. The training film maker who says, "Let us make a story out of it" should say "Let us find the story in it." The training film maker who adds characters to add interest is in danger of adding new and unrelated problems. A simple problem deserves a simple story. The simple story will hold interest when the length of the film and the complexity of the solution of the problem are commensurate with the complexity of the problem.

The series of pictures on shipbuilding skills presents a new high in training film excellence. That series portrays a group of problems involving comparatively simple technical achievement. The characters are limited to man and his machine. The plots are simple.

Man sees a job to be done, he selects the tools with which to do the job, he does it. The presentations are direct and concise. Interest is held throughout because the men responsible for the series found a simple story in each problem and presented it directly in a simple way.

(2) The best training films to date appear to give the greatest opportunity for directed identification.

The motion picture producer is an expert in the field of identification. He knows that the success of his production depends upon the universality of the identification of the audience. He knows also that identification is not only relating the picture to the experience of the audience, but also the relating of the self of each individual in the audience to the individual characters.

With the acceptance of the thesis that control of behavior is the aim of the training film, the importance of both phases of identification cannot be minimized. The first phase is inherent in the phrase, the trainee must be taken from the known to the unknown. The second is the process by which the trainee gains the behavioral concept and pattern.

The ordinary movie audience identifies itself with screen behavior for the escape it offers, the trainee for quite a different reason. The trainee must in effect experience the behavior so that with the minimum of practice he can repeat it. The trainee not only must fit the situation to his past experience, but he may and indeed he must move with the characters through their behavior with sufficient identity to have introduced the basis for habitual action.

A sequence from a picture on the assembly of a marine engine will illustrate. A mechanic is securing one part of the engine to another with a bolt. In close-up the mechanic starts the bolt with his hands. One sees the hands manipulate the bolt and perceives the amount of pressure applied by noting the strain on the fingers. When the fingers meet with sufficient resistance the mechanic reaches for a wrench. One sees the hands manipulate the wrench into position to continue with the tightening. By watching the hands, the arms, the back, and the expression on the face of the mechanic, a trainee experiences the muscular feel of the process. When the strain tells the mechanic (and the audience) that the bolt is tight enough, the mechanic moves to another part of the job leaving the audience with the picture, the sound, and the feel of the procedure.

The extent or quality of identification provided is subject to



restriction. Smooth, easy, expert behavior presented in a logical way may provide opportunity for identification. The film that portrays casual competence in a skill, that portrays subcortical behavior resulting from a deeply entrenched habit may encourage identification. Such behavior is indeed an excellent setting for identification for escape, and therein lies the danger. Realizing this danger, in the film on the disassembly of the torpedo stabilizer, the camera pans between the expert and the novice. The expert is showing the method, the novice the reason. In a film on combat action 4 fliers show us the right technique, while two show us the wrong. One of the two loses his life. Both pictures provide directed identification, but preclude the possibility of identification for escape.

A common error lies in the elaboration of characters. One film involves one of the most dramatic problems of wartime communication. The obvious characters were man and his equipment.

The setting for identification was good. But the writer added a new character in the form of a teacher. The resulting cast included a teacher, 2 pupils, and the equipment. The teacher lectured for the most part; the pupils' behavior was limited principally to listening. In other words, the teacher identified himself with the equipment; the pupils identified themselves with the problem through the teacher's words. The audience was left with a complex situation and to its own devices. Extraneous characters with interesting but unimportant functions may serve only to upset the direction of the identification. The identification must prevail along the lines and in the direction in which the change of behavior is expected.

(3) The best training films to date are convincingly logical. A procedure that is expected to produce a behavior pattern must be developed in logical order. Possibly the commonest logical order is chronological. The assembly and disassembly of machinery are portrayed in such order for the most part. In technical training, chronological procedure predominates. But whenever a film says in effect, "Let us go back and check up," a new element of logic is introduced. Chronological order not sufficing, the training film maker has resorted to presentation in psychological order. The chronological order serves the machine, the psychological the man.

In the film on how an officer should report to a new station, the young Ensign sends his personal gear aboard ship in a small trunk. His gear properly stowed, he goes through the accepted chronological series of steps in the completion of reporting. Near the end

he glances through the porthole to see his trunk floating in the bay. He recalls that he was instructed to forward his gear in a wooden box that could be destroyed, because of the lack of stowage space. The script writer could have had the Ensign come aboard with the box in the first place, but he chose well to use this psychological device of delayed action in one short scene to impress the trainee with the logic of the entire picture.

Man may control a machine in a defined chronological order, and there may be chronological steps in the assembly and disassembly of that machine. But man learns in whole patterns. Man does not learn in chronological steps. Man learns by grouping steps into a comprehensible whole. In the training film which portrays the disassembly of a small marine engine, a mechanic is seen removing the bolts that secure the engine head. He takes out one after the other in a logical numerical sequence. Following the removal of the final bolt, the engine head is lifted. At that point the trainee is impressed with the logic of the procedure, and he combines all the steps into a pattern. He has gained the pattern for the removal of the engine head.

The procedure in the removal of the engine head has a natural convincing consequence. But a chronological procedure may have no evident consequence. In such cases one or more must be discovered if learning is to occur. A film without such psychological checks is particularly ineffective.

One film portrays the duties of a petty officer in preparation for the starting of a steam turbine. He is to open or close approximately 15 steam, water, and oil valves. These valves are distributed at uneven intervals around 4 of the 6 walls of an L-shaped room. The petty officer proceeds around the room opening or closing the valves in order of their occurrence. At the close of the series the audience can see that the petty officer believes the assignment to be complete. But the audience is without conviction. The trainee has been given no consequences of the activities of the character around which he can unify the preceding steps. In short, the trainee has not learned the procedure and he cannot learn it from the film alone.

In leading the trainee from the known to the unknown the order of procedure is dependent no more on how the equipment acts than on how the trainee *reacts*. The trainee reacts best to a new procedure when that procedure is convincingly logical.

(4) Finally, the most effective training films are works of art.

A production is an artistic production when it begets appreciation. A production is a great production when it begets in a heterogeneous group the appreciation desired by the artist. Such appreciation is emotional. The trainee must be provided with the information as neatly presented as possible, but, in addition, he must want to learn it. That desire to learn is emotional. The trainee must know what to do and when to do it, and, in addition, he must want to do it. That desire to act is emotional.

Motivation to change behavior may depend upon many factors. If the trainee is in a state of readiness, straight information may be enough. Readiness may have been developed in the trainee previous to the showing of the picture, but the training film maker can rarely be sure of that condition. If the trainee is not in a state of readiness to learn or to act (and the training film maker, in the majority of cases, must assume that he is not) the film has a responsibility for motivation in learning and action. Such motivation is emotional.

Thus, to produce the necessary emotional response, every training film, in a sense, must be a great artistic production. Responsible for motivating the greatest possible number of a heterogeneous group it must possess a variety of emotional appeals. The expert in the use of music cannot rely on that medium alone. Some of the trainees may be reached by the music, a few by the acting, others by the photography, by the narrator, by the tempo, by the color, or by another device. But somehow, through artistic appeal, the training film must reach them all.

However, it is not safe to assume that the desired motivation will be achieved automatically because a variety of appeals has been used. Men are trained far from home. They may see films when they are jaded and frustrated. The grave situations in which men train call for a persistent search for appeals that are appropriate.

A training film will evoke an appreciation no greater than the effort, feeling, and inspiration that go into it. The producer, the writer, the photographer, the director, the cutter, and each of the others must ask himself, "What have I contributed that will assure the appreciation which will motivate to learning and to action?"

A training film, then, to be an effective instrument for the control of behavior, must have 4 basic characteristics: it must be built in the form of a narrative, around the successful solution of a problem; it must possess opportunities for directed identification; it must be convincingly logical; and it must be an artistic production.

## TREATMENT OF NAVY SLIDE FILMS FOR PSYCHOLOGIC IMPACT\*

JAY DRESSER\*\*

*Summary.*—In preparing slide films to teach pilots in the South Pacific how to survive if forced down in enemy territory, the Training Film Branch has carried on experimental work that has definite implications for the motion picture training film field. *The Jap—His Honorable Self*, a slide film on how to “out-Jap” a Jap, provides a good example of this experimental work.

The initial problem was to get pilots in the final stages of operational training or on combat duty to be willing to view slide films to which they were frankly allergic as a medium smacking too strongly of the traditional classroom.

Secondly, because of the complexity of the material to be presented, an original treatment had to be devised to achieve a psychologic impact that would enable pilots to remember survival facts months after viewing the film. This treatment involved fresh approaches in script and art work, and the use of a color process new in the 35-mm commercial field.

Although a discussion of slide films may appear to be out of place in a meeting of the Society of Motion Picture Engineers, the experimental work carried on by the U. S. Navy in the production of a series entitled *Theaters of War—Pacific Area* has definite implications for motion picture training film production.

One of these films, *The Jap—His Honorable Self*, provides a good example of the research work in this field. Within the space of thirteen minutes it attempts to tell pilots the complex story of “what makes Tojo tick”—how to “out-Jap” a Jap in the event of capture by the enemy.

Everyone has read the gruesome stories of what has happened to some of our pilots when forced down and captured by the Japs. To try to determine what a man should do in the event of capture posed a real problem. The unspoken reaction of many people was that it probably was best to keep the last shot in a .45 for just such an

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\* Presented Apr. 18, 1944, at the Technical Conference in New York.

\*\* Lieutenant, USNR, Project Officer, Training Film Branch, Bureau of Aeronautics, U. S. Navy, Washington, D. C.

emergency. However, research indicated that there might be more encouraging procedures to follow.

It is obvious that what goes on behind the horn-rimmed glasses of these little yellow, buck-toothed fellows is quite different from what "percolates" in the upper story of the average American boy. There are certain things a white man unwittingly can say or do that will drive a Jap into unreasonable fits of murderous temper, and when a man is an unarmed prisoner he can find it quite unhealthy to anger his Jap guards.

The Navy writer and story sketch staff had the initial problem of visualizing a maze of abstract facts and theories in such a manner as to enable our men to remember how literally to keep their heads while enjoying the doubtful hospitality of the Nips.

In addition to this problem, the authority requesting the material specified that the subject must be presented in slide-film form. Frankly, this posed quite a challenge.

Pilots under the strain of operational training or combat duty have little or no interest in slide films. They will accept motion pictures, but slide films smack too strongly of the academic classroom. And at this stage of training, the average "hot" pilot feels that he is too advanced to go back to school.

Our production crew, then, had this double-barreled problem:

- (1) A form of slide film had to be devised that pilots would accept and find interesting.
- (2) The film must present this complex subject with enough punch to enable men to remember it for months after seeing the film.

In other words, as the professors would put it, a treatment had to be devised to give a psychologic impact that would insure the maximum of learning.

#### GENERAL PLAN

**Use of Color.**—To arouse the curiosity of training officers and pilots to the point where they would take a look at the film, it was decided to use color. In addition to the fact that the average person is a sucker for films in color, there were several good psychological reasons for this choice. Not the least of these reasons is the basic principle that the more a training aid stimulates the visual senses, the more effective it will be. And, in spite of the present limi-

tations of color, it is more stimulating than the world of lights and shadows which the black-and-white photograph portrays.

A new type of color process, which was used to photograph this subject, will be discussed later.

**Simplification.**—The facts had to be simplified and boiled down to what could be shown within 15 min. Again, research had shown that the span of interest in training films was limited to not much more than a quarter of an hour.

Moreover, it was deemed advisable to limit the narration to one side of a 16-in. recording. This would overcome the undesirable features of stopping the picture while the "platter" was turned over.

The type of transcription disk which was cut for Navy work was limited to an absolute maximum of 13 min. It is not difficult to see why the writer, faced with the job of funneling a welter of facts into such a narrow space, suffered from a new form of claustrophobia.

**Use of Drawings.**—As another means of catching and maintaining interest, it was decided to use drawings. There were several other reasons for this choice:

- (1) Owing to the poor quality of available photographs on Japan, it would have been impossible to make satisfactory prints.
- (2) Drawings offer the advantage of complete control of subject matter and composition.

**Use of the Vernacular.**—To wipe out any further traces of the classroom, the narration attempted to use a more picturesque form of gab, which would be acceptable to the average pilot.

**Use of Psychology.**—To insure this thing called "psychologic impact," every effort was made to develop pictures that would stick in the mind. Unusual visual patterns and color schemes had to be found that would help men to remember facts by association months after seeing the film. The writer used figures of speech, gags, and other such devices that would catch the imagination and stay in the memory of the audience, for the chances were that most men would be able to see this film only once.

#### PRODUCTION PROCEDURES

**Story Sketch.**—The plan of presenting the information was first developed in story-board form. One of the story sketch men, formerly well known as a staff member at a West Coast studio, suggested a novel cartoon approach. It was to be the life story of an

average Japanese boy up to the time that our pilot might run into him as one of Tojo's tough little soldiers.

**Finished Frame Cards.**—Owing to the simplicity of the cartoon treatment as planned, the story sketch was made in the form of finished frame cards. Thus, with a staff of only 3 artists, the art work was planned and finished within 14 days.

**Script.**—The script was then written against the story sketch plan. Final polishing was done when the narration was read against a test print.

**Color Printing.**—The frame cards were photographed and printed in color by means of an iodide mordant process. Somewhat of a newcomer in the field of commercial 35-mm color reproduction, this iodide mordant process offered a relatively fast, cheap, and reliable process.

The duplicates from this process gave a definition well suited to this type of work. Moreover, "thin" colors did not wash out when photographed in conjunction with denser shades.

**Recording.**—Many ships had not used slide films simply because in a rolling sea the needle of the playback equipment would not stay in the groove of the record. Consequently, it was decided to cut fewer lines per inch and to plow out a groove deep enough to hold a needle in most conditions. The recording in this case uses about 96 lines to the inch, which limits the total running time of a 16-in. disk to less than 13 min.

The objectionable bell tone used in the average "gong opera" to signal change of frame was replaced by an oscillator tone carefully regulated to a set frequency of 370 kilocycles, which is less noticeable and unpleasant.

Attempts were made to develop pace and timing in the script in order to keep interest from lagging.

A narrator was found whose voice was of a frequency best calculated to reproduce satisfactorily on the average slide-film equipment.

#### RESULTS

Though it is too early to obtain results on the use of this particular film in the fleet, training officers in the Bureau of Naval Personnel and in the Deputy Chief of Operations for Air have expressed an opinion that this film will be very effective.

Others in this same series have been the first slide films to be accepted and used by pilots in advanced operational training and in the

South Pacific. Therefore, it is believed that some element of success has been attained in the search to make training films that have an effective psychologic impact.

However, in all humility, let it be said that the Training Film Branch feels that the possibilities of slide films as a versatile teaching tool have only been indicated. The field is wide open to great improvements in film quality and treatment, and the need still exists for a truly foolproof automatic projector that would do away with the bell or oscillator changing signal.

(*Ed. Note:* At the conclusion of the paper, Lt. Dresser presented the slide film, *The Jap—His Honorable Self*, using a projector of the latest type designed to overcome the limitations of older slide-film equipment now in the field.)



## GETTING THE MOST FOR THE NAVY TRAINING FILM DOLLAR\*

L. R. GOLDFARB\*\*

*Summary.*—The responsibility for the expenditure of funds for the production of training films, the making of release prints, and the purchase of miscellaneous items in connection with the Navy's training film program is centered in the Procurement Section of the Training Film Branch.

This Section, with a personnel of thirteen, consisting of officers, enlisted men, and civilians, operates in much the same manner as an efficiently run purchasing office of a large commercial organization. However, film producers have had to learn that the basis of their dealings with the Navy differs radically from the manner in which they had been accustomed to dealing with their commercial customers. From its inception, the Procurement Section has applied much of its energies to "indoctrinating" producers in Navy procurement policies and procedures.

The Procurement Section has been almost constantly beset with various problems, some of which were inherently problems of the Section, but many of which were problems merely because they were the problems of producers. At the present time, however, most of the problems have been solved to such an extent that commercial producers of Navy training films are operating on an efficient basis that assures them a reasonable profit. At the same time, the Navy is getting the most for its training film dollar in quality, quantity, and timeliness.

Still fresh in everyone's mind is the recent struggle with his income tax return and the resulting payment of his share of the heaviest taxes in our history—most of it earmarked for war purposes. A part of those tax dollars—a comparatively small part, it is true—will be spent in producing and distributing training films for the United States Navy. Although the outlay for this purpose is a "drop in the bucket" compared to the total war costs, the same concern is given to these expenditures as is given to the administration of budgets approaching astronomical proportions. The responsibility for the expenditure of these training film funds rests with the Procurement Section of the Navy's Training Film Branch.

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The functions of the Procurement Section may be segregated into the following *broad* categories:

- (1) To negotiate and initiate contracts with Commercial producers for the production of Navy training films;
- (2) To negotiate and initiate contracts with commercial film laboratories for the processing and printing of training films; and
- (3) To purchase other miscellaneous materials necessary to implement the Navy's training film program.

Needless to say, the effective execution of these functions necessitates the performance of countless routine operations and the maintenance of a myriad of records. At the present time the services of 13 persons, including officers, enlisted men and civilians, are devoted to the performance of these duties.

Anyone watching the Procurement Section in operation and being unaware that it is part of the Navy would think it was nothing more than an efficiently operated purchasing office of a large commercial organization. Fundamentally, he would be correct because the supplying of training films for the entire Navy is "big business" and requires big business methods. The only differences are these: Instead of spending the money of a comparatively limited group of stockholders, we are spending the money of the nation's taxpayers; and instead of being governed by the policies of a board of directors responsible to a group of stockholders, we are controlled by the policies and regulations of the United States Navy, responsible to the nation as a whole.

Those are the reasons why training film producers are soon made aware that the basis of their dealings with the Navy differs radically from the methods by which they have been accustomed to doing business with their commercial customers. For example, instead of determining the price to be charged for a film by estimating the cost of material and labor and adding to it a liberal percentage to cover overhead and profit, the producer of Navy training films is required to account for every dollar of his price. To some this may seem like "much ado about nothing"—that the amounts involved do not justify the meticulous attention accorded them. While it is true that the savings on training films may represent "small potatoes" when compared to the expenditures for the entire war effort, it must be remembered that the same policy of diligence followed in spending many billions of dollars for countless other war needs results in an over-all saving which is far from being "small potatoes."

As stated previously, one of the functions of the Procurement Section is to negotiate and initiate contracts with commercial producers for the production of Navy training films. It is to this phase of its work that this discourse will be limited.

Like other sections within the Training Film Branch, the Procurement Section, in the course of its development, has experienced growing pains and has passed through one or more awkward stages. From its inception, one of the biggest problems confronting the Section has been the drafting of the right type of contract for training films—one that was sufficiently flexible to protect producers against the contingencies of training film production, yet rigid enough to ensure that full value was being received for the Navy's money.

One of the earlier types of contracts by which it had been expected that this could be accomplished was the so-called "range price" contract. This type of contract was simply one which established a minimum price and a maximum price, the final price to be between the minimum and maximum and determined on the basis of a statement of actual costs of production submitted by the contractor upon completion of the film. This type of contract had the element of flexibility, but eventually met with objection on the ground that it was too similar to a cost-plus contract, which type of contract for training films is not looked upon with favor by the Bureau of Aeronautics. It might be explained at this point that the Training Film Branch is under the cognizance of the Bureau of Aeronautics, although it is responsible for furnishing training films for the *entire* Navy.

Another type of contract that was in use for a while was a contract with a fixed price in which was included a specific amount for contingencies. This also eventually met with Bureau objection on the ground that it was contrary to changed Bureau policy.

Another means by which training film contracts were awarded was through the use of the "letter of intent." Briefly, the letter of intent was an instrument issued to a producer authorizing him to produce a specified film or films and expressed the Navy's intention to award a formal contract prior to completion of the film. The letter of intent did not establish a contract price. It was merely a legal "go" signal. The contract price was decided upon when the production reached a stage of completion at which the final cost could be ascertained with reasonable certainty, and at that point the letter of intent was converted to a formal contract. Letters of intent were used for a com-

paratively long period, but were eventually discontinued as the result of a directive issued by the Secretary of the Navy in June 1943.

Consideration of each of the aforementioned methods of contracting for training films makes it evident that every effort was made to consider the welfare and best interests of the commercial producers as well as the Navy. It will be noted that in each instance the element of flexibility was attained, thus protecting the producer against the unforeseeable conditions of production. The Navy's interests were not entirely without protection, however. They were taken care of in the following ways:

- (1) By selecting the right producer for each project;
- (2) By conducting negotiations with the producer prior to awarding each contract;
- (3) By tight control, by the Training Film Branch's Project Supervision Section, during production; and
- (4) By close scrutiny of the producer's final cost as evidenced by the detailed cost breakdown required from every producer.

The evolution of the contractual policies and procedures finally resulted in the adoption of the current policies of the Section. These policies, which are consistent with those of the Bureau of Aeronautics, assure the efficient producer a reasonable profit, and at the same time protect the Navy against paying for producers' errors and inefficiencies. These policies and procedures can best be explained by describing a typical contract negotiation for a training film production.

Before proceeding, however, it should be explained that under current procedure, negotiations for the *production* of a film are not undertaken until the master script for that film has been approved by all cognizant parties. The script may have been written by the Navy, by an independent writer, or by a producer. Let us assume, then, a master script has been written and approved, and that it has been decided to have the film produced commercially and not by Naval personnel.

The first step will be to solicit a price proposal for production of the film from one or more of the many producers, regarding whom the Section has much detailed information in its files. But *which* producer or producers should be solicited for a proposal? It would be impracticable, obviously, to solicit *every* available producer each time a new production is contemplated. To do so would result in the waste of so much time that the value of the training film program

would be almost completely neutralized. How, then, does the Navy choose its producers for specific projects?

There are many factors that govern the selection of producers to be solicited in any given instance. As examples, consideration is given to the producer's proximity to the shooting locale, to the producer's experience and skill in the particular production techniques desired, whether the producer has satisfactorily produced films of a similar nature in the past, the producer's record as a "high-cost" or "low-cost" producer, his ability to deliver the film within the required time, and other considerations.

When it has been decided which producers are to be solicited, a copy of the master script is submitted to each with a request for the submission of a price proposal for production of the film. The Navy requests each producer to submit with his proposal a cost breakdown showing in detail the individual items of cost which comprise the total price—how much for raw stock, how much for direction, how much for photography, *etc.* It is by means of this cost breakdown that all the pertinent facts relating to the cost of the film are revealed.

The advantages of the cost breakdown are manifest. First, it induces the producer to estimate the cost of the film in a logical and orderly manner. Instead of leaning back in his chair, clasping his hands behind his head, looking up at the ceiling, and saying, "Well, let me see now. I guess it ought to cost somewhere around \$10,000," he must give it the same careful thought that a builder would give to the building of a house—listing everything that is expected to go into its construction and what each item will cost. It is not intended to imply that all producers, prior to their doing business with the Navy, used such methods of estimating the price of a film. It is a matter of record, however, that methods not much different were common practice.

The second advantage of the cost breakdown is that it enables the Navy to determine the reasonableness of the price by evaluating each of the individual items comprising the total cost. In this manner the Navy protects itself against buying "a pig in a poke." Each item of cost, from raw stock to editing, from direction to overhead, is given individual scrutiny. When an item does not appear to be "reasonable," the producer is asked to explain. Once it has been established that the individual items are reasonable, the total price is considered from an over-all viewpoint. If it is not "in line," the

individual items are again examined to determine the reason. It might be explained at this point that the Procurement Section realizes there is no "bargain basement" for buying training film productions, but it does not consider that as justification for paying "Fifth Avenue" prices.

The cost breakdown form serves another purpose. It provides a convenient means of listing the specifications for a production. The term "specification" as used in Navy training film contracts refers to the various materials, labor, *etc.*, that will be consumed in the production of a film. Included in the specifications of a typical motion picture production would be the amount of raw stock of all types, the number of men to be used, and the time to be spent on research, script writing, direction, photography (production crew), *etc.*, the type of sound recording, estimated cutting and editing time, equipment to be rented, travel locations and number of trips, number of days for crew subsistence, percentage of live action, animation, and stock footage, whether black-and-white, Technicolor, or Kodachrome, final edited length, and other pertinent details.

Aside from their relationship to cost, there is a basic reason for requiring such detailed specifications. The specifications are eventually incorporated in the contract and are a source of protection to the producer in such cases where production changes result in increased costs. Training film contracts are not cost-plus, and the only justifications for an increase in price are:

- (1) The furnishing of materials or services which are in addition to, or different from, what was originally contracted for; and
- (2) Increases in cost due to causes beyond the control of the contractor.

Prior to the policy of incorporating production specifications in training film contracts, it was frequently difficult to amend contracts upward. This was so because the contracts lacked specific details of what the price purported to cover, and it was, therefore, difficult to establish, contractually, that a requested increase in price was due to a change in specifications and not to errors of judgment on the part of the contractor. To remedy this situation, complete specifications similar to those previously referred to are now included in all training film contracts. Thus, when a producer's costs are increased because of changes, that fact can be established more easily and is given recognition by the Counsel's Office of the Bureau of Aeronautics as sufficient reason for amending the contract.

Let us assume, then, that at this point the cost details and specifications have been reviewed and the producer for the film has been selected. The next step is to request the Contracting Officer of the Bureau of Aeronautics to award a contract to the producer selected. Before the contract is awarded, however, the request must pass through certain other sections in the Bureau, each one forging a link in the chain of routine operations which leads from the contractor's letter of proposal to the awarding of the formal contract.

One of the sections through which the request for contract passes is the Office of Procurement and Material Liaison, commonly referred to as OP&M. This Section, which maintains liaison with similar OP&M sections in other Navy bureaus and with the Army procurement activities to exchange information on contractors' prices and procedures, reviews all price proposals with the particular section requesting the contract. Although the result of negotiations conducted by the Training Film Procurement Section usually is accepted, it is often necessary to furnish OP&M Liaison with detailed explanations of various items of cost contained in requests for contracts. This explains partially the necessity for the Procurement Section to probe deeply into each proposal before requesting a contract.

After the contract has been awarded and the producer has commenced production, the Navy frequently requests changes involving increases in cost. For purposes of expediency, the Navy Project Supervisor assigned to the project is given authority to authorize individual changes which involve an estimated additional cost of not more than \$1000. If a change involves an expenditure of more than \$1000, the approval of the Training Film Branch is necessary. Before completion of the film the producer may consolidate all of these authorized changes into one request for an amendment to the contract. Training film contracts, as currently drafted, also provide for increasing the price of a contract for additional costs resulting from causes beyond the control of the contractor. Chief of these causes is "stand-by" time due to adverse weather conditions and unavailability of Naval personnel or equipment.

Thus it can be seen that the type of contract now in use has the quality of flexibility desirable and necessary in training film contracts, yet adequately protects the Navy's interests. In effect, the Navy says to the producer, "We agree to pay you so many dollars for producing a film in accordance with the approved master script

upon which your proposal was based. If we request you to make any changes which involve additional costs, the contract price will be increased accordingly, or if circumstances beyond your control necessitate additional expenditures, the contract price will likewise be increased. If, however, your actual cost exceeds the contract price because you estimated incorrectly or were inefficient, you will be paid the contract price only."

There are many cases in which changes requested by the Navy result in *decreased* costs. Situations such as these are taken care of by including in most contracts a "reduction in contract price" clause. The practical effect of this clause is to reduce the price of the contract if the producer's final costs plus a reasonable profit are less than the contract price.

Evidence of the effectiveness of the Procurement Section's policies and procedures may be found in the results of audits of training film producers' records. These audits are conducted by the Navy Supervisory Cost Inspectors of the various Naval Districts. Such audits have revealed that the majority of the firms producing films for the Navy are earning what the Navy considers a reasonable profit. In the few cases in which the profits earned exceeded what is considered a reasonable rate, the causes were found to be due primarily to differences between the Navy's and the contractor's methods of computing costs.

Officers of the Procurement Section maintain personal contact with producers by periodic visits to the producers' places of business. Experience has proved that by meeting the producer on his home grounds it is much easier to become acquainted with his problems. It is realized that only when producers' problems, whether they relate to finances, production, procedure, contractual matters, *etc.*, are ironed out can the utmost efficiency be expected. These visits also enable the officers to familiarize themselves with the producers' facilities and methods of operation.

To facilitate contact with producers located on the West Coast, the Procurement Section has an officer representative stationed in that locality, attached to the United States Naval Photographic Services Depot in Hollywood. All negotiations and other details involving the procurement of training films on the West Coast are handled by this officer, and the results are forwarded to the Training Film Branch in Washington for final action. The presence of this representative on the West Coast reduces materially the disadvantages arising from



being separated from these producers by the width of the continent.

Although this discourse is limited mainly to a discussion of that phase of the Procurement Section's activities which relate to the *production* of training films, it would not be complete without mentioning that a large part of the responsibilities of this Section pertains to the purchasing of materials and services for the making of release prints of training films for distribution to Naval activities all over the world. As a matter of fact, the amount of money spent for the making of release prints is only slightly less than the expenditures for productions, and the same attention to details that is given the expenditures for productions is given the expenditures for prints. To give some idea of the magnitude of this particular phase of the Procurement Section's activities, the total length of release prints purchased in the last 12 months alone approximated 35,000 miles—enough to encircle the earth almost one and one-half times, and enough to keep a single projector running 24 hr a day, every day, for approximately 9 years!

The Training Film Branch is appreciative of the efforts of the commercial organizations who have made it possible for the Navy to train its personnel more quickly and more effectively than ever before. Most of them have put patriotism above personal gain and have cooperated to the fullest extent in enabling the Navy to get the most for its training film dollar in quality, quantity, and timeliness.

## IT IS TO LAUGH\*

J. E. BAUERNSCHMIDT\*\*

**Summary.**—*The best teaching is that which is done in a relaxed atmosphere—one in which the students are in sympathy with the instructor. Therefore, when a training film is used as an aid to the instructor, it should also to some degree provide a measure of relaxation. One of the most effective methods of creating a relaxed atmosphere is by the use of humor.*

*In film form, humor may manifest itself in many ways. There is the humor of negative example, of situation, and of plot. There is narrative humor, pictorial humor, custard-pie humor, and the subtlety of camera humor. These various types of humor may be blended so that the resulting laugh is derived from the combination of any two or even three of these techniques.*

*But, however the humor is achieved, it may serve as a genuine neurotherapeutic measure to the men who view the films aboard ships at sea, or at shore stations at distant advance bases, and create a closer union between the teacher and the taught.*

Humor at its best is a fluid and transitory element. Anatomically considered, the result of humor is the sensation of feeling good all over and showing it principally in one spot. The common denominator of humor is the contact of incongruous ideas which generates the element of laughter. If you say to a man "Here's a nickel, drop down to the corner and get me a cigar" and he drops through a trap door and disappears, that is humorous, but not even the experts can tell you why. E. B. White, a professional humorist, says, "Humor is a final emotion, like breaking out into tears. A thing gets so bad and you feel so terrible that at last you go to pieces and it's funny. Laughter does just what tears do for you. My life as a humorist began in a Child's restaurant when a waitress spilled buttermilk down my neck. That great smear of wet white coming down over a blue serge suit, and her words '— —!' were the turning point in my career."

The philosophers Kant and Pascal agreed that the essence of

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humor was in starting toward a plausible goal, and ending up nowhere at all; thus Groucho Marx's familiar "When I came to this country I didn't have a nickel in my pocket. Now I have a nickel in my pocket!" Sigmund Freud propounds the belief that humor and laughter are both based on the release of the subconscious will. The trouble is, there are all kinds of humor. Some is derisive, some sympathetic, and some merely whimsical. That is what makes comedy so much harder to create than serious drama. People laugh in many different ways. They cry in only one.

But whatever the proper definition of humor may be, laughter is as much a part of the temperament of America as baseball, or trying to get something for nothing. And if it is agreed that teaching must be in tune with the temperaments of the taught, then there can be no question that laughter should be a part of our teaching devices—specifically, our training films. Teaching is, at its best, guidance. For guidance to be effective, the instructor must first win the affections and confidence of his students. This cannot be accomplished in the Olympian isolation of precious, exclusive dignity. The defense for dignity is that it engenders respect. But the reward of a frozen face is a lukewarm lesson.

Laughter is a psychological whip which may snap an audience into alertness. How many of you have seen a dull scene or sequence livened up with a humorous twist, and noticed how immediately the air is surcharged with eagerness. There is something in the mere act of laughing which jostles a person both physically and mentally and jiggles his equilibrium. A group of students who are alert will learn better than those who are apprehensive or uninterested.

Moreover, so far as it eliminates emotional blocking, laughter is a stimulant to learning. By emotional blocking is meant that state of mental constipation that results from apprehension, annoyance, or tension. Any newly indoctrinated reserve officer who suffered the rigors of Indoctrination School knows what tension in the learning process is. The absolute necessity of learning fast imposes a mental hazard to the process that is not easy to overcome. Relaxation in learning is essential, and the subjects that were easiest to learn were those that were presented in the most interesting and relaxed manner.

Fear is a strong inhibition to the acquisition of learning. Fear paralyzes. An individual afraid is in no mood for intellectual adventures. There is nothing like laughter to route a bogey. Reports from the fleet reveal that men, as they near the combat area, forsake

classrooms, manuals, charts, and all other aids to learning, but they will look at films, perhaps for deriving some measure of relaxation from the tradition of entertainment that films provide. In film planning for men of the fleet, we must capitalize on this preference for films as a teaching medium. We must make them entertaining as well as authoritative, for a relaxed audience is one that will learn more.

Akin to fear is worry. It precludes concentration and stifles initiative. But care can be laughed away. People turn to levity and amusement in order to forget their anxieties. Comedians from ancient times on have been regarded as healers for the oversolicitous. The need for mental therapy inherent in humor is tremendous among personnel afloat and at advance bases.

Moreover, it is a psychological truism that subconsciously we tend to forget the unpleasant and remember the pleasant. Hilarity is so pleasurable that everything connected with it becomes something to enjoy and to preserve in the memory. The happy learning creates the deepest impression.

With technical subjects, humor may be an ignition spark to the mental engine. A student is stumped. No matter how repeatedly or how variously something is explained, he is stopped at the point of comprehension. Then something occurs to start him laughing. And suddenly the solution becomes clear. It is a strange phenomenon, but it works. The blocking is probably caused by intellectual or neural rigidity brought on by an anxiously fixed mind. The individual tries so hard to scale the barrier along his line of attack that his mind gets one tracked. It loses its flexibility. What is needed is some distraction to jerk the reason back to normal. And laughter is an eminently satisfactory distraction.

The simplest type of film comedy—the one that will most readily produce a laugh—is the comedy of negative example. It is the comedy of the unpleasant taken playfully. It may be divided into 2 categories: the sympathetic, and the derisive or derogatory. Sympathetic negative example is best used where the subject material is difficult either to perform or to comprehend, and where we do not expect the student to acquire comprehension without a certain degree of difficulty. The derisive or derogatory technique is best used where the subject material is easy to comprehend, and where we expect the student to acquire comprehension immediately, if, indeed, he does not already possess it. This is the comedy of superiority.

By implication, the film says, "We here in the audience are a good deal wiser than *this* jerk!" Thus, we teach by indirection. We put our teaching on an assumptive level. We flatter the audience and win their affection and support.

Another type of film comedy is the comedy of allegory. In ancient times the actors wore masks which immediately indicated to the audience the mood and character of the player. The film form that begins with a shot of a naval aviator with wings, knocking at a highly imaginative interpretation of St. Peter's gates, sets a mood immediately. It becomes obvious from the very first scene just exactly the point of view the film intends you to assume. It, too, is the comedy of assumption, coupled with the humor of negative example. It is particularly suited to the motion picture medium because it provides unlimited opportunities for the use of the imagination. This type of film humor is slanted for an audience that "knows better," but its treatment is such that it can be "preachy" without being offensive. It can be highly sarcastic and continue to be highly amusing.

The humor of parody or caricature achieves its effect by means of grotesque or ludicrous exaggeration, or by means of distortion by exaggeration of parts or characteristics. It tickles the funny bone and provides a pleasurable experience. Thus a film on handling heavy loads may be brightened immeasurably by a live action shot or a cartoon insert of a typical sailor overwhelmed by a pile of bedding, clothing, cleaning gear and ammunition staggering manfully along to the accompaniment of a bright comedy musical signature.

Animation gives us the facility to visualize anything the brain can imagine or the hand can draw. To create an atmosphere of acceptance based on laughter, animation can be used to good advantage in training films either as an introductory device, or as a parenthetical vehicle to emphasize a point. The introductory technique is most effective in creating an atmosphere of relaxation. A film on damage control may be enlightened by a 40-sec introductory cartoon animation sequence which reveals a Japanese shark sawing a hole in the hull of a boat, and the ensuing slapstick comedy that results when a sailor uses everything he can get his hands on to plug up the hole. This technique says, "Relax boys, we are going to teach you something here about damage control. But don't let it scare you, it's really a very simple proposition." Thus the film starts out with the students in a receptive mood. Anyone who has

addressed an audience knows the value of getting it on your side at the very beginning. You have got to break the ice.

Animation as a parenthetical vehicle to emphasize a point provides a film exclamation point. It affords a moment of visual pleasure and aids retention. If it is necessary to emphasize the fact that much care must be taken when unloading a pistol clip to prevent the spring from uncoiling in your face, the fact will be remembered if in cartoon animation a dopey character unloads the clip the wrong way and almost has his head knocked off in the resulting catastrophe.

As a parenthetical device, animation can be designed to present a problem in a simplified form, to reduce it to its simplest terms, and translate the terms by means of a comedy device.

Perhaps the most difficult and most desirable type of comedy to achieve is the comedy of situation—plot comedy. This may be broken into 2 categories: first, the comedy of a natural situation; and second, the comedy of an artificial or created situation. If a writer lives with and takes a part in the activity or operation he is commissioned to write about, he will find much natural humor that needs no elaborate staging to be presented effectively. But when a writer tries to invent a situation by creating a funny episode, he may be tripped up by the fact that the episode may not be natural to the situation. Such a device is strained and unfunny. It is too obvious a play for a laugh. The humor of a natural situation requires a nicety of perception and judgment on the parts of both the writer and the director. It must be considered carefully before being enacted before the camera.

The comedy of an artificial situation is easier to create. "Pratt-fall" comedy is a part of this category. It is easy to place a hammer so that the actor will cause it to fall on his head. It is difficult to create natural humor in handling the hammer so that it is funny without being slapstick.

Another type of humor is narrative humor. The writer of a script that is breezy but not smart alecky is a valuable gentleman. A "between-us-boys" narrative tone wins attention immediately and makes the audience feel that The Voice is in the know—a regular guy. Humorous narrative is the opposite from oracle-like style that is boring, soporific, and offensive. The narrative that speaks the language of the audience for which the film was designed is better apt to succeed than the narrative that is precious to a fault, and pedagogical beyond all comprehension.

Simple pictorial comedy may often be employed to brighten up an otherwise dull graphic presentation. When statistics must be presented in film form, they may be relieved by the judicious use of humorous sketches.

Finally, the technique of the running gag is particularly suited to the film medium. This is the technique in which we establish in the opening sequences of our film a situation that is ludicrous—such as a sad-faced sailor working feverishly but ineffectively to assemble a mechanical device—and from time to time cut back to him still at work on the device and still as unsuccessful as he was in the beginning. This is a form of sympathetic negative example that can win friends and influence audiences.

And so the types of film humor that find a place in training films may be classified as follows:

- (1) The Comedy of Negative Example.
  - (a) Sympathetic.
  - (b) Derisive or derogatory.
- (2) The Comedy of Allegory.
- (3) The Comedy of Parody.
  - (a) As a film entity.
  - (b) As an introductory device.
  - (c) As a parenthetical device to emphasize a point.
- (4) The Comedy of Situation or Plot.
  - (a) The humor of a natural situation.
  - (b) The humor of an artificial situation.
- (5) Narrative Humor.
- (6) Pictorial Humor.
- (7) The Humor of Camera Subtlety.

There may be other types of comedy that have been omitted here, and there may be combinations of any two or more of the types of humor outlined above. But regardless of their types, they can and should be translated into film terms and used in the planning of training films to better insure response from and effectiveness on the vast audiences to be taught.

## THE CAMERA VERSUS THE MICROPHONE IN TRAINING FILM PRODUCTION\*

HERBERT R. JENSEN\*\*

*Summary.*—The training film is primarily a motion picture, not a sound track illustrated with pictures. A training film succeeds in its mission to the extent that it can maintain eye-attention, and consequently interest. The major responsibility for arousing and sustaining interest is the job of the camera, not the microphone, as is too infrequently demonstrated. The substitution of track modulations for pictures results in a deadly kind of training film, effective only as a sleep-producer or sedative. Subverting the track and placing the burden of maintaining interest on the camera, where it rightfully belongs, will result in training films that are stimulants.

New techniques and new equipment may be needed to fully exploit the camera. Whatever motion picture engineers can do to increase the flexibility and mobility of the camera, especially in non-studio use, will help.

The state of the art of producing training films, despite the volume achieved, still leaves much to be desired. This paper will point out a principal shortcoming of the art as it is presently practiced, from the point of view that the primary power of the screen (in instruction or entertainment) lies in its ability to maintain attention and interest through the eye rather than the ear.

The function of the training film is to present its subject primarily to the visual and not the auditory sense. The film's instructive power comes through seeing, not hearing, as is so admirably stated in the Chinese phrase, "one hundred hearing not so good one seeing."

The fact that the motion picture was originally designed for the sense of sight is too often forgotten in *writing* and producing a training film. The word "writing" is stressed, for that is where the fault too often lies; scripts are written rather than pictured. This is understandable for we have been able to use and manipulate words for hundreds of years while we have had less than 50 years of practice in using and manipulating pictures. The adoption of the policy of

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\* Presented Apr. 18, 1944, at the Technical Conference in New York.

\*\* Lieutenant, USNR, Training Film Branch, Bureau of Aeronautics, U. S. Navy, Washington, D. C.



using the spoken word instead of the picture is not from lack of knowledge. The experience gained from the days when films were silent taught us otherwise.

The extent to which the word has been used instead of the picture is indicated by the results of an analysis of a few typical scripts. The script of a picture judged an excellent production had a word-to-scene ratio of 3 to 1, 3 words per scene. The script for another picture that had "sleeper" tendencies had 38 words per scene. It is admitted that this method of judging the effectiveness of a film is a crude one, but it does give some indication of the extent to which words have been substituted for pictures. The quality and effectiveness of a training film are undoubtedly related to the word-scene ratio, and the lower the ratio the better the film.

A further indication that the camera has not been used efficiently is the oft-heard remark that training films put men to sleep. The auditory sense, as may be proved by this discussion is a powerful sedative, and even its use here may put you to sleep. The same thing happens in the training film, or more accurately stated, the film lecture in which the eye is subverted by the ear. If the audience sleeps the picture fails. One of the reasons why men sleep may lie in the fact that the screen does not hold the eye because words have been substituted for pictures and the film thereby fails to maintain the attention of the learner. To avoid this the eye must receive the major impact and not the ear.

The problem of maintaining attention is also related to film length. Many training films are longer than they need be because of inadequate handling of the screen image. Not enough of the right pictures are used in the right way, with the result that the track has to say the things the screen does not say. Word explanation is less efficient than picture explanation, and the greater the number of words needed to explain the item under instruction the more feet of film needed to carry them. This overdependence on narrative explanation results in a sound track packed with voice modulations from beginning to end with nary a pause in between. The constant bombardment of words on the auditory nerves dulls them and the learner is lulled to insensibility. Adroitly used, the narrated track must allow pauses between sentences and paragraphs. Phrasing sound and silence is necessary if the mind is to absorb and make each thought presented its own before the next one drives it out.

Training film makers must learn that some silence is golden, es-

pecially that resulting from the cessation of the narrator's voice. The camera must be employed in a manner that will permit the screen to form a silent and attentive bond between it and the viewer's eye, aided by the microphone only when and where absolutely necessary.

It is easy to see why the microphone has become a "Quisling," so to speak, because of its subversive activity in undermining the job of the camera. It could not have become so without its being aided and abetted by film makers who used it as a tool, something that could be had easily and manipulated without much trouble. The ease with which a sentence is conjured up, reworked, rewritten, erased, and formed again is simple compared to the labor involved in conceiving the most efficient picture images. Further, the sentence can always be changed with ease; a picture image can seldom be changed or manipulated without the expenditure of considerable time, energy, and money. The subsequent delivery of a sentence to a microphone in a modern comfortable recording studio is nothing compared to the difficult manipulation of a camera on location. Contrast these working conditions with those confronting the camera.

Cameramen doing Navy location shooting are required to work under handicaps that seldom exist in the studio. Much of the Navy's camera work could be classified as "triphibian," involving as it does photography on land, at sea, and in the air with attendant problems almost as complicated as those involved in this type of warfare. The cramped quarters of a bridge or an engine room, the unstable platform of a landing boat or an airplane make camera handling hard work. The narrow passageways and the vertical or near-vertical ladders that must be traversed with heavy equipment to gain access to the various parts of a ship involve almost as much sweat, if not blood, as is involved in following a trail in New Guinea. It is not without cause that once a camera position is achieved it seems that it is seldom abandoned until every usable foot that can be extracted from the scene has been shot. Why move in to get a close-up or another angle when the item can be described so much more easily in the sound track? And so the microphone takes over the camera's work, the audience goes to sleep and the information fails to become part of the learner's experience.

What should happen instead of this is that the *camera* should be used to isolate, describe, and explain the item, relegating the narrated track to the background in a merely supporting role. The

camera should be used as a pointer, moving in, out, and across the scene as dynamically as the galvanometer on a recorder. Attention should be aroused and maintained by the camera's ability to interest and excite the eye.

The type of camera handling desired is of a level that would deliver to the screen an effect similar to that which the human being gets with his own eye. The effect to be striven for is the appearance of the same fluid mobility that the human eye enjoys in examining an object. This would result in more effective training films because of the subsequent increased eye attention to the screen. In this regard we should err on the side of using too many pictures rather than too few. The one act of going all-out for pictures and using words only when practically forced to, will put the camera back in its rightful role.

Now in all this what part of it relates to the work of the motion picture engineer? Some subversive activity on his part directed at the microphone, or the amplifiers, or the recorders? Not that, but rather constructive work on the camera's home front.

Mobility and ease of manipulation of the camera have been problems receiving attention for some time, but mostly in relation to studio use. If all training films could be produced under controlled studio conditions, the present equipment would be adequate. This is seldom the situation confronted, however. What studio could arrange space and accommodations to handle a battleship or a battle force, an army or an air force, even if it could get them? Since the mountain cannot be moved to Mahommet, Mahommet must be moved to the mountain. Lighter, versatile equipment of all types is needed to make this move easier and to insure that it is made.

The extensive application of light metal alloys in camera and accessory equipment will take some of the curse off the handling of equipment. Lighter cameras, tripod heads, tripods, battery cases, and so on, would free cameramen and their crews of the sometimes killing weight of equipment that has to be moved. Collapsible, lightweight magnesium dollies and tracks would aid in making it possible to move the camera in and out, to permit it to be used as a pointer. Perhaps a spring-suspended gyro-stabilized camera head can be designed which would permit moving the camera on locations where track cannot be laid. Lightweight collapsible camera platforms would be of considerable use. If these were fitted with detachable pneumatic tires they could be used to move the object into and away

from the camera in situations where it would be difficult to move the camera smoothly.

Because the photography involved in making training films must be done under handicaps not found in studio work, attention should be directed at making the camera as mobile as possible. The pen is mightier than the sword. Freeing the camera would make it mightier than the pen and subsequently the microphone. Paraphrasing an old saw, it is "every camera to itself and may the microphone take the hindmost."

## 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

25 (Aug., 1944), No. 8

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| Recent Advances in the Physics of Color (p. 259)           | H. V. WALTERS |
| Color Filters and Their Use (p. 260)                       |               |
| Film Production in Argentina (p. 261)                      | W. B. LARSEN  |
| Tropical Problems in Aerial Camera Maintenance (p. 263)    | R. H. BAILEY  |
| Kodachrome and Exposure Meters (p. 265)                    | A. WYCKOFF    |
| Television Needs Hollywood's Ace Cinematographers (p. 266) | H. HALL       |

### British Kinematograph Society, Journal

7 (Apr.-June, 1944), No. 2

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| Consistency in the Laboratory (p. 47)               | M. V. HOARE |
| The Design of Sub-Standard Sound Projectors (p. 63) | H. CRICKS   |

### Electronic Engineering

17 (July, 1944), No. 197

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| Maintenance of Quality in Film-Recorded Sound | H. CRICKS   |
| 17 (Sept., 1944), No. 199                     |             |
| Electronic Colour Television (p. 140)         | J. L. BAIRD |

### Electronic Industries

3 (Aug., 1944), No. 8

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| Recording Sound on Film (p. 98) | G. SONBERGH |
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### International Projectionist

19 (July, 1944), No. 7

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| Projection Room Equipment: Its Care and Maintenance (p. 11) |               |
| Projectionists' Course on Basic Radio and Television (p. 7) | M. BERINSKY   |
| Television Today, Pt. X—Reproducers (p. 20)                 | J. FRANK, JR. |

19 (Aug., 1944), No. 8

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| The Paramount Transparency Process Projection Equipment (p. 7)        | F. EDOUART  |
| Projectionists' Course on Basic Radio and Television, Pt. II, (p. 10) | M. BERINSKY |

How to Make Your Own Schematic Diagrams (p. 13)  
 Television Today, Pt. XI—Television Receivers (p. 18)  
 Proper Fusing in the Projection Room (p. 21)

L. CHADBOURNE  
 J. FRANK, JR.  
 H. B. SELLWOOD

#### Radio News

32 (Aug., 1944), No. 2

Theater Acoustics (p. 29)

W. MOODY

### SOCIETY ANNOUNCEMENTS

The first meeting of the fall series was held by the Atlantic Coast Section on Wednesday evening, September 27, at the Hotel Pennsylvania, New York. Mr. R. E. Farnham of the General Electric Company, Nela Park, gave a talk on "Appraisal of Illuminants for Television Studio Lighting." In analyzing the various light sources used up to the present time in television studios, Mr. Farnham took into account such factors as (1) spectral sensitivity of the iconoscope, (2) requisite illumination levels, and (3) reflection characteristics of televised areas.

The amount of heat in proportion to the light produced, the constancy of the light, and electrical interference were also discussed. Mr. Farnham compared light sources using mercury arc lamps, tungsten filament lamps, and fluorescent lamps as sources of television studio lighting.

Following Mr. Farnham's talk Mr. Worthington C. Miner, manager of Columbia Broadcasting System's Television Department, discussed the requirements for studio lighting from the standpoint of television production.

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*We regret to announce the death of William Lattimore Douden, Active member of the Society, on August 19, 1944.*

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(Correct to October 15)

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# JOURNAL OF THE SOCIETY OF MOTION PICTURE ENGINEERS

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# JOURNAL OF THE SOCIETY OF MOTION PICTURE ENGINEERS

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## WESTERN ELECTRIC RECORDING SYSTEM—U. S. NAVAL PHOTOGRAPHIC SCIENCE LABORATORY\*

R. O. STROCK AND E. A. DICKINSON\*\*

*Summary.*—This paper describes the complete 35-mm film and  $33\frac{1}{3}$  or 78 rpm disk recording and rerecording equipment installed for the U. S. Navy at the Photographic Science Laboratory, Anacostia, D. C. Modern design excellent performance, and ease of operation are features of the installation.

When Western Electric was called upon by the U. S. Navy, Bureau of Aeronautics, in the summer of 1942 to provide complete studio type of 35-mm recording equipment for the Photographic Science Laboratory, Anacostia, D. C., a considerable number of problems were presented immediately. During this period materials for fabrication of equipment were very critical and, in addition, our stock of modern recording equipment was considerably depleted and could not be replaced without proper priority.

It was required that we supply 2 complete studio channels, one recording and one rerecording channel, with the necessary accessories. The equipment was to be of the latest design and to embody all improvements of the recording art necessary for the production of high-quality sound training films for the U. S. Navy. Space and room layout had already been allocated for the Sound Division, including one main recording stage and one combination theater review room and rerecording monitor room. It was required that our equipment be installed within this area to provide the most efficient use of the designated space and to provide highest operating efficiency for the operating personnel.

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\* Presented Apr. 18, 1944, at the Technical Conference in New York.

\*\* Electrical Research Products Division of Western Electric Co., Inc., New York.

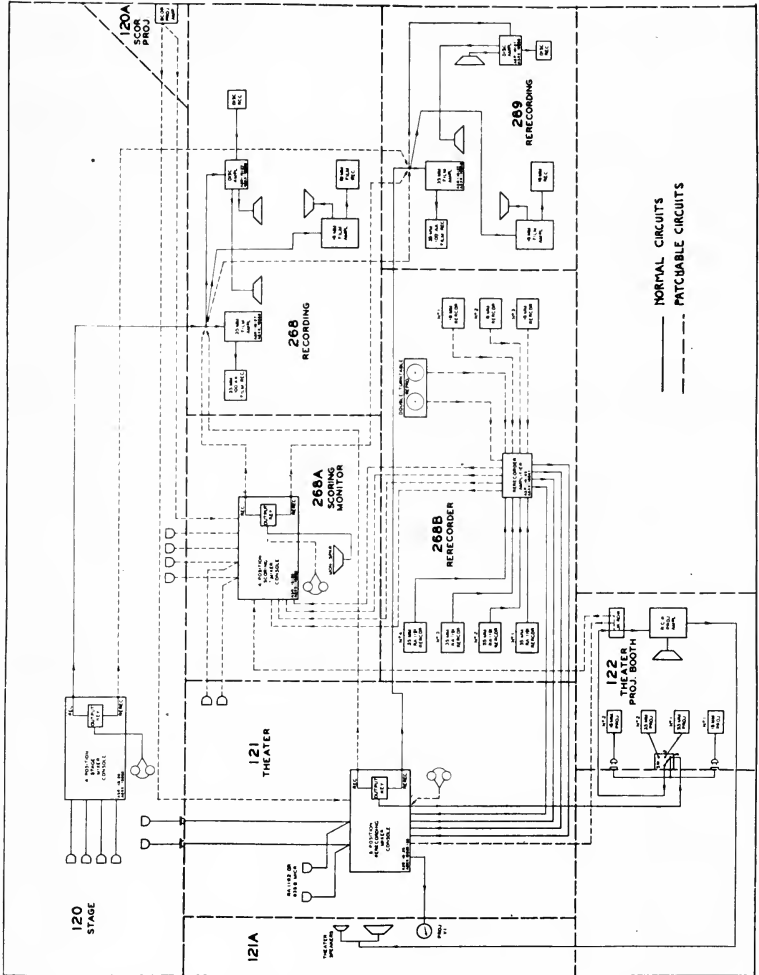


FIG. 1.

From these requirements the problem was approached with 3 objectives:

- (1) Engineering perfection.
- (2) Ease of operation and servicing.
- (3) Over-all appearance.

Since our stocks of standard equipment were low and much of the equipment to be supplied had to be designed and fabricated, it was felt that this was an excellent opportunity to embark on a new line of attack to comply with the above 3 objectives. Accordingly, a partial list of proposed requirements was drawn up as follows:

(a) All equipment and controls associated with any particular activity should be incorporated in a "packaged" unit if possible.

(b) All layouts and units in each channel should be identical to permit interchangeability and easier training of the operating personnel.

(c) Circuit changing to be done by switching wherever possible instead of by patch cords.

(d) All standard circuits to be "normalled" through and to operate with a "dead" patch bay.

(e) Mixer consoles to incorporate a level limiting amplifier as protection against overloads.

(f) Rapid key switching of the mixer console outputs to either recording channel.

(g) Push-button equalizer switching into any input circuit of the mixer consoles.

(h) Talk-back facilities between all locations.

(i) Monitoring inputs, all at the same signal level, at any location from either channel.

(j) All lines between rooms to be 600-ohm impedance.

(k) Recording amplifier inputs to be high impedance for added flexibility.

(l) Carrier-type noise reduction with reverse bias facilities.

(m) Pre- and post-equalization with standard or push-pull track.

(n) Light valve feedback amplifier to control the light valve resonant peak.

(o) Stage playback unit completely self-contained to operate from any input source.

(p) Disk recording for 78 or  $33\frac{1}{3}$  rpm with reproducing facilities for either vertical or lateral disks.

(q) Low level and high level test trunks between the recording rooms and all locations.

(r) Provision to supply bus level to the 16-mm recording equipment.

(s) Provide for utilization of output sources from 16-mm reproducers and non-sync turntables.

(t) Adequate test equipment and accessories.

A block diagram of the recording and rerecording facilities is shown in Fig. 1. A stage console for direct pickup is normally connected to

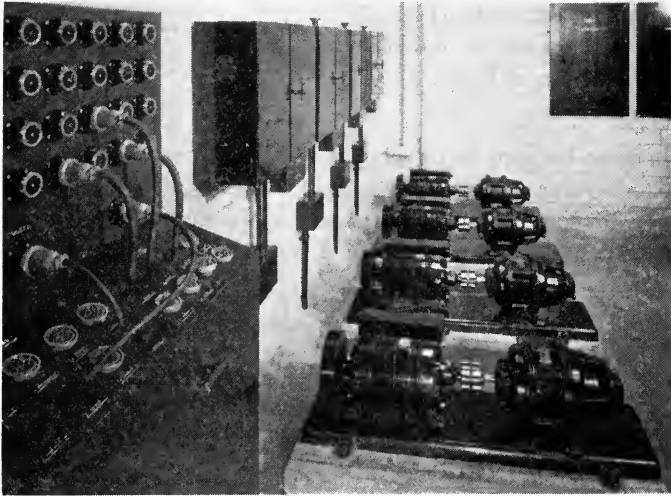


FIG. 2. Western Electric motor drive system.

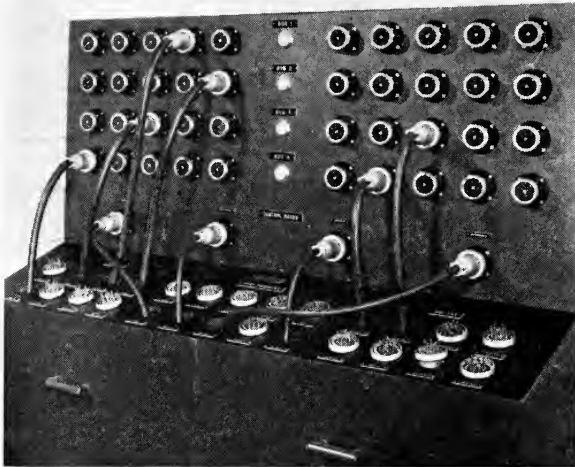


FIG. 3. Distributor and motor drive patch panel.

the recording channel bus, but by operating the console output key, the output is transferred to the rerecording channel. Similarly, the output of the rerecording console, which is normally connected to the rerecording channel, can be switched to the recording channel. A second mixer console, similar to the one on the stage, is shown in the scoring monitor room. Its output feeds trunks to both channels but is not normally connected to either. If it is desired to use it on either channel, this can be accomplished by making one patch on the input of the channel selected and throwing the output key on the console to the proper position. The stage and scoring monitor consoles are identical and can be used interchangeably.

Microphones used are the *RA-1142* directional cardioids and pickup trunks from either the stage or theater appear at the inputs of all 3 consoles, making complete flexibility for utilization of live pickup positions.

The outputs of four 35-mm rerecording reproducers "normal" into the rerecording console, but also appear at the scoring monitor console. In addition, the 16-mm reproducers, reproducer turntables, scoring projector, and theater booth projector outputs can be patched into either the rerecording console or the scoring monitor console, giving complete input flexibility for rerecording if desired.

Both recording channels are identical, each consisting of one 35-mm film recorder, one 78- or 33 $\frac{1}{3}$ -rpm disk recorder, each with its associated amplifiers and control equipment, and the recording bus feeding the 16-mm recording equipment, which was furnished by J. A. Maurer, Inc.

Headset and loudspeaker monitoring are provided on all consoles. Regular theater monitoring is normally used for rerecording by using the theater amplifier and horn system. If rerecording and mixing of voice scoring to the projected picture in the theater is desired, headset monitoring is used with the horns disconnected to prevent feedback. Headsets are used for stage pickup, but a loudspeaker is normally used in the scoring monitor room. Headsets are the *714-C* receivers and loudspeakers are type *753-C*.

Flexibility of monitor selection has been accomplished very easily. Two monitoring busses, one for the recording and one for the rerecording channel, run to all locations, each bus consisting of 3 monitoring sources from each channel, direct—PEC—and disk reproduction. Each monitoring source is 600 ohms and its level has been adjusted to -30 dbm. Thus, we have 6 monitoring sources

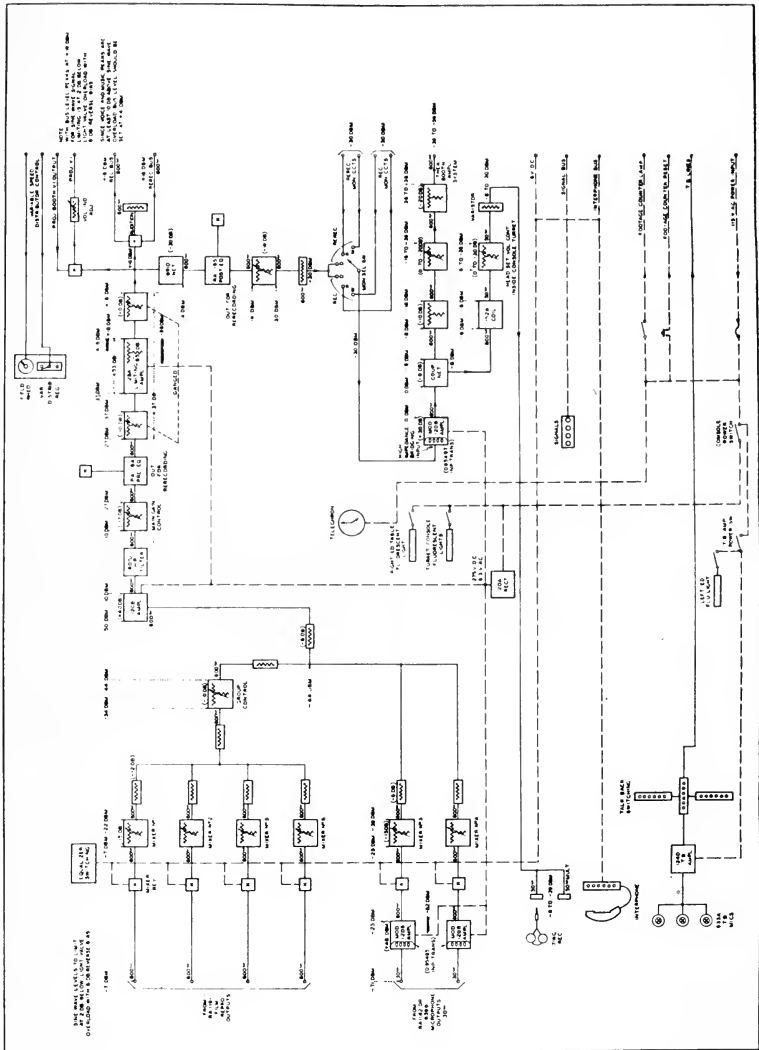


FIG. 4.

appearing at all locations, each at 600 ohms and at the same signal level. At all locations a 6-position selector switch has been provided to select whichever monitoring source is desired and a high-impedance bridging amplifier feeds the monitor horns or receivers. It is thus possible to have all positions monitoring the same source, if desired,



FIG. 5. Over-all view of rerecording console.



FIG. 6. Operating control panels of rerecording console.

or a different selection can be made at any location without affecting the others. These 6 monitoring positions and, in addition, the outputs of the four 35-mm rerecorders, the theater projectors, and the scoring projector, also appear in the stage playback wall box. Thus, 12 circuits are available on the stage in a selector switch to feed signal at 600 ohms and all at a level of  $-30$  dbm to the portable playback unit.

Push-button talk-back selection is provided at each machine and on the mixer consoles, in addition to an interphone and a signal light system. This gives an adequate communication system between all locations, as well as promotes rapid and efficient production operation.

The standard Western Electric motor drive system is used. This consists of an accurate speed controlled d-c motor driving a distributor,

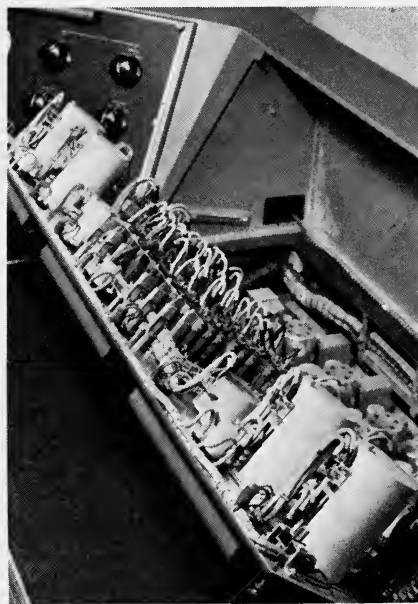


FIG. 7. Turret panels are hinged for easy access and servicing.

which in turn drives the individual recording, projector, or camera motors. Four such distributor systems were furnished feeding into a distributor and motor patch panel (Figs. 2 and 3). All motors and start circuits run directly to this panel where any combination of motors can be run from any selected distributor with the start position at any location. The starting of the recording system motors is normally confined to the recording machine position, but start positions have been provided at the re-recording-reproducers to permit rehearsals for recording without bothering the recording operators. Four separate

start positions have also been provided in the theater booth to permit running a double film, continuous interlocked show if desired. Start positions also appear at the 16-mm equipment, the scoring projector, and on the stage for the process projector and camera motors.

An additional motor system feature has been included at the re-recording console control panel by providing a switch and field rheostat for manually controlling the speed of one distributor. By using one manually controlled variable speed distributor on one or more rerecording effect tracks many useful effects can be obtained.

The rerecording mixer console is considerably more elaborate than



the stage and scoring consoles, although each contains the same circuit arrangements and operational features. A very desirable and useful feature for a rerecording mixer to be used particularly in the

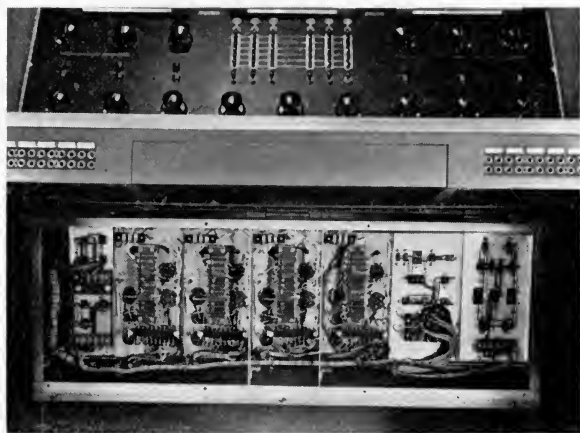


FIG. 8. Preamplifiers and other components are mounted in the trough which can be lowered for servicing.

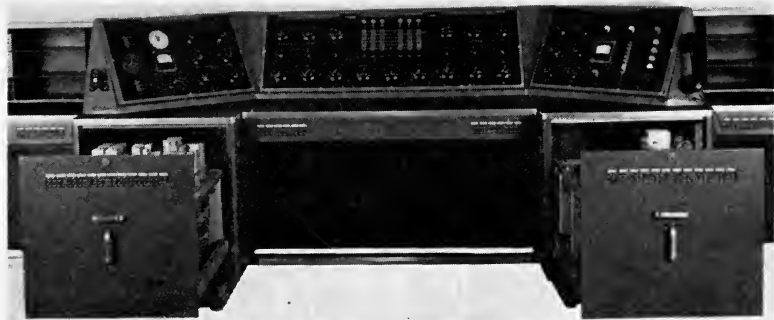


FIG. 9. Amplifier and channel components are contained in cabinet-type drawers.

assembly of high-quality training films, is a sufficient number of equalizers with various characteristics that can be rapidly switched into and out of any input circuit. Six such equalizers have been included in this rerecording console and include 2 low-high equalizer-amplifiers (*RA-1195*), 2 telephone-radio effect equalizers, one com-



FIG. 10. Stage and scoring console.



FIG. 11. Equipment may be serviced through panel doors on 5 sides of the console, two of which are shown.

bination series of low-pass and high-pass filters, and one combination low-end and mid-range dialogue equalizer.

The *RA-1195* is a newly designed equalizer-amplifier combination which will raise or lower the low- or high-frequency end, either or both 15 db, at a constant 1000-cycle gain regardless of the adjustment of the equalizer. The 2 telephone-radio effect equalizers are variable effect units, each with its own adjustable output control. These are very useful in training film production in that each can be set for the effect desired and can be rapidly switched from one track to the other.

A block schematic of the rerecording mixer is shown in Fig. 4. Four reproducer and 2 microphone input positions are included. A group control is a part of the reproducer mixer circuit and is useful for controlling the level of the combined effect and music tracks under the voice. A main gain control, pre- and post-equalizer facilities and a limiting amplifier feeding the recording bus complete the "program" circuit of the mixer. Mixer keys connect the pickup points directly to the mixer controls in the "down" position, or if thrown to the "up" position, connect the pickup points to an equalizer push-button selection bus which permits any equalizer to be placed in any input position. Direct monitoring is taken from the mixer console output through the monitoring selector switch, which can pick up any of the other monitoring points as described previously. The monitoring selector switch feeds the regular theater projector amplifier and horn system. By operating the console output key it may be connected to either the recording or rerecording channel.

The level limiting amplifier (type 1126) is very useful to control peak overloads to the recording system and light valve. It has a flat

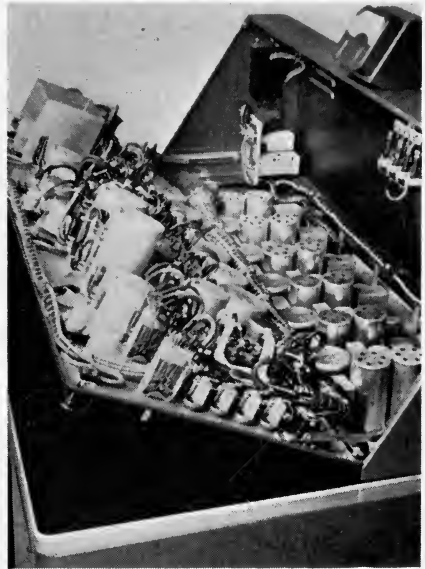


FIG. 12. Operational controls mounted on hinged turret panel for easy access.

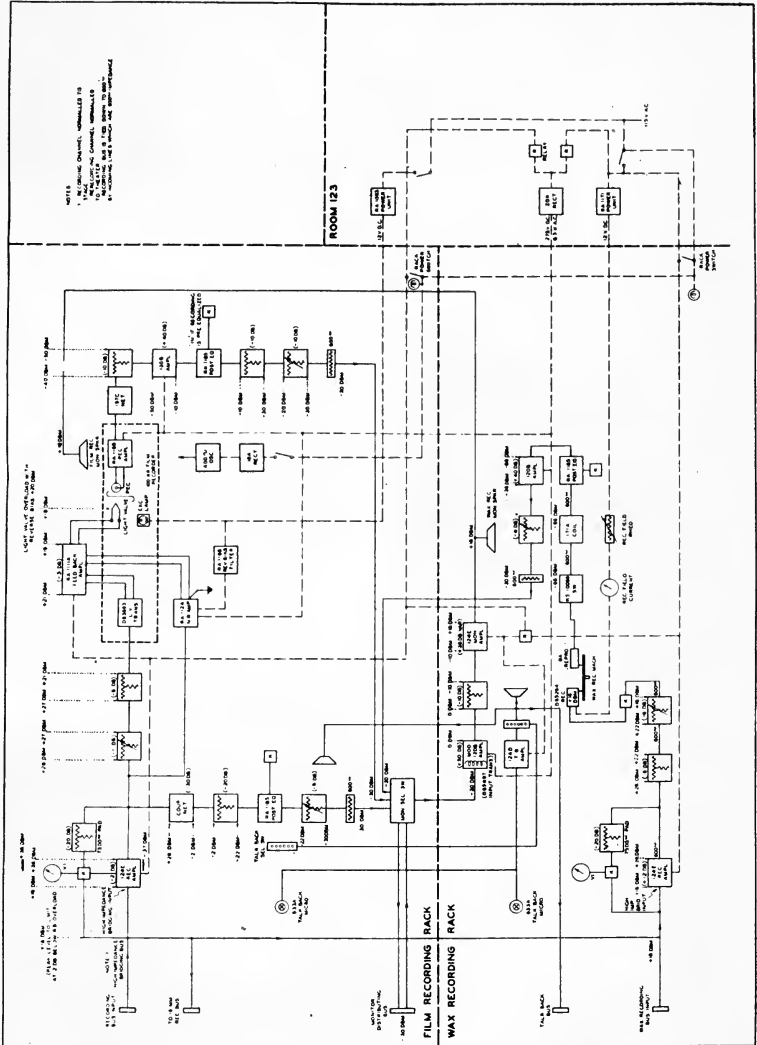


FIG. 13

frequency characteristic, a power-carrying capacity of +17.5 dbm, and a peak limiting ratio of 10 to 1. This means that if the input level to the limiting amplifier is suddenly increased to 10 db above the level for which limiting is adjusted, the output level is increased by only one db and its action is instantaneous. Limiting level can be controlled in one-db steps up to 10 db. Recovery time is variable from 0.2 of a second to one second and its output distortion is less than one per cent for peak limiting of 5 db.

Signal-to-noise ratio of the rerecording console is in excess of 60 db.

The rerecording console embodies numerous constructional and operational features not found in previous units. An over-all view is shown in Fig. 5. Its over-all length is 15 ft including the 2 director-editor tables on each end. Space is provided for 2 mixer operators and 2 editors or directors at each end position. Small shielded fluorescent tubes are used for panel illumination. Because of its diffuse properties and the use of non-glare table top covering, very few shadows are cast on the operating panels with its attendant reduction in eye fatigue.

The operating control panels are shown in Fig. 6. Two reproducer mixers, one microphone mixer, and one each of the equalizer controls have been placed on either end of the main control panel to permit one mixer operator to have the necessary controls within easy reach for small rerecording jobs. All controls are in turret panels arranged for easy access in operation. The turret panels are hinged, as shown in Fig. 7 for rapid and easy servicing. The preamplifiers and other components are mounted in the trough directly behind the main



FIG. 14. Thirty-five millimeter film recording equipment.

panel. The trough can be lowered for servicing, as shown in Fig. 8. A similar mounting trough arrangement is used in both director's tables to mount the talk-back amplifier and the power unit.

The amplifier and channel components are contained within the unit and are readily accessible for servicing, as shown in Fig. 9. Filing



FIG. 15. All switches, meters, and other equipment are readily accessible on hinged panel.

cabinet drawer construction is used and has proved very satisfactory. Low-level equipment is mounted in the left-hand drawer and the high-level equipment is mounted in the right-hand drawer, top units of both of which are hinged. Parallel talk-back microphone and selector switches are also mounted in each director's table for added communication facilities to speed up operation.

A projected volume indicator using the VU meter and footage counter is placed directly below the screen for cuing and level indication. The footage counter is operated from an interlocked motor and can be reset by push-button control from the mixer position.

The stage and scoring console is shown in Fig. 10. This unit is on castors, which are not shown in the photograph, and is moved



FIG. 16. Disk recorder, table, and associated equipment, showing accessibility for servicing.

easily. It is a completely self-contained unit, with a 4-position mixer used primarily for stage and microphone pickup but can also be used for small rerecording jobs. The same operational and technical features found in the larger rerecording console are also included in this unit. One low-high equalizer-amplifier (*RA-1195*), and 2 combination low-end and mid-range dialogue equalizers are supplied and connected for rapid push-button equalizer selection in the input circuits. Since this unit is portable, connections are made to it by cords into plugs and jacks on the rear of the unit. These cords connect to

outlet boxes in the scoring monitor room and on the stage, and are identical permitting the 2 small consoles to be used interchangeably.

The equipment units are mounted to be readily accessible for servicing on 5 sides of the console, two of which are shown in Fig. 11. All operational controls are mounted on the turret panel which tips forward for servicing, as shown in Fig. 12. The preamplifiers and associated equipment are mounted directly behind the panel in a trough arrangement, as can be readily seen from the photograph.

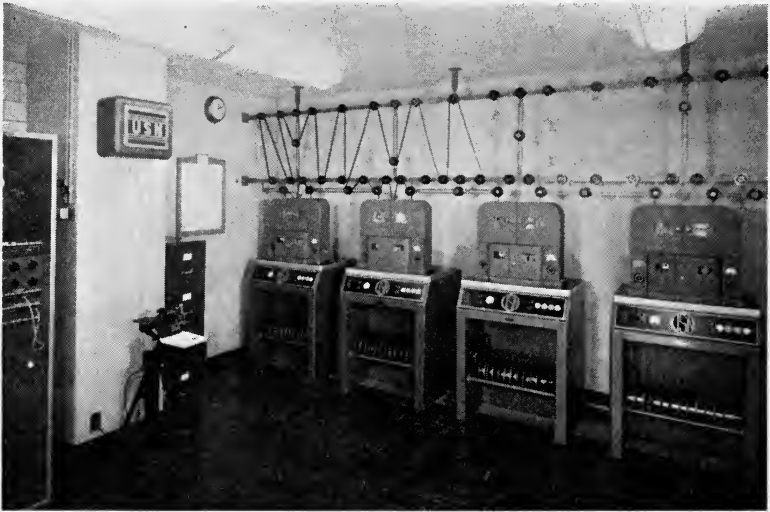


FIG. 17. Four newly designed RA-1191 rerecording-reproducers mounted on tables, showing the associated loop rack.

The amplifier and circuit schematic including the limiting amplifier is identical to the rerecording console, except that a monitoring power amplifier is included for driving a loudspeaker. In spite of the relatively confined space for the equipment the signal-to-noise ratio of this unit is in excess of 60 db.

The consoles operate into 600-ohm lines which feed the recording bus on either of 2 channels. A block schematic of the recording and rerecording channels is shown in Fig. 13. This bus on either channel operates into one 35-mm film recording equipment, one 78- or 33 $\frac{1}{3}$ -rpm disk recording equipment, and one 16-mm film recording equipment. The film recording and disk recording equipment are mounted



in separate rack cabinets adjacent to the recording machines. As can be seen from the block diagram, a bridging amplifier (*124-E*) feeds the noise-reduction equipment (*RA-1124*) and the light valve feedback amplifier (*RA-1111-A*) which works into the light valve (*RA-1061*) in the film recorder (*100-AA*). The noise-reduction equipment is a carrier-type unit with reverse bias facilities.

A VU type of volume indicator meter is mounted on both the film and disk racks and arranged to read either the incoming line level or the output of the bridging amplifier. Monitoring, direct—PEC—or disk, is fed to the selector switch mounted in the film rack for local monitoring and also feeds the monitoring busses at the remote locations, as described previously. Local continuity monitoring is done by bridging a high-impedance amplifier across whichever position is selected and driving local speaker units mounted above each recorder. The power supplies for the film and disk equipment are all mounted in the power room, but are remotely controlled from each rack.

An identical bridging amplifier feeds the lateral disk recording machine (*D-85249*) which has been modified to cut either 78- or  $33\frac{1}{3}$ -rpm disks. Recording is normally made on acetate disks, and reproduction from these disks is accomplished with a *9-A* reproducer pickup and associated equalizers.

The film and disk recording equipments on both channels are identical both as to components and rack layouts.

A view of the 35-mm film recording equipment is shown in Fig. 14.

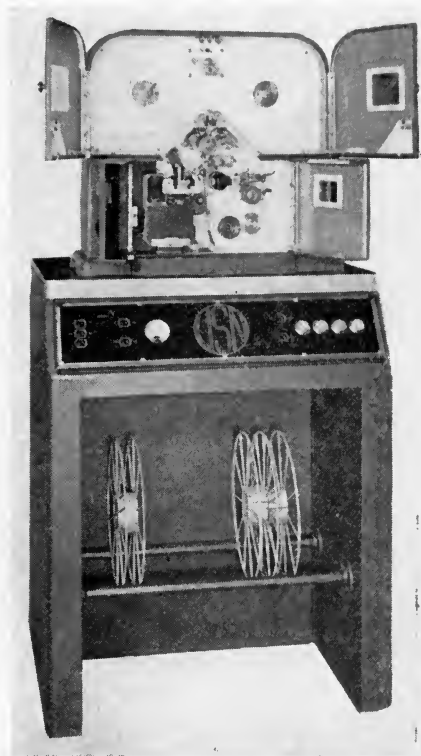


FIG. 18. Full view of reproducer and mounting table.

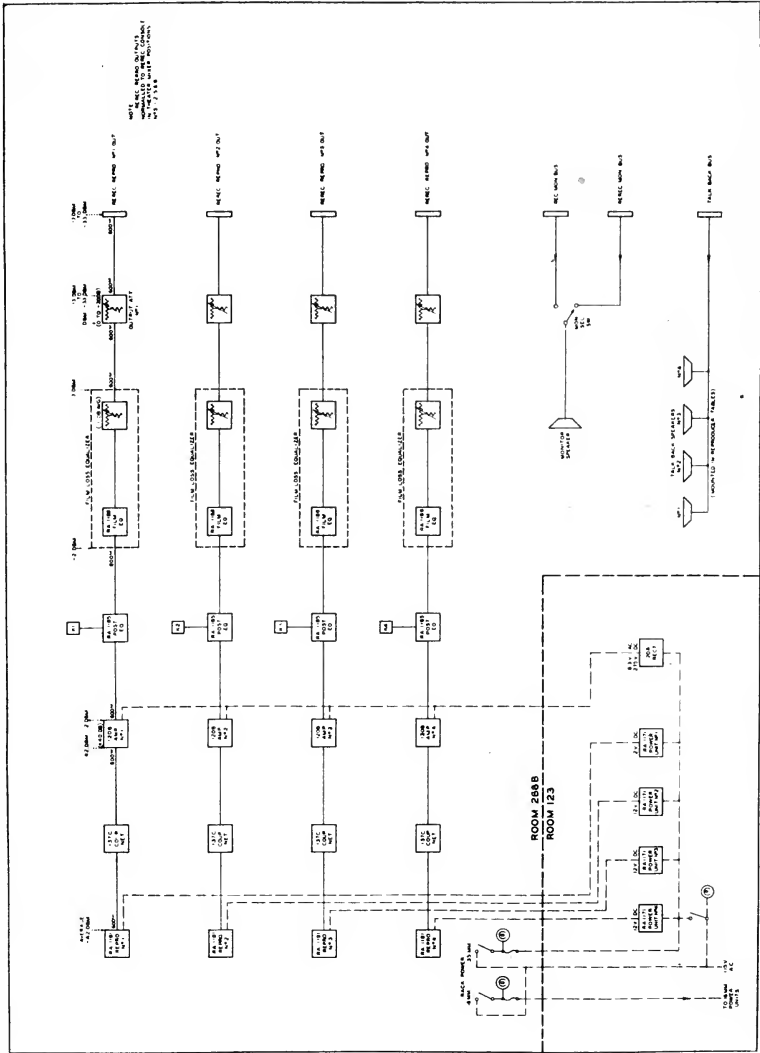


Fig. 19.

The amplifiers are of the vertical chassis type and by removal of the front panel all wiring is exposed, facilitating rapid servicing. The rack cabinets are completely enclosed and provided with adequate ventilation.

The 35-mm film recorder is the *100-AA*, which uses an *RA-1061*



FIG. 20. Portable test unit.

2-ribbon or 4-ribbon light valve to record either 100-mil standard or push-pull sound track.

The recorder mounting table follows the same general lines of construction as the recorders and the consoles. Talk-back selection and talk-back speaker, motor system start switches with speed indicating meter, and signal system are mounted on a sloping panel immediately below the table top which, combined with the controls on the recorder, puts all the operating controls within easy reach. This control panel hinges for servicing, as shown in Fig. 15. Space is pro-

vided in the table for film magazine and equipment storage. Door switches operate tubular lights for interior illumination when the doors are open. A recess is provided at the floor level for "toe" room for the operators. Vertical barriers are placed inside the rear panel to provide channels for segregation of the different service wiring brought up from the conduit ducts into the recorder unit.

The disk recorder, recorder table, and associated equipment are shown in Fig. 16. The same design and construction are followed in this unit and servicing is accomplished easily.

The *RA-1191* rerecording-reproducer is a newly designed 35-mm film reproducer for rerecording. Its exterior appearance was made to conform to the general design of the rest of the equipment supplied. A photograph of four of these reproducers and their mounting tables with the associated loop rack is shown in Fig. 17. These *RA-1191* reproducers reproduce 100-mil standard and 100- and 200-mil push-pull sound track. A view of the reproducer and its mounting table is shown in Fig. 18. Here, again, the controls are mounted on a sloping panel for convenience in operating and which, as in the other tables, is hinged for ease in servicing.

The height of the reproducer, as well as the recorder tables, has been adjusted to cause a minimum of operating fatigue to the personnel. Space has been provided for reel storage

in both the front and rear of the table. The end legs of the tables are hollow and equipped with barriers for circuit segregation through which all wiring is brought into the machine controls from the

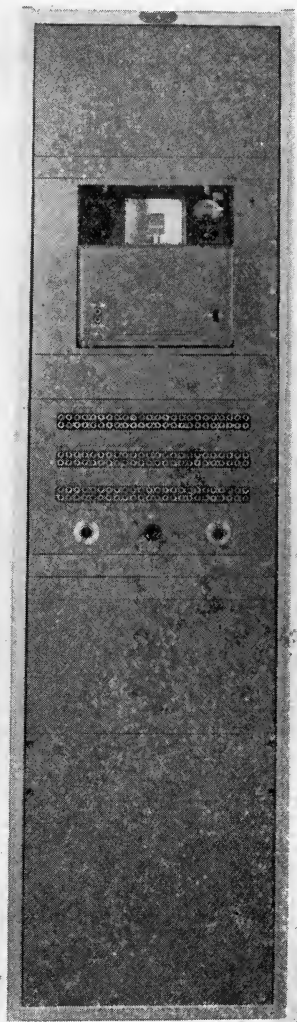


FIG. 21. Test trunk rack.

duct beneath. The end panels are removable for ease in installation.

A block schematic of the rerecording reproducer system is shown in Fig. 19. All 4 circuits are identical and include a booster amplifier, a post-equalizer which may be switched in the reproducer circuit by a key, a variable film loss equalizer, and an output attenuator. The outputs of the 4 reproducers normal to the rerecording console. The power units are located in the power room and are remotely controlled from the rerecorder equipment rack. Monitor facilities from the monitoring bus and talk-back are also provided.

A portable test unit equipped with casters, shown in Fig. 20, can be easily moved to any location for testing, but is normally located in the recording room. As can be seen in the photographs, it contains an oscillator, gain set, vacuum tube test meter, and a voltohmyst. Patching and test terminations are also included. Space is provided for equipment storage and kneehole room added for additional ease in using.

Two pairs of low-level and 2 pairs of high-level test circuits run to every location and terminate in the recording room in a test trunk rack, shown in Fig. 21. Normally all routine testing can be done from this position since the portable test unit is located in the recording room adjacent to this rack, but for other test work the portable unit can be easily moved. Since 4 pairs of circuits run to every location, special circuit setups can be accomplished by merely cross-patching in the test rack, which greatly adds to the flexibility of the whole installation. A-c and d-c test voltages are also available on this rack for added testing convenience.

A portable stage playback unit is shown in Fig. 22. This unit is self-contained and uses a high-impedance amplifier for bridging across



FIG. 22. Portable stage playback unit.

the 600-ohm monitoring bus. The input circuits feeding the unit are all at  $-30$  dbm level and sufficient gain is provided to drive the loud-speaker reproduction at 20 w. The input plugs into a selector switch on the stage wall where 12 different pickup sources can be used. Headphone jacks are provided on the unit so it may be used for pre- or post-scoring. Accessibility to equipment in the unit is shown in Fig. 23.

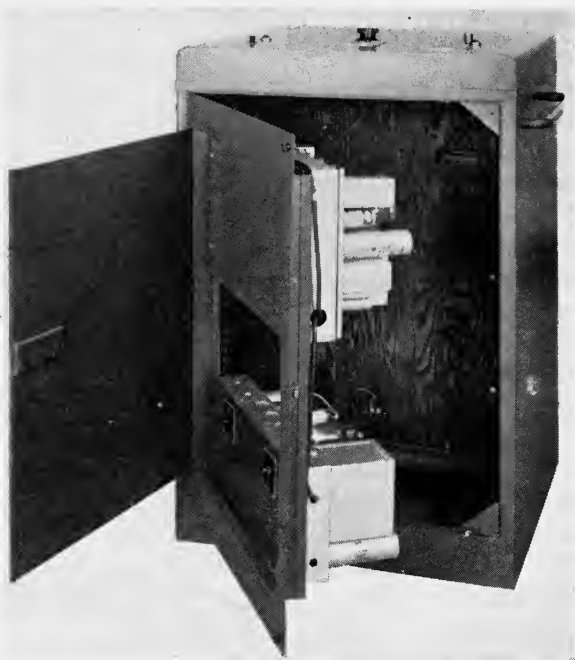


FIG. 23. All equipment is easily accessible.

Two very useful accessories are the light-valve projector and the light-valve stroboscope (*RA-1196*). The projector is shown in Fig. 24. The light valve is mounted on the inspection table, and a beam of light projected through the ribbons passes through a lens system and prism which forms an enlarged image of the ribbons on a  $4\frac{1}{2}$ -in. light-shielded screen. Signal and d-c are fed into the light-valve ribbons, and the ribbon action can be observed on the screen. Ribbon unbalance, grounds, ribbon bowing, and foreign matter can be easily

and quickly detected. For ease in use, this instrument has been mounted at eye level in the test trunk rack.

The light-valve stroboscope (*RA-1196*) is shown in Fig. 25. This unit consists of a microscope designed to mount on the light valve in the recording machine in such manner that a magnified image of the



FIG. 24. Light-valve projector, showing ribbon image on rear screen.

ribbons is produced in the eyepiece of the microscope. A stroboscope disk operated by a small variable-speed motor interrupts the light beam. The speed is variable over a considerable range so that when frequencies of from 50 to 15,000 cycles are applied to the light valve they appear to be "stopped" in motion and their behavior may be observed and studied. The motor normally operates from 115 v a-c, but if frequencies below 50 cycles are to be observed the voltage may

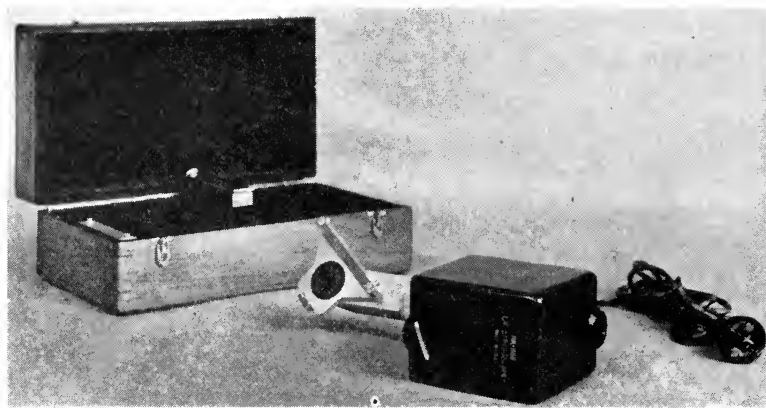


FIG. 25. Light-valve stroboscope.

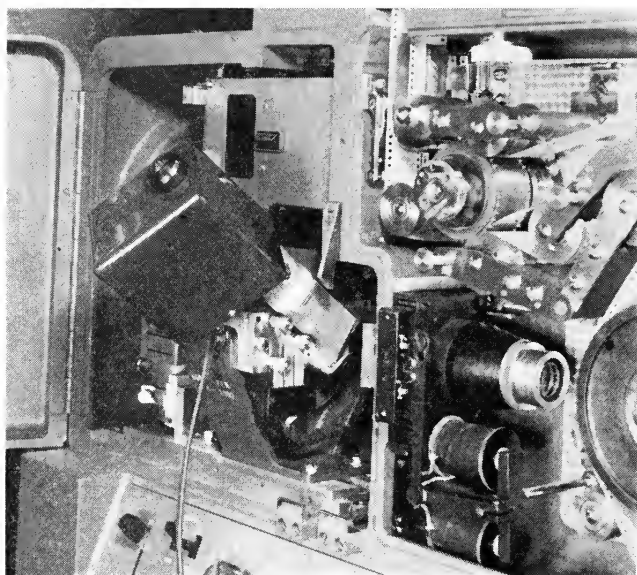


FIG. 26. Light-valve stroboscope mounted for use on the 100-AA film recorder.





FIG. 27. Sound equipment in U. S. Naval Photographic Science Laboratory, Anacostia, D. C.



FIG. 28. Sound equipment in U. S. Naval Photographic Science Laboratory, Anacostia, D. C.

be lowered by a Variac or other means and the ribbon action at the lower frequencies studied.

The speed of the stroboscope disk light beam interrupter is varied by changing the amount of magnetic drag applied to an aluminum cup attached to the motor shaft at the opposite end from the interrupter disk. A permanent magnet is mounted on a movable shaft so that it just clears the contour of the aluminum cup. When the magnet is moved in or out of the aluminum cup varying amounts of eddy current drag are exerted which varies the speed of the motor. This damping force tends to stabilize the motor driving the interrupter disk and prevents "hunting" or "drifting" which occurs with the usual voltage control. A photograph of the unit in use on the *100-AA* film recorder is shown in Fig. 26. This unit supplies a long-felt need for an instrument which is easy and rapid to use for observing the action of the light valve ribbons in operation on the recording machine at any frequency.

Views of the sound equipment in the completed installation are shown in Figs. 27 and 28.

The system as herein described fulfills the primary objectives originally set up. The recording system has a normally flat frequency characteristic from the microphone to the light valve, an adequate factor of safety for overload, slightly less than  $1\frac{1}{2}$  per cent over-all harmonic distortion, and a signal-to-noise ratio in excess of 60 db. The equipment layout provides a high degree of flexibility and rapid, efficient operation with a minimum amount of time required for training of operating personnel. A departure has been made from previous concepts of constructional design to facilitate ease of operation and servicing of the equipment. It presents a pleasing appearance which materially aids, psychologically, the production of high-quality training films.

Some of the equipment referred to in this paper has been covered fully in previous technical papers before the Society. It is planned to describe in more detail, at later meetings of the Society, the technical features of the apparatus designed especially for this project.

We want to take this opportunity to thank Commander Thorne Donnelley, Lt. George Carrol, Lt. Franklin Hansen, and their staffs for their cordial help and cooperation, and their suggestions during the design, fabrication, and installation of the equipment.

## UNITED STATES NAVAL PHOTOGRAPHIC SCIENCE LABORATORIES\*

HELEN R. CLIFFORD\*\*

*Summary.*—This paper is the narration to a sound slide film introducing the Navy's new laboratory at Anacostia, D. C. (construction completed December, 1943). It gives a brief history of military photography leading to the Navy's need for its own laboratory for secret and confidential projects, discusses military organization, gives a tour of the laboratory, presenting especially the work of divisions concerned with motion picture production, still photography, aerial photography, graphic arts and photolithography, and sketches the services which the laboratory performs for all ships and stations.

American wars were the first wars in history to be recorded by photography. Although a few daguerreotypes were made of the leaders in the Mexican War, it was by the photographs of William Brady that the Civil War was promptly reported to the civilian population. By the time of the Spanish-American War the infant motion picture process was used to report the activities of Theodore Roosevelt and his Rough Riders. Aerial reconnaissance from planes was essayed during World War I. Thus it was that photography became associated with aviation, even though the Navy had not yet officially recognized its importance. The first photographers ratings were not issued until 1920; prior to that time Naval photographers had been variously rated as ship's cooks, pharmacist's mates, gunners and aviation printers.

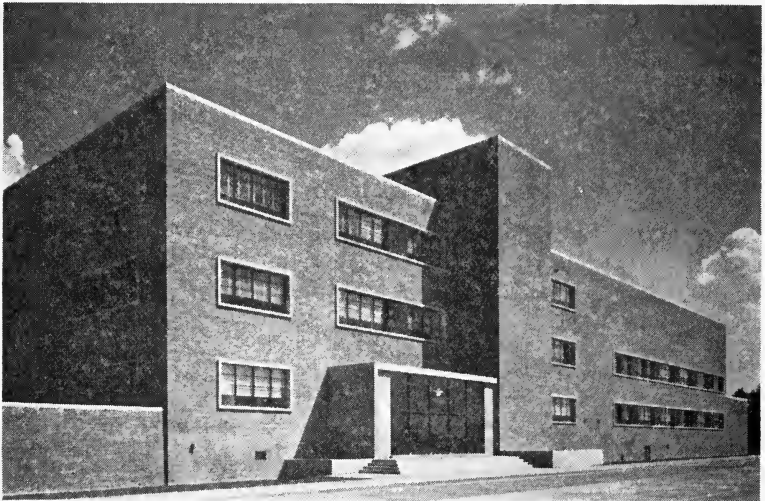
In the period between World War I and World War II, both the quality and the quantity of photography grew by leaps and bounds. By its commercial use, for both entertainment and journalism, it became one of the most important media of modern communication. During this period Naval photographers were experimenting with aerial geodetic mapping for the Hydrographic Office, vertical and oblique photography for the Departments of Commerce, Interior, and Agriculture, and aerial reports on fleet firing and aircraft bombing.

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\* Presented Apr. 18, 1944, at the Technical Conference in New York.

\*\* Lieutenant (j.g.), W-V(S), USNR, U. S. Naval Air Station, Anacostia, D. C.

As the war clouds again gathered over Europe, the importance of photography in mechanized and psychological warfare became increasingly apparent; so the Secretary of the United States Navy convened a board to review the Navy's photographic facilities and to make recommendations for its needs. Several months before the Japanese attack upon Pearl Harbor, this board presented its recommendations, which included expansion of existing facilities under the cognizance of the Bureau of Aeronautics, and construction of a laboratory fully equipped to supply the Navy's every photographic need, particularly upon secret projects.



Official U. S. Navy Photograph

FIG. 1. Photographic Science Laboratory, Naval Air Station, Anacostia, D. C.

Construction of the Photographic Science Laboratory was begun in February, 1942. The Bureau of Yards and Docks supervised the planning and construction of the building; the Eastman Kodak Company provided architectural, engineering, and equipment-procuring services; the Bureau of Aeronautics was technical adviser to co-ordinate and approve plans. In December, 1943, the modernistic building on the grounds of the Naval Air Station at Anacostia, D. C., was completed (Fig. 1). Its personnel is composed of highly specialized technicians, artists, and administrators who have been trained to maintain Naval security. About one-fourth of the ship's com-

pany is composed of members of the Women's Reserve. Military duties taking precedence over photographic projects may be assigned to anyone. Members of the Women's Reserve have their own watches, comparable to those of the men.

By authority of the Commanding Officer of the Naval Air Station, Marine guards challenge all persons entering or leaving the grounds. Upon entering the building authorized visitors identify themselves to the Duty Officer. They move through the air-conditioned, fluorescent lighted passageways under escort, and are admitted only to the areas where they have particular business.

Commander Thorne Donnelley, USNR, Officer in Charge of the Photographic Science Laboratory, is responsible to the Chief of the Bureau of Aeronautics via two commands: For administrative procedures and military security via the Commanding Officer of the Naval Air Station; for functional and productive procedures via the Director of Photography, Bureau of Aeronautics.

The organization under administration consists of a number of divisions, directed by division officers. Any division may request the work of any other division; but the services of Personnel Division, Supply Division, Ship Service, Engineering and Maintenance Division, and Technical Developments Division are directed specifically to providing efficient operational conditions for all.

The Personnel Division has helped procure the highly technical staff. With camera crews and students of the Motion Picture Camera School and the Photolithography School (both offering advanced training to graduates of the Navy's School of Photography at Pensacola, Florida) constantly coming and going, this division does a volume business in writing temporary duty orders and arranging transportation to all parts of the world.

The Supply Division procures materials for photographic productions: Film in cases, chemicals in kegs, other equipment in carloads—difficult as they now are to obtain. In its stock rooms are kept the materials necessary to operate the laboratory for a period of 3 to 6 months. This division also outfits all the Navy's advance base photographic interpretation units.

By providing wholesome, appetizing food, Ship Service helps to keep the ship's company in good spirits.

The Engineering and Maintenance Division has facilities which include a carpenter shop, a machine shop, a precision shop, and temperature chambers for checking aerial cameras under arctic and

tropical conditions. In addition to repairing and maintaining specialized photographic gear, this division constructs miniatures and models and provides the mechanical and electrical services necessary for the efficient operation of the sound stage.

It has been said that within the Technical Developments Division occurs the science that spells the laboratory's middle name. This division works constantly for the advancement of photography by standardizing processes, solving problems, adapting mechanisms or inventing new ones as needed. It prepares all photographic solutions used within the laboratory and distributes processing instructions to combat units. At its optical testing bench, lenses are evaluated for focal length, centering, aberrations, run-off, and definition by examining an image of an artificial star produced at the end of a 275-ft collimating tube. Other activities of this division include photomicrography, microscopy, and photometry.

Since the laboratory is a service facility for the entire Navy, it receives requests for motion pictures to be produced, for still photography to be processed, enlarged, and copied, for aerial equipment to be distributed to the fleet, for aerial photographs to be corrected for distortion and aerial mosaics to be made, for photographic services for the Office of Public Relations, for photolithographic services, and for a wide variety of other needs.

Requests for photographic services are addressed to the Director of Photography, Bureau of Aeronautics. If approved, they are forwarded to the Officer in Charge, Photographic Science Laboratory. From his office they are turned over to Operations which is really the "nerve center" of the entire organization. By Operations the work is allocated to the divisions concerned.

A large part of the work orders which are received calls for the production of motion pictures for which the activities of a number of divisions are needed: Writers and Directors Division, Motion Picture Photography Division, Motion Picture Processing Division, Editorial Division, Art and Animation Division, Music Division, and Sound Division.

Writers and Directors Division provides the ideas through which the best psychological and pedagogical principles are combined with originality of treatment. Different techniques are employed in the preparation of scripts for industrial incentive films, recruiting films, training films, and reporting films. A procedure has been developed whereby the script is generally submitted to the requesting agent at

three stages of development. After an initial conference in which the needs to be met by the motion picture are discussed, a preliminary outline is prepared. Later an action outline is submitted; and finally, a master shooting script is prepared, with storyboard attached if necessary. The requesting agent supplies a technical adviser who is responsible for the technical accuracy of the film. At each stage of script preparation, written approvals are obtained so that complete satisfaction with the finished product will be assured.



Official U. S. Navy Photograph

FIG. 2. On the stage cameras photograph action within a Navy plane set, while the sound recording is controlled from booth on the second deck.

When the master shooting script bears written approvals, for content by the technical representatives of the requesting authority, for form by the Division Officer of Writers and Directors Division, a 16-mm or 35-mm camera crew is assigned and equipment is issued by the Motion Picture Photography Division. The camera crews work under varied conditions, on the land, in the air, on the sea, and under the sea. Their assignments may take them to Naval activities near to Anacostia, or they may accompany the fleet to its advance

depots or into combat areas. When feasible, productions are made on the sound stage at the laboratory (Fig. 2). There, the sets usually represent military locales: for example, the bridge of a ship, the interior of a patrol bomber, engine rooms, fire-control stations, or radio rooms. The facilities of the sound stage include completely modern electrical and lighting equipment, grip equipment, and background projection equipment. In line with Navy construction the catwalks are of metal rather than wood.



Official U. S. Navy Photograph

FIG. 3. Three of the 6 continuous drying cabinets in the Motion Picture Processing Division. From loading to final take-off, the film travels 7000 ft or 1.3 miles.

Three shifts daily in the Motion Picture Processing Division develop and print the footage which the camera crews turn in, whether 16-mm or 35-mm, black-and-white or Kodachrome, and sound film of both variable area and variable density (Fig. 3). In addition to processing film for motion pictures in production, this division also processes a large percentage of the combat footage flown in from the fleet to the Navy Department.

To each director of a motion picture, a cutter is assigned by the Editorial Division. When it is necessary to cut in stock shots, such



as those of disasters, foreign craft, or historic combat, the files of the Film Library are consulted. Editorial Division is responsible for approximately twenty stages of film handling from the completion of photography to the delivery of the first composite print to the requesting authority. It is charged with the storage of all negative film, both still and motion picture, for the United States Navy. The vaults in which nitrate film is stowed are constructed with explosion hatches.

Simultaneously with the shooting, processing, and rough cutting of the motion picture, animation is being prepared as needed. Animated diagrams, teaching the operation of secret new Naval equipment, are recorded by the specially constructed animation camera. In addition to the work supplied for motion pictures, the Art and Animation Division produces slide films, supplies titles, designs insignia, creates art work for books and posters, and at times and perhaps most important of all, diagrams action which assists in the development or protection of combat tactics.

If necessary, original music, suited to the mood and tempo of any motion picture, is provided by the Music Division. A library of stock music is being accumulated by making recordings of the United States Navy symphonic band.

The Sound Division is completely equipped for all recording needs, either fixed or portable. The former includes facilities to rerecord six 35-mm, three 16-mm, and 2 disk sound tracks simultaneously; the latter includes portable production channels and newsreel-type recorders for both 16-mm and 35-mm. A theater with specially designed acoustical construction and with seating capacity for 50 is used as a rerecording chamber and for acceptance screenings.

After the sound has been recorded and an interlock screening has been held, the composite print is made and the original requesting authority is invited to an acceptance screening.

In addition to requests for motion pictures, many calls are also received by Operations for the services of the Graphic Arts, Still Photography, and Aerial Photography Divisions.

The facilities of the Still Photography Division include a wide variety of cameras, developing tanks, washers, driers, trimmers, enlargers, and printers. Photomurals, microphotography, and color photography are some of the specialized activities. Thousands of contact prints and enlargements are made for the Navy Department, frequently of pictures taken in sorties over combat areas. A supply

of prints is delivered at frequent intervals to the Photographic Interpretation Center for strategical information.

The Graphic Arts Division provides mimeographing and photo-static services. On its monotype process camera, negatives up to 20 X 24 in. can be made. This division makes 300-line screen reproductions which are run off on Harris offset presses at the rate of about 4500 impressions per hr. It prints and binds booklets for distributing tactical information to the fleet and other operational units.

Last but not least, is the Aerial Photography Division. It checks all aerial cameras and specialized equipment supplied to the Navy's widely separated ships and stations. Its laboratory section makes ratio prints from aerial photographs and large negatives. This division also tests photographic installations in aircraft, experiments with aero-Kodacolor which can be processed in the field, compiles maps from aerial photographs and makes aerial mosaics.

This hasty tour of the Photographic Science Laboratory has shown that it is a photographic service center for the United States Navy, especially for assignments of a secret or confidential nature that should be handled only by Naval personnel.

Upon request approved by the Bureau of Aeronautics, Director of Photography, it produces motion pictures on the sound stage or on location. When advisable, motion picture units are sent outside the United States to record tactics used by the fleet or by land-based Naval forces. These films vary in content and treatment. Incentive films may increase industrial production or aid recruiting programs. Training films may teach Naval organization, customs, and specialized techniques to the "boot," or they may instruct officers and mates of many years' experience in the use of secret ordnance or new detection devices. Report films may record Naval action on the high seas, or may serve research upon cures to be effected or new mechanisms to be perfected.

To Navy photographers with the fleet or at advanced bases, the laboratory sends equipment and film as well as processing instructions suited to various climatic conditions. With the information supplied by specially trained photographers using cameras shipped from Anacostia, invasion strategy is planned. For the footage exposed in these advanced areas and flown back by Naval Air Trans-

port Service, there are processing and copying services available at home.

Whatever job, large or small, is assigned to this shore establishment, it is the function of its personnel to carry through as quickly as possible for the most efficient operation of the United States Fleet.

## COMMERCIAL PROCESSING OF 16-MM VARIABLE AREA\*

ROBERT V. McKIE\*\*

*Summary.*—This paper presents a series of curves showing the tolerance for commercial processing of 16-mm variable-area sound tracks. Values of distortion encountered in commercial practice are indicated.

The problems of processing control for 16-mm film are basically the same as the problems of processing control for 35-mm film. The processing control of 35-mm variable-area sound track has been successfully established by the cross-modulation method.<sup>1</sup> This method was also adopted to establish the processing tolerances for variable-area track on 16-mm. It has taken us many years to establish adequate controls for 35-mm film and many improvements in developing, printing equipment, and technique have been necessary. Laboratory equipment for 16-mm has not kept pace with the improvements in 35-mm equipment, hence we found more difficulty with 16-mm processing at this time than we now experience with 35-mm processing.

Nevertheless, the increased activity in the 16-mm field makes it necessary to establish commercial processing tolerances for 16-mm film. This increased activity results from the fact that the greater part of the pictures being produced by Hollywood studios is reduced to 16-mm for war activities, either by rerecording or by the photographic process.

These pictures are distributed to the Army and Navy for projection at various camps overseas. From 65 to 75 composite prints are made on each picture and, including the many training films being produced at this time, the total 16-mm film being processed will average millions of feet per month.

Two types of measurements were desired. First, measurements to determine processing controls and, second, measurements of distortion on 16-mm sound track properly processed.

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\* Presented Apr. 19, 1944, at the Technical Conference in New York.

\*\* RCA Victor Division of Radio Corporation of America, Hollywood.

A "family" of 16-mm negatives was recorded at 80 per cent amplitude, each negative consisting of (1) 400 cycles for reference level, (2) 4000 cycles for measuring high-frequency loss, and (3) 4000 cycles modulated in amplitude at a 400-cycle rate for cross-modulation measurements. The 400-cycle section of the test was used to obtain the data for the distortion measurements.

Using a Corning 584 filter, EK 5372 fine-grain recording stock was exposed as a negative material over a density range from 1.80 to 2.15. This negative was developed at a pre-established speed for variable-area sound track negative determined by a series of exposure tests in a print-type developer. A family of contact prints was then exposed with unfiltered mercury-vapor light covering a density range from 1.00 to 1.40 using EK 5302 as a positive material.

A review of the quality of recording equipment showed that even a better than average commercial 16-mm reproducer would be unsatisfactory for measuring these tests. Accordingly, a special 16-mm reproducer of the "grindstone" type was set up and used for the measurements subsequently discussed. The tests were measured through the special film measuring channel by

running the film in the form of a loop.

Fig. 1 shows the cross-modulation curves plotted against print density. It has been established by numerous frequency tests and by practical experience with music and dialogue recordings that 30-db cancellation of the 400-cycle component in the cross-modulation test is satisfactory for all types of material, and density tolerances have been established at this value. From Fig. 1 the print density tolerance for a negative density of 2.15 is 0.92 to 1.42.

However, experience has proved that owing to variations in exposures and emulsions it is more practical to maintain the print density within the smallest possible tolerance, and to allow the max-

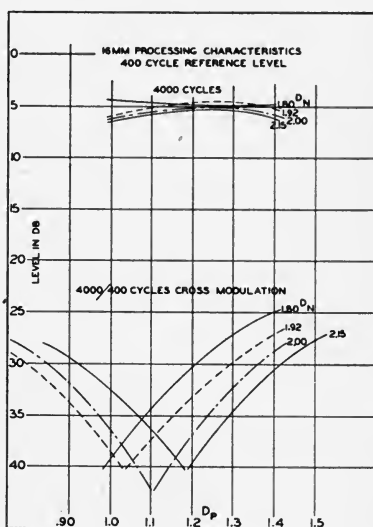


FIG. 1.

imum variations in negative density. All laboratories now have a well-established control department, and tests covering the entire process are made at definite intervals so that the variations which do occur can be controlled easier in the laboratory than during actual production, where the sound tracks are recorded under varying conditions of temperature that may effect the emulsion and cause changes in the density of the sound track negative.

This method of maintaining the print density within the smallest possible tolerance and allowing the maximum variations in negative density, requires the least number of timing corrections. Negative densities can easily be maintained within the wide tolerances permissible for a given optimum print density under reasonable processing conditions. This method eliminates unnecessary handling and timing of each scene of the negative when sent to the laboratory, or the necessity of keeping elaborate records on the density of each scene. Only negative variations, which do not fall within the wide negative tolerance as indicated by the cross-modulation test, need be noted.

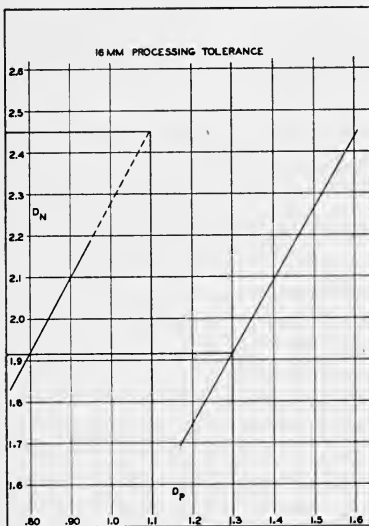


FIG. 2.

Fig. 2 shows density tolerances for a combination of negatives and prints having 30-db cancellation and indicates a negative density range of 1.92 to 2.45 for an optimum print density of  $1.20 \pm 0.10$ .

The 400-cycle section of the test recording was used for distortion measurements. The grindstone was used as a means of running this film. For any given negative or print density covered by the density range, as indicated above, the distortion measured from 2.5 per cent to 3.5 per cent using a General Radio distortion factor meter.

Under adequate control the sound quality depends largely upon the mechanical performance of the printer and, to some extent, upon the type of developer used by the laboratory.

The processing conditions under which these tests were made

represent commercial practice and may not represent the optimum conditions for processing 16-mm film. They do, however, represent the average and the distortion figures as indicated in this paper, even though they may not represent the absolute minimum, appear to be about the right order of magnitude for the average commercial recording.

It should be remembered that the distortion figures include the distortion of the recording and reproducing systems, as well as the distortion of the film itself. We do not know of any satisfactory method for separating these distortions. Under existing circumstances, we do not consider this magnitude presents a serious problem.

#### REFERENCE

- <sup>1</sup> BAKER, J. O., AND ROBINSON, D. H.: "Modulated High-Frequency Recording as a Means of Determining Conditions for Optimal Processing," *J. Soc. Mot. Pict. Eng.*, **XXX** (Jan., 1938), p. 3.

## A PLAN FOR PRESERVING 16-MM ORIGINALS OF EDUCATIONAL FILMS\*

WM. H. OFFENHAUSER, Jr.\*\*

*Summary.*—The growth of 16-mm release print volume has been so rapid as a result of the war that there is serious danger of the destruction of priceless originals if the present haphazard methods of supervision of print manufacture are continued. The situation has already become acute in 16-mm Kodachrome.

The solution appears to rest in anticipating print needs and in purposefully preserving originals by dead storage under suitable refrigeration. To accomplish preservation, it is necessary that all release prints be made from intermediate copies made specifically for the purpose. In this manner, it is possible to keep the originals in storage for a relatively long time, removing them periodically for the sole purpose of making intermediate copies, such as dupes, but in no case using them for making release prints. A cycle of 51 weeks of storage and one week of use is suggested as a starting point.

With the recommended procedure and with present-day materials under good control in duplicating, upward of 2500 release prints can be made from a single original. This large number is by no means the maximum, as the number of copies that can be produced in each step can be materially increased with care in handling. The method is applicable to the making of black-and-white prints from Kodachrome and similar originals, as well as to color prints. In the broader aspect it may be applied to the preservation of educational films however made.

It has been said that the maturity of an age can be judged quickly by the amount of recorded material that is purposefully preserved for a future time. If today we look forward a generation, let us say, and review what we are now doing, we find that we are at the beginning of a new era in motion picture history: an era of purposefully recording in films the ideas that we wish to convey to others of our own generation and to generations to come. Our civilization is "coming of age."

There has been much talk lately of post-war planning; the planning of individuals, the planning of governments and nations, the planning of social groups, the planning of industry, and the planning of education. Hollywood is doing its share of planning; planning not only

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\* Presented Apr. 19, 1944, at the Technical Conference in New York.

\*\* New York, N. Y.



for bigger and better entertainment films, but also helping in the standardization of 16-mm equipment and materials now required by the Armed Forces. Much planning is still in the formative stage; most of it has not materialized so far into plans that concern themselves with the physical materials and their preservation.

The motion picture has proved a most effective teaching aid in the present war. It is in very wide use and has been especially valuable in reducing the amount of time required by a student to acquire a particular quanta of information and, in the case of equipment, a particular degree of skill. All who have observed it in action agree that the motion picture can serve an even more useful purpose in the post-war period. This paper will be limited in scope to 16-mm films whose primary purpose is education in the broader aspect.

**Present Status.**—If material is to be preserved, there must be a plan to accomplish the preservation. At this time we are so engrossed with the job of "getting the war over" that we have given little thought to what we shall do with the material being currently produced. The thought has been expressed, "We'll worry about that when the time comes," to which the reply is made, "You won't have to worry about it; the originals and the duplicates are in such bad condition now, that there won't be anything left to worry about by the time you get around to it."

Unfortunately, when a future generation looks back into our present history and finds this little controversy, there will be but one comment, "How *very* shortsighted." The only serious preservation efforts made so far have been those of the Museum of Modern Art and of The National Archives. The situation is still far beyond solution with the meager budgets of these organizations and with their limited powers, as they do not ordinarily become actively concerned with the preservation of material until long after the material is first released for use. (In the interim, the original is often altered, mutilated, destroyed, or partially damaged by the unrecorded removal of scenes or sequences.) Attempted preservation at this late stage is quite like trying to close the stable door after the horse is stolen.

If some of today's expansive dreams are to come true, preservation (and its corollary, storage) must be planned, and the time is now. We must *design* our film-handling methods to make the long-term use of an educational film possible. This must be thought out *before* a film is produced, not *after* the originals are irretrievably ruined. This

cannot be accomplished by our present haphazard and planless approach; for example, a Kodachrome original of long-term usefulness (as judged by the subject matter) that is handled in the present planless way will not last even 6 months. Such a film will be torn to shreds long before it has outlived its usefulness. Today the owner of a priceless 16-mm original ships it *out of his sight* for the making of prints to a laboratory or other nominal caretaker where others are authorized to make almost limitless copies of it without any handling precautions—and ruin it in the process. Once ruined, the owner frantically hunts for a copy that is in good condition, hoping to use this as a printing master from which to make the additional copies he needs. This story does *not* have a happy ending; it is rare that such an unmarred copy can be found. And so it ends—a valuable original leaves nothing behind for future study except some useless scrap.

Under today's wartime conditions, the prospect of a 6 months' probable life for a Kodachrome original is quite discouraging, especially if the subject matter is vital (such as a subject on malaria, for example) and should have a long planned life. Assuming basic treatment, this might run to 20 years or more.

It is true that during peacetime the pace is not so fast and the probable life of the hypothetical malaria subject might run to 2 or 3 years; but even this is disappointing if we are thinking in terms of a 20-year useful life. While the calendar life of a Kodachrome original may be considerably longer during peacetime than during war, this results far more from the fact that the total number of prints of the subject is smaller than because the handling of the material is better coordinated and planned. The industrial and educational uses for films demand a far longer calendar life. This *can* be obtained if it is planned beforehand. It is perfectly feasible with today's materials and methods if the plan is rigidly followed.

**The Three Stages of Storage.**—Webster defines preservation as "the act or process of preserving or keeping from injury or decay." For an original 16-mm film, therefore, the objective is *to keep and save the originals from injury or decay* (which can be accomplished by storing the originals under suitable physical conditions)—and at the same time provide copies for use that are derived from those originals. As it is impossible to "have one's cake and eat it too," it follows that the release prints shall be made from intermediate copies during the time the originals are in proper storage.

The general method is not new; a modification of it has been used for years by the entertainment motion picture industry. Briefly, there are 3 stages of storage:

Stage 1. The originals (in the custody of the owner) are in "dead" storage under suitable conditions. (Temperature constant and maintained in the range 40 to 50 F.)

Stage 2. The intermediate copies (in the custody of the laboratory or other processor) are in "live" storage under the best conditions possible yet assuring ready availability for the making of copies. The intermediate copies are used to provide release prints.

Stage 3. The release prints—available for ready use yet stored under the best available conditions. (Temperatures above room temperature to be avoided where possible, and sudden changes in temperature to be avoided where possible.)

The responsibility for storage falls upon the parties logically responsible—the owners for the originals, the processors for the intermediate copies, and the libraries or other users for the prints. This arrangement has all the advantages of the customary handling of "protection copies," with the further advantage that possible damage or loss is anticipated.

**The Mechanics of the Method.**—The mechanics of the method are simple. Once each year the originals are withdrawn from storage. The user of the subject advises the laboratory or processor of the probable requirements for release prints for the forthcoming year. The laboratory is then asked to make up *all* intermediate copies (derived directly from the originals) necessary for a full year's operation. These are all made up at one time.

As soon as the intermediate copies specified above are completed, the originals are returned to the owner for stage 1 storage for the forthcoming year. This storage presumes the best conditions known; such conditions are not assured merely by the appearance of a warehouse bill once each month. For 16-mm originals (such as Kodachrome picture and 16-mm track negative) storage may be quite simple, as described later in this paper. The important characteristic of the method is that originals remain in "dead" storage a very long time as compared with the length of time they are being used for the making of intermediate copies. Storage for 51 weeks of the year and use for one week, as indicated, would represent a typical schedule.

It may well happen that the owner of a film will underestimate (or overestimate) his need for prints during a particular year. This will not vitiate the utility of the suggested preservation method unless

he fails to learn by his experience. Time and a little experience will provide the best solution concerning operational details.

With regard to the suggested interval of one year, there is nothing sacred about it. It is the author's opinion that with present materials handled in the present manner, this interval represents the best compromise starting point for the various factors involved.

**Print Quality.**—It should be obvious that good quality is assumed in *all* prints manufactured in accordance with this method, not merely good prints in the sample lot.\* With the original suitably preserved, it should be an easy matter to check quality of release prints made by one laboratory with release prints made by another or, for that matter, to check the quality obtained at one time with the quality obtained at another.

Up to this point, only Kodachrome originals have been discussed. The case of 16-mm reversal is functionally just the same as the case for Kodachrome. The current interest in Kodachrome arises from the problems now being faced that are already acute. Without radical changes in the present manner of handling, the situation can not but become progressively worse. In the case of reversal, the situation has not been so obvious since the demand for black-and-white prints from 16-mm originals has not grown at the same tremendous rate as the demand for color prints. Should the demand for black-and-white prints grow at the same rate, however, the interest will be just as keen and the problems no less serious.

**2500 Copies from a Single Original.**—A question often asked is "What is the largest number of Kodachrome duplicates possible from a Kodachrome original—assuming that the originals are

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\* The difference in quality between sample prints supplied by the producing contractor and subsequent lots is now aggravated by an unfortunate circumstance in government contracts for training films and the like. The producing contractor is called upon to deliver the picture original, the sound negative original, one duplicate negative of the picture, one duplicate negative of the sound, and 3 composite black-and-white prints. The composite prints and the intermediate films have no relation whatever to the production processes used in the laboratories that contract to manufacture the release prints. There is no guarantee that the materials, equipment, processes, and methods used in release printing will be capable of reproducing the quality of the sample prints; nor is there any clause in the release printing contract by which prints inferior to the sample are rejected. The result of this contract method may be good "sample" prints, but because of the absence of quality specifications and suitably planned release print procurement, release print quality is questionable, and there is no assurance that the life of an original will not be cut short by improper handling.

properly stored and handled?"\* If printing intermediate copies are made for release printing, at least 50 such intermediates can be made from a Kodachrome original properly prepared and carefully handled. If each of these intermediate copies is used to make release prints, at least 50 release prints can be made from each intermediate copy. If each intermediate copy is printed as a one-light master (as it should be in most cases), the number of release prints from an intermediate master copy may be increased to 100 or 150; on some films already printed the number has run over 250. A good place to start, however, will be 50 prints from each intermediate copy, and it would be well to consider the difference between 50 prints and any larger number as quality insurance necessary to maintain the smallest quality differential between the first production print and the fiftieth.

**Storage Recommendations.**—For proper storage, it is advisable to follow closely the recommendations of the film manufacturers. For Kodachrome, it is first necessary to clean the film lightly yet thoroughly; carbon tetrachloride (Carbona) sparingly applied is probably the best cleaning agent. The film should be wound firmly on a core without cinching and placed in an ordinary metal film can. Cleaning and packing is best performed in a dust-free air-conditioned room where the temperature is near 65 or 70 F and the relative humidity around 40 per cent.

The film cans are then identified and sealed—Kodatape is excellent for the purpose. (Certain film cans made by Bell and Howell and others have holes in the underside of the can that must be sealed to accomplish the purpose. Kodatape may be used for this sealing also.) After such sealing, merely put the cans—lying flat—in an electric refrigerator set to maintain a constant temperature in the range 40 to 50 F.<sup>1</sup> (The storage space actually used and the accuracy

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\* For maximum print-to-print uniformity and quality of release prints, an intermediate color duplicate of the picture should contain all the color and timing correction necessary to permit release printing at one light under a single set of predetermined conditions (such as color temperature of the source and filter color-balance). A good starting point is the current picture color duplicating recommendations of the Eastman Kodak Company. Once proper timing and color correction has been obtained in a test intermediate duplicate, all intermediate duplicates required for the forthcoming year should be exposed and color developed as a single lot. Side-by-side projection of each such intermediate duplicate with the test intermediate duplicate will quickly indicate to an alert and informed inspector which copies show deviations in quality beyond the normally small process variations that are to be expected.

of temperature control employed is a matter of compromise among the various factors involved.)

For the black-and-white sound track negative, it is desirable that it be made upon film base of low shrinkage (such as Eastman Kodak 5372). The only other physical requirement that needs mentioning at this time is that the film be properly washed and dried. Under present conditions, most production laboratories developing 16-mm sound negative as a regular part of their business do not have much difficulty with excessive hypo content, but their products are not, for the most part, properly dried. For this reason, when 16-mm sound track negative is to be stored, the film should be loosely wound and permitted to become moisture-stabilized by drying at room temperature and humidity for 24 to 48 hr. (Room temperature is presumed to be 65 F; humidity to be 40 per cent relative.) From that point on, the storage and preservation procedure is the same as for Kodachrome.

It may well be asked, "Are such simple storage techniques adequate?" The best answer to this question is that for *acetate* base films (such as the Kodachrome picture and the sound track negative discussed), the effectiveness of further measures that have been considered has been doubtful and, at the same time, costly. Until such time as the more complicated procedures justify their costs, they should be looked upon with suspicion for use with ordinary films.

#### DISCUSSION

MR. BRADLEY: I am speaking as Chairman of the SMPE Committee on Preservation of Film. As the membership knows, this Committee has given considerable thought to the problem of preservation, and we are glad to have Mr. Offenhauser give this additional emphasis to the problem. In a manner of speaking he has sounded an alarm which is timely; that is, the danger of losing certain motion picture records of the present war effort.

Let me hasten to add, however, that constructive work is being done in an effort to preserve current and pertinent motion picture films relating to the prosecution of the present military conflict. In the first place, The National Archives is continuing its activities in terms of government motion pictures of an archival or record character. In the second place, The Library of Congress is collecting and preserving certain categories of motion picture film principally as library material. Again, the United Nations Central Training Film Committee is taking steps to preserve its collection of training film. In all cases efforts are being made to preserve not only a negative and master positive of each film subject, but a reference projection print as well.

In the case of color film, the members of the Committee on Preservation of Film would welcome any contribution that can be made which would promote the

longevity of this type of film. As far as the Chairman knows, the dyes used in the making of color film are fugitive and unstable in character. In view of this situation governmental agencies are being urged to make a black-and-white copy of each color film as an extra insurance precaution.

#### REFERENCE

<sup>1</sup> CALHOUN, J. M.: "The Physical Properties and Dimensional Behavior of Motion Picture Film," *J. Soc. Mot. Pict. Eng.*, **43**, 4 (Oct., 1944), p. 257.

# CALCIUM SCUMS AND SLUDGES IN PHOTOGRAPHY\*

R. W. HENN AND J. I. CRABTREE\*\*

*Summary.*—Calcium salts may be introduced into photographic processing solutions from (a) the water supply, (b) the emulsion, or both, and these salts combine with some of the developer constituents to form insoluble compounds which may appear as (1) a sludge suspended in the developer or accumulated on the filters, (2) a scum on the film, or (3) a scale on rollers, sprockets, racks, and the walls of tanks. The control of the water supply will reduce the quantity of these precipitates and the scum may be removed by suitable acid rinse or acid fixing baths, but calcium-sequestering agents are often used for more complete control. When selecting these agents, their calcium-sequestering power, stability, photographic effect, and their effect when carried over into the fixing bath must be considered, and on the basis of these requirements, sodium tetraphosphate was found the most suitable.†

Appropriate quantities of sodium tetraphosphate added to the developer were found to (1) prevent sludge formation in mixing, storing, or use of the developer, (2) prevent the formation of scum on the film when in the developer, and (3) greatly diminish the rate at which incrustations accumulate on the tank walls, sprockets, and mechanical parts.

If developers are stored at high temperatures, the polyphosphates present tend to hydrolyze to the simple phosphates which, when carried over into the fixing bath, may precipitate as aluminum phosphate. This hydrolysis does not occur on storage of the dry solids and only very slowly below 85 F when in solution. Solutions stored at high temperatures or for prolonged periods may be protected by the addition of sodium citrate which extends the life of the tetraphosphate solution and prevents precipitation in the fixing bath if hydrolysis has occurred.

## (A) INTRODUCTION—CALCIUM PRECIPITATES

Calcium and magnesium salts are usually the chief impurities present in water supplies, and they often cause difficulties in photographic processing, namely, (1) turbidity and sludging of the developer, (2) scum on the surface of film and prints, and (3) scale deposits on hangers, rollers, sprockets, racks, and the walls of tanks. Precipitation most frequently occurs in the developer but may also take place in fixing baths, toning solutions, *etc.* In the case of de-

\* Presented Oct. 17, 1944, at the Technical Conference in New York.

\*\* Kodak Research Laboratories, Rochester, N. Y.; Communication No. 968.

† Patent applied for.



velopers, the precipitate consists of calcium sulfite, or a form of basic calcium sulfite, mixed with calcium carbonate and possibly magnesium carbonate, depending on the constitution of the developer and the quantities of impurities present. The tendency to precipitate and the character of the precipitate formed also differ with the developer (see Table 1). In general, (a) low pH developers with a high concentration of sulfite, such as *D-76* or *D-103*, and (b) those with a relatively high concentration of carbonate, such as *D-72* and *D-16*, show the most marked tendency to cause precipitation.

**Properties of Calcium and Magnesium Precipitates.**—Calcium sulfite is a white compound which crystallizes in the hydrated form ( $\text{CaSO}_3 \cdot 2\text{H}_2\text{O}$ ). Only about 43 parts per million are soluble in water

TABLE 1  
*Calcium Concentrations to Give Precipitate in Developers*

Developer	Calcium Chloride Immediate Precipitate		At Equilibrium		pH Value
	(Grams per Liter)	P.P.M.	(Grams per Liter)	P.P.M.	
Kodak <i>DK-20</i>	0.3	300	0.07	70	8.2
Kodak <i>D-76</i>	0.35	350	0.10	100	8.7
Kodak <i>DK-60a</i>	0.5	500	0.25	250	9.6
Kodak <i>D-72</i> (1:2)	0.35	350	0.12	120	10.3
Kodak <i>D-19</i>	0.7	700	0.15	150	10.4
Kodak <i>D-8</i>	1.7	1700	—	—	13.0
Kodak <i>D-16</i>	0.3	300	0.10	100	10.0

at 18 C (about 65 F), and like many calcium compounds, it is somewhat less soluble in hot water. There is evidence for the existence of basic sulfites ( $\text{Ca}_x(\text{OH})_y(\text{SO}_3)_z$ ) when precipitation occurs from alkaline solutions. Calcium carbonate ( $\text{CaCO}_3$ ) is also a white compound and is even less soluble in water than the sulfite, namely, 12 to 14 parts per million. Magnesium sulfite ( $\text{MgSO}_3 \cdot 6\text{H}_2\text{O}$ ) is relatively more soluble (1250 parts per million) and would not ordinarily precipitate in a developer, but magnesium carbonate may precipitate, although its solubility varies greatly with the conditions of formation. All of these compounds are soluble in dilute acids, such as a 1 per cent acetic acid solution.

**Types of Precipitates.**—(1) *Developer Sludge.*—The white precipitate which often forms in developers freshly mixed with hard water has been shown by Crabtree<sup>1</sup> to consist principally of calcium sulfite, while in developers of high carbonate content the sludge has

been found to be mostly calcium carbonate. In low  $pH$  developers, such as *D-76*, the deposit is largely crystalline but, in the more alkaline developers, it tends to be flocculent. In general, this sludge is more of an annoyance than a real difficulty unless it is necessary to observe the progress of development. It will rarely remove sufficient sulfite or carbonate to change the photographic properties of the developer. The sludge becomes serious when developing

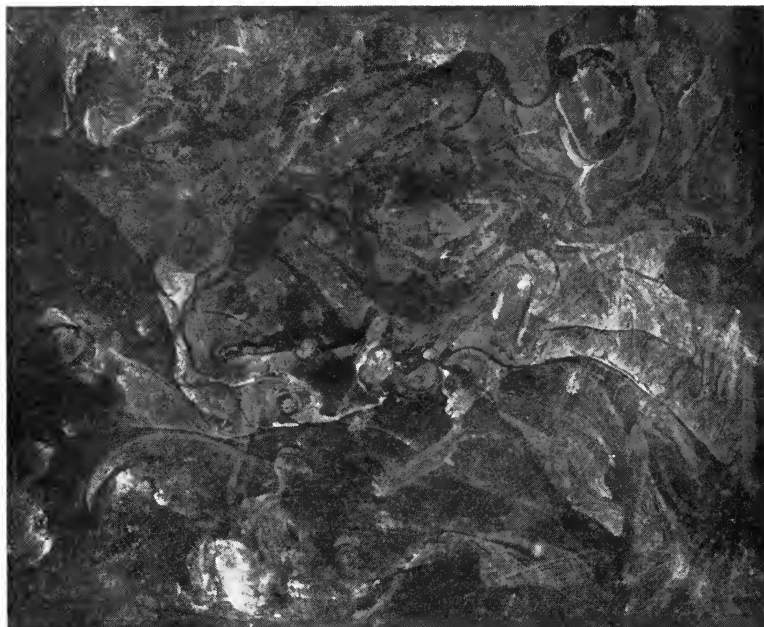


FIG. 1. Calcium Sulfite Scum. This white deposit of calcium sulfite was produced on a film processed in the *D-76* developer and fixed in plain hypo.

paper prints under a safelight since enough sludge is often formed to interfere with clear visibility.

(2) *Scum*.—Probably the most objectionable type of calcium deposit is a white scum on the surface of the film (see Fig. 1). This scum tends to cling strongly to those areas which may have been touched with the hands during development and takes the form of well-defined finger marks, but it is sometimes quite evenly distributed over the surface of the film. It is slowly soluble in fresh acid fixing bath and the rate of solution is greatly aided by agitation. However,

it may dissolve more slowly than the silver halide, especially if the bath has been used sufficiently to lower the acidity, in which case the film may appear to fix very slowly. Since the scum may be wiped off the surface with the fingers, this test may be used to distinguish it from the unfixed silver halide. It also dissolves slowly in the wash water and may be wiped off before drying although, in some forms, it is so transparent that it is not readily visible until dry.

(3) *Scale*.—The third objectionable type of calcium precipitate is a scale on the walls of the processing tanks and on film rollers, sprockets, racks, and other equipment. When the rate of deposition is slow, a tough deposit is formed which is very difficult to remove. It is particularly troublesome in the case of continuously used solutions as in deep tank work where it incrusts upon tank walls, hangers, sprockets, and nozzles. Analysis of a tank scale deposited from the *D-76* developer disclosed that it consisted almost entirely of calcium salts, about 75 per cent as the sulfite and 25 per cent as the borate.

(4) *Drying Spots*.—When films are washed in hard water and are imperfectly squeegeed before drying, white deposits are apt to remain on the surface of the film after evaporation of the water. These deposits may be prevented by (a) a final rinse in distilled water, (b) the use of a wetting agent which permits the water to drain evenly from the film, or (c) thorough wiping or squeegeeing of the film before drying.

#### (B) SOURCES OF CALCIUM IN THE DEVELOPER

Calcium and the slightly less troublesome magnesium salts are found to some extent in all natural waters except fresh rain water, and may be present as carbonates, bicarbonates, chlorides, or sulfates.

Table 2 reproduces values taken from the U. S. Government Bulletin on "The Industrial Utility of Public Water Supplies in the United States" (1932), and indicates that the "hardness" of water supplies varies greatly; in general, for surface supplies possibly 100 to 200 parts of "hardness" (calculated as calcium carbonate) per million is fairly typical. Most well water is much harder, and 250 to 600 parts per million is not uncommon. In Hollywood, the average hardness value for several laboratories was 144 parts per million, while the hardness of a Culver City well supply was 305 parts per million. In general, this hardness will be divided between

calcium and magnesium in a 2:1 or 3:1 ratio, with calcium as the chief impurity.

A second source of calcium is from the gelatin of the photographic emulsion. Gelatin is produced by "liming" hides, that is, by treating them with calcium hydroxide. The proportion of calcium salts present may be as high as 1 per cent of the weight of the gelatin. It has been calculated that during a long exhaustion life as much as 1 gram (15 grains) of calcium salts could accumulate in a liter (32

**TABLE 2**  
*Hardness of Typical Water Supplies\**

City	Source	Total Hardness (As Parts Calcium Carbonate per Million)
Portland, Ore.	Bull Run River	9
Boston, Mass.	Wachusett Reservoir	15
New York, N. Y.	Catskill Supply	20
Rochester, N. Y.	Lake Ontario	105
Cleveland, Ohio	Lake Erie	120
Denver, Colo.	Platte River Tributaries	121
Chicago, Ill.	Lake Michigan	125
Hollywood, Calif.	Average of 5 Motion Picture Laboratories	144
Minneapolis, Minn.	Mississippi River	172
San Antonio, Texas	Wells	220
Jacksonville, Fla.	Wells	270
Culver City, Calif.	Well	305
Wichita, Kansas	Wells	411
Chikasha, Okla.	Washita River	626

\* Values from "The Industrial Utility of Public Water Supplies in the United States" (1932), U. S. Department of the Interior, Geological Survey Water Supply Paper No. 658.

oz) of developer which would be equivalent to a concentration of 1000 parts per million.

These 2 sources of calcium, (1) the water, and (2) the emulsion, must be considered when studying the control of difficulties attributed to calcium salts.

#### (C) CALCIUM-SEQUESTERING AGENTS

The prevention of calcium precipitates (including scum and scale as well as sludges) is far preferable to their removal, which may be difficult and time-consuming. They may be prevented to some extent by treating the water supply with water softeners, but the

calcium from the gelatin will accumulate as exhaustion progresses and still cause difficulty. Suitable methods of treating the water include (1) boiling to remove temporary hardness, (2) removal by Zeolites and synthetic resins, and (3) precipitation of the calcium as oxalate and filtering.<sup>2</sup>

However, the use of calcium-sequestering agents will not only control the calcium present in the water but also that coming from the film during processing. These agents segregate or "sequester" the calcium in the form of a complex compound which, although soluble, no longer yields the reactive calcium ions which combine with the sulfite (or carbonate) to form the troublesome precipitates.

(1) **Organic Acids.**—One group of sequestering agents consists of organic hydroxy acids or their salts, such as tartaric acid, sodium citrate, *etc.* They are effective, at least temporarily, when employed in sufficiently high concentrations, such as 50 to 100 grams per liter, but when carried over into the fixing bath cause loss of hardening power by combining with the alum. Certain  $\alpha$ -amino polycarboxylic acids have also been employed<sup>3</sup> but are relatively expensive.

(2) **Polyphosphates.**—A second type of sequestering agent is of greater practical importance.<sup>4,5</sup> This comprises a group of complex phosphates to which the term "polyphosphate" has been applied. The most common of these are (1) the sodium salt of polymerized metaphosphoric acid, known as sodium metaphosphate or under the trade name "Calgon," ( $\text{NaPO}_3$ )<sub>6</sub>, and (2) the sodium or potassium salts of pyrophosphoric acid,  $\text{Na}_4\text{P}_2\text{O}_7$  and  $\text{K}_4\text{P}_2\text{O}_7$ . Calgon has been widely used experimentally during the past few years and for large-scale work by at least one motion picture laboratory. Another member of this group which has not previously appeared in the photographic literature but which is especially effective is (3) sodium tetraphosphate,  $\text{Na}_6\text{P}_4\text{O}_{13}$ . Some of the comparative properties of these phosphates are given in Table 3.

A sequestering agent placed in the developer should not affect its photographic properties, should remain unchanged over considerable periods, and should not react adversely with the fixing bath or other solutions into which it may be carried. Consequently, tests made with these polyphosphates included (1) the calcium-sequestering properties, (2) keeping properties, (3) effect on developer activity, fresh and aging, and (4) tendency to precipitate with the fixing bath, fresh or on aging.

(a) *Calcium-Sequestering Properties.*—The values (see Table 3 and Fig. 2) were determined by adding a dilute calcium chloride solution to the developers containing various concentrations of the polyphosphates until a light precipitate was visible. Since this precipitate tends to form slowly, long standing periods (24 hr) were re-

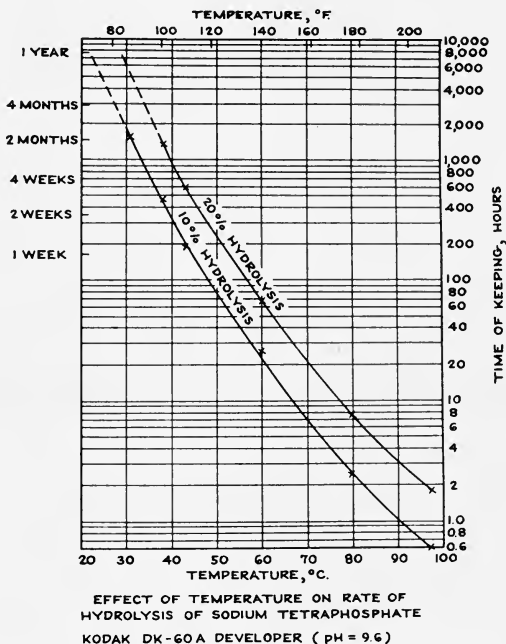
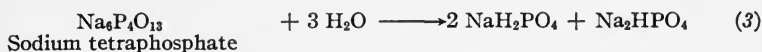
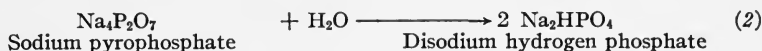
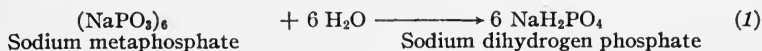


FIG. 2. Illustrating the effect of temperature on the keeping properties of sodium tetrphosphate in the developer solution. Hydrolysis occurs rapidly at high temperatures but decreases rapidly as the temperature drops and becomes negligible under normal conditions.

quired, or the reaction was accelerated by rotating the reaction tubes in warm water; in this case, virtual equilibrium was attained in 30 min. In much of the preliminary work, the value to produce an immediate precipitate was used and this figure has been found to be roughly proportional to the final equilibrium value. In general, it has been found necessary to employ a much higher concentration of pyrophosphate than of either tetrphosphate or of metaphosphate to produce a given calcium-sequestering action, while the magnesium-

sequestering powers of the pyrophosphate and tetrakisphosphate appear to be superior to those of the metaphosphate. The calcium precipitation tests have been found to run closely parallel to practical exhaustion or scumming tests.

(b) *Keeping Properties*.—On prolonged standing when warm or in the presence of strong alkali (or acid), the polyphosphates tend to hydrolyze to the simple phosphates (orthophosphates). The scheme of these hydrolysis reactions for the 3 groups of polyphosphates is represented by the following equations:



This hydrolysis results in (a) loss of calcium-sequestering power, and (b) change in pH value. The sodium dihydrogen phosphate is acid while the disodium hydrogen phosphate is alkaline; the mixture as represented by Eq (3) has a pH of about 6.5, or is nearly neutral and consequently produces little change in activity. (c) The release of phosphate ions in the developer which, when carried over into the fixing bath, react with the alum to form insoluble aluminum phosphate which deposits as a sludge in the fixing bath and as a white scum on the film, which is more difficult to remove than calcium sulfite. The hydrolysis of the polyphosphates occurs only in the presence of moisture. The solids will keep indefinitely in well-stoppered bottles, but slowly deteriorate in the presence of moist air.

Normal hydrolysis is a very slow process, requiring weeks or months at normal temperatures, and it was necessary to warm the solutions in order to study relative rates. The values in Table 3 were determined by heating solutions containing the polyphosphate and a calcium salt and taking the time of precipitation as a measure of the decomposition of the polyphosphate-calcium complex. These tests, plus prolonged keeping tests at lower temperatures, showed that the tetrakisphosphate possessed a definite advantage with regard to stability.

(c) *Chemical Effect*.—The polyphosphates are not active photographically, but may influence the pH (alkalinity) of the less active developers if used in considerable concentrations. Sodium meta-

phosphate is ordinarily somewhat acid, and the pyrophosphates are quite alkaline, while the pH of sodium tetrakisphosphate differs but little from that of low-activity negative developers, such as *D-76*, and therefore has little effect upon the rate of development.

(d) *Tendency to Precipitate in the Fixing Bath.*—The phosphates form insoluble compounds with aluminum, a constituent of most acid fixing baths. A precipitate will form in an alum solution to which solutions of the polyphosphates are added. Practically, in a well-designed fixing bath, such as Kodak *F-5*, only the pyrophosphate is likely to cause trouble.

TABLE 3  
*Comparison of Polyphosphates*

(1) Name	(2) Formula	(3) Sequestering Power Grams per Liter		(4) Keeping Properties (212 F)		(5) Alum Precipitation	
		In <i>D-76</i>	In <i>D-72</i> (1:2)	In <i>D-76</i> In <i>D-72</i>		Alum to Cause Precipitate	Phosphate to Cause Precipitate in <i>F-5</i>
				min	min		
Sodium meta- phosphate	(NaPO <sub>3</sub> ) <sub>6</sub>	2.0	0.6	4	4	7 gm	over 5 gm
Sodium pyro- phosphate	Na <sub>4</sub> P <sub>2</sub> O <sub>7</sub>	1.5	0.4	1½	2	3 gm	2 gm
Sodium tetra- phosphate	Na <sub>6</sub> P <sub>4</sub> O <sub>13</sub>	2.0	0.75	6	7	10 gm	over 5 gm

*Notes:*

*Column 3—Sequestering Power:* In terms of grams of calcium chloride per liter to cause a light precipitate. (1.0 Gram per liter = 1000 parts per million.)

*Column 4—Keeping Properties:* Reported as minutes for calcium to precipitate from solutions held at 100 C (212 F).

*Column 5—Alum Precipitation:* (a) Grams of potassium alum to precipitate 1 per cent polyphosphate solution. (b) Grams of phosphate to cause precipitate in Kodak *F-5* fixing bath.

The simple phosphates formed on hydrolysis of the polyphosphates are a greater source of difficulty, and 50 per cent hydrolysis of as low a concentration as 0.5 gram of one of the polyphosphates in a liter of developer can produce an aluminum phosphate scum under certain conditions. The degree of stability of the polyphosphate is therefore very important.

From the above discussion and from Table 3 it is seen that sodium tetrakisphosphate is probably the most suitable of the group of polyphosphates. It has slight advantages over the metaphosphate in sequestering power, stability, and alum precipitation propensity and



causes the least change in alkalinity when fresh or hydrolyzed. Sodium pyrophosphate (also potassium pyrophosphate) is less desirable.

(D) SODIUM TETRAPHOSPHATE AS A SEQUESTERING AGENT

(1) **Effect of Concentration.**—The behavior of the various sequestering agents is strongly dependent on the *pH* and constitution

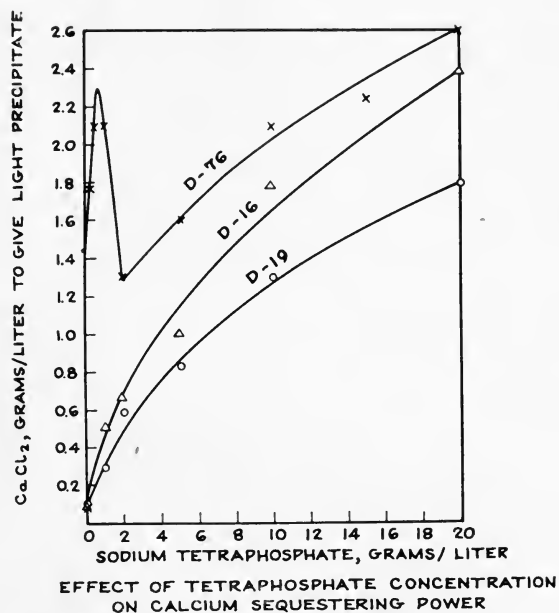


FIG. 3. The behavior of sodium tetraphosphate as a sequestering agent is very dependent on the nature of the developing solution. The existence of an optimum concentration is found with other low *pH* developers as well as *D-76* while high *pH* developers show a progressive effect only and require higher concentrations of the tetraphosphate.

of the developer. The effect of increasing concentrations of sodium tetraphosphate in 3 developers is shown in Fig. 3. The sequestering action is seen to be more powerful in the low *pH* developer (*D-76*) than in the relatively high *pH* developers (*D-19* and *D-16*). Also, in the case of the *D-76*, a maximum effect is obtained at low tetraphosphate concentrations; a similar effect is obtained with other low *pH* developers and with metaphosphate, as well as tetraphos-

phate. The cause of this maximum has not been determined definitely although it has been studied in several groups of experiments. The crystalline precipitate formed at low tetraphosphate concentrations is apparently calcium sulfite, while at high phosphate concentrations the flocculent precipitate formed appears to be a complex phosphate.

It is desirable to employ as low a tetraphosphate concentration as possible to reduce the dangers resulting from possible hydrolysis on prolonged or high temperature storage. In the low and medium pH developers, such as Kodak *D-103*, *DK-20*, *D-76*, *DK-50*, or *DK-60a*, 0.5 gram of sodium tetraphosphate per liter provides adequate

TABLE 4  
*Recommended Tetraphosphate Concentrations*

Developers	Grams per Liter		Calcium- Sequestering (Diluted Developer) P.P.M. Calcium Chloride	Estimated Life 25 Per Cent Hydrolysis at:		
	Stock	Di- luted		70 F	90 F	110 F
<i>Group 1—Low Activity</i>						
Kodak <i>DK-20</i> , <i>D-23</i> , <i>D-25</i> , <i>D-76</i> , <i>D-103</i>	0.5	0.5	Over 1000	3 yrs	9 mos	6 wks
<i>Group 2—Medium Activity</i>						
Kodak <i>DK-50</i> , <i>DK-60a</i> , <i>DK-93</i>	0.5	0.5	About 800	2½ yrs	6 mos	4 wks
<i>Group 3—Carbonate Developers</i>						
Kodak <i>D-11</i> , <i>D-16</i> , <i>D-19</i>	2.0	2.0	About 500	1½ yrs	3 mos	2 wks
Kodak <i>D-52</i>	4.0	2.0	About 500	1½ yrs	3 mos	2 wks
Kodak <i>D-72</i>	6.0	2.0	About 500	1½ yrs	3 mos	2 wks

protection against calcium entering from the water or from the film. In the carbonate developers, such as *D-16*, *D-19*, or *D-72*, about 2 grams of tetraphosphate per liter of developer as diluted for use will protect against all but the hardest water combined with moderate exhaustion. While higher concentrations may be employed for very hard water, such developers should not be stored for long periods since hydrolysis of a relatively small proportion of the phosphate might cause difficulties. Table 4 lists the recommended concentrations for most of the Kodak developers.

(2) **Effect on Calcium Precipitates.**—Developers containing the tetraphosphate concentrations mentioned above display very satisfactory freedom from propensity to give precipitates, namely:

(1) Their sludging propensity is greatly reduced, either during mixing or when diluted with hard water or during exhaustion.

Some sludge may be anticipated on severe exhaustion and prolonged standing owing to (a) the slow release of some calcium ions, (b) the formation of free silver, especially in the *D-76* type of developer,<sup>6</sup> and (c) the presence of foreign substances entering from the emulsion. In the case of a print developer such as Kodak *D-72* diluted with hard water followed by rapid (one day) exhaustion, the improvement in clarity and print visibility is usually very great.

(2) No calcium scum has been encountered even with developers otherwise displaying the greatest scumming tendency, either fresh or on prolonged exhaustion, when the tetraphosphate was added to both the developer and the replenisher.

(3) Almost complete freedom from tank scale and incrustation of equipment has been found for both negative and positive developers during extended use of polyphosphates in the Kodak processing laboratories.

(3) **Keeping Properties.**—Difficulty with hydrolysis of the tetraphosphate has been noted under simulated tropical conditions, but this reaction is very dependent on temperature. Fig. 2 shows the effect of temperature on the rate of hydrolysis of sodium tetraphosphate in *DK-60a*, a moderately alkaline developer ( $pH = 9.6$ ). Data for *D-16* would be approximately similar. Samples of the developer containing the tetraphosphate were held at various temperatures for a series of times and the degree to which hydrolysis had occurred was then determined by two tests: (a) the tetraphosphate remaining was indicated by the calcium-sequestering powers of the developer, and (b) the orthophosphate formed was measured by precipitating it as the ferrous salt from a weakly acid solution. The values obtained with the stored developers were compared with those determined using known mixtures of tetraphosphate and orthophosphate corresponding to different degrees of hydrolysis in the developer. The extreme dependence of hydrolysis on temperature is clearly shown in the figure. It was necessary to use a logarithmic plot in order to reproduce the wide variances in time for relatively slight changes in temperature. Checks run for 3 months at room temperature indicated that no pronounced phosphate hydrolysis occurred in this typical developer under favorable conditions, while keeping tests in the more alkaline developer, *D-72*, have shown only 10 per cent hydrolysis in 5 months at 75 F.

In the presence of high sodium carbonate concentrations, such as in the *D-19* developer or the *D-72* stock solution (but not in the

diluted *D-72* developer), a compact precipitate of sodium calcium carbonate (Pirssonite) slowly forms at the bottom of the containing vessel, apparently caused by the slow release of calcium ions from the tetraphosphate complex. This precipitate is not ordinarily serious since it is small in volume and is not easily dispersed to interfere with solution clarity, while it does not adhere to the walls to form tank scale or form a scum on films.

(4) **Stabilization.**—Since the chief danger in the use of polyphosphates is the hydrolysis to simple phosphates and the precipitation of these in the fixing bath, it is important to stabilize them for keeping under tropical or summer conditions and to prevent scum formation if hydrolysis should occur. The hydroxy acids, previously mentioned, and their salts fulfill both of these requirements, and sodium citrate is probably the most powerful of those readily available at the present time. Used in even relatively small concentrations (2 to 4 times the weight of the tetraphosphate), it will double the life of the phosphate and effectively prevent aluminum phosphate scum when the tetraphosphate is partially hydrolyzed.

Greater and more permanent sequestering action is obtained from the citrate-phosphate mixture than from either the phosphate or citrate alone. While the concentration of citrate required will not appreciably impair the hardening properties of the fixing bath or repress development, it will prevent the formation of the aluminum phosphate scum.

#### (E) RECOMMENDATIONS

**Prevention of Calcium Precipitates.**—(1) *Control of Water Supply.*—If the water supply contains more than 200 to 300 parts per million of total hardness expressed as calcium carbonate, the load on the sequestering agent may be excessive. If a substitute supply is not available, this water may be softened by a commercial Zeolite or "Permutit" system, or by one of the newer synthetic resin exchange systems. An alternate method is to precipitate the calcium from the water by adding about 1 gram of potassium oxalate per liter (60 grains per gal) and, after standing, decanting the clear liquid.

(2) *Addition of Sodium Tetraphosphate to the Developer.*—About 0.5 gram of sodium tetraphosphate added per liter (30 grains per gal) of the Kodak *D-103*, *DK-20*, *D-76*, *DK-50*, or *DK-60a* developers will effectively prevent calcium scum and scale during normal use.

If the solution is replenished, the same quantity should be added to the replenisher. With carbonate developers, such as Kodak *D-16*, *D-19*, and *D-72*, 2.0 grams per liter (120 grains per gal) are advisable. The employment of sodium tetraphosphate is not advised in developers containing caustic soda, such as Kodak *D-8* or *D-82*, since (a) the tendency of calcium to precipitate in these developers is relatively slight, and (b) the keeping properties of the tetraphosphate in these solutions are rather poor. These values apply to the developer as diluted for use; if added to a stock solution, as in the case of *D-72*, the concentration should be increased proportionally (see also Table 4).

(3) *Use of Phosphate and Citrate.*—If the developer solution is to be stored for long periods or at temperatures in excess of 85 F, the danger from hydrolysis may be reduced by employing a combination of sodium tetraphosphate and sodium citrate. In the case of developers containing only borax or Kodalk, 0.5 gram of sodium tetraphosphate with 1.0 gram of sodium citrate per liter (30 and 60 grains per gal) is recommended. In the case of the carbonate developers, 2.0 grams of tetraphosphate with 8.0 grams of sodium citrate per liter (120 grains and 1 oz per gal) should be employed. These mixtures are not advised for caustic developers.

(4) *Use of an Acid Rinse Bath.*—Use of an acid rinse or "stop" bath will not prevent calcium sludge or scale in the developer, but will remove scum from the film and, at the same time, extend the life of the fixing bath. The film is placed in this bath and preferably agitated for one to 2 min following development.

*Stop Bath*  
(Kodak SB-5)

Kodak Acetic Acid, glacial.....	10 cc
<i>or</i>	
Kodak Acetic Acid, 28 per cent.....	32 cc
Kodak Sodium Sulfate (desiccated).....	45 gm
Water to make.....	1000 cc

*Caution:* Acid stop baths should be used with caution when processing film in a carbonate developer at high temperatures, or blistering may result.

This bath may be replenished after processing each 25 rolls per gal by adding one-half of the above quantity of acetic acid. Discard the bath after 100 rolls per gal.

**Removal of Precipitates.**—(1) *In Developer.*—If considered objectionable, sludges may be removed by filtration or decantation.<sup>7</sup>

(2) *Calcium Scum*.—The scum may be removed as suggested above by means of a fresh acid rinse bath. This method is applicable even if the scum has dried on the film before being discovered, although swabbing of the film while in the acid bath may be necessary. It may also be removed by agitating the film in a fresh acid fixing bath, such as Kodak *F-5*. A system employing 2 successive *F-5* fixing baths is very effective in removing calcium scum in addition to insuring permanence and adequate hardening. In this system, the first bath, when exhausted, is replaced by the relatively fresh second bath with resulting economy of material. Calcium scum may usually also be removed by swabbing the surface of the film while in the wash water, or by wiping previous to drying.

If the scum is not removed by the acetic acid rinse bath it indicates that it is probably an aluminum sulfite scum formed in the fixing bath. This aluminum scum is soluble in 5 per cent acetic acid or 2 per cent sodium hydroxide, but it may be necessary to swab the film gently to remove it completely. It is always good policy to harden film thoroughly as, for example, in the Kodak *SH-1* before this treatment.

It is therefore possible to differentiate between "calcium scum" and "aluminum scum" by treating with 1 per cent sodium hydroxide which dissolves only the aluminum sulfite.

(3) *Scale*.—Calcium scale deposits may be dissolved or loosened from tanks and hangers with dilute acids. Acetic acid, in a 2 to 5 per cent solution, is effective in dissolving calcium carbonate deposits and will not attack stainless steel; hydrochloric acid, used in about a 2 per cent solution, is much more effective in removing calcium sulfite and borate deposits, but will corrode stainless steel. The equipment may be scrubbed with the acid solution, protecting the hands with rubber gloves and avoiding the vapors as much as possible, or the tank may be filled with the acid solution and hangers immersed in it for about 24 hr to first dissolve or loosen the deposit. Scale deposits do not generally cling very tenaciously to polished surfaces, such as the walls of stainless steel tanks, and may ordinarily be removed with a putty knife.

#### ACKNOWLEDGMENT

The authors gratefully acknowledge the contributions of their colleague, Dr. H. D. Russell, to the early stages of this investigation.

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- <sup>2</sup> CRABTREE, J. I., and MATTHEWS, G. E.: "Effect of Water Supply in Processing Motion Picture Film," *J. Soc. Mot. Pict. Eng.*, **XVI**, 4 (Apr., 1931), p. 437.
- <sup>3</sup> Brit. Pat. 496,252, Nov. 28, 1938.
- <sup>4</sup> KEISER, K.: "Precipitation in Developers with Hard Water," *Brit. J. Phot.*, **84** (Apr. 9, 1937), p. 232.
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- <sup>6</sup> LOBEL, L.: "On the Formation of Colloidal Silver in Photographic Developers," *Bull. Soc. Franc. Phot.*, **60** (1920), p. 21.
- <sup>7</sup> For discussion and illustration of these methods see CRABTREE, J. I., and MATTHEWS, G. E.: "Photographic Chemicals and Solutions," Amer. Phot. Publishing Co. (Boston), 1939, pp. 31-38.

## SOCIETY ANNOUNCEMENTS

### AMENDMENTS OF BY-LAWS

#### SPONSOR REQUIREMENTS

In canvassing for new members, it has been found that many individuals who would be worthy candidates for Associate or Active membership were not acquainted with the requisite number of sponsors for these grades. Therefore, the Board of Governors proposed a change in sponsor requirements stated in By-Law I, Section 3 (c) and (d), which was published on page 219 of the JOURNAL of September, 1944. The amendment was approved unanimously at a business session held on October 16 during the recent Technical Conference.

Therefore, applicants for **Active membership** shall now give as sponsors at least one member of Active or higher grade in good standing, and applicants for **Associate membership** shall give as sponsors at least one member of the Society in good standing, or two persons not members of the Society but who are associated with the motion picture or allied industries.

#### OTHER AMENDMENTS

Proposed amendments of By-Laws III, V, and VI, as published in the September JOURNAL, were also voted on by qualified members present at the business session on October 16. All were approved and are now in effect.

#### EMPLOYMENT SERVICE

The General Office has received requests from companies desiring motion picture engineers and other technical personnel. In addition, some members have recently asked the Society for aid in making new business connections.

In order to render mutual service to members of the Society in this manner, the Editor of the JOURNAL will accept notices from business organizations for technical personnel, and from members of the Society desiring technical jobs. These will be published in the JOURNAL as soon as possible after receipt—those received before the 15th of the month will appear in the JOURNAL of the following month.

Notices should be brief and must give an address for *direct* reply. The Society cannot serve as a forwarding agent for inquiries, and reserves the right both to edit or reject any notice submitted for publication.

It is hoped that the establishment of this service will not only benefit members of the Society who may desire new business affiliations in the post-war era, but will enable employers to make their needs known to a large group of engineers and specialists in the motion picture industry.



## OFFICERS, GOVERNORS, AND SECTION MANAGERS FOR 1945-46

As a result of the elections held recently, the following is a list of Officers and Governors of the Society for the term beginning January 1, 1945:

\*\* *President*: DONALD E. HYNDMAN

\*\* *Past-President*: HERBERT GRIFFIN

\*\* *Executive Vice-President*: LOREN L. RYDER

\* *Engineering Vice-President*: J. A. MAURER†

\*\* *Editorial Vice-President*: ARTHUR C. DOWNES

\* *Financial Vice-President*: ARTHUR S. DICKINSON

\*\* *Convention Vice-President*: WILLIAM C. KUNZMANN

\* *Secretary*: E. ALLAN WILLIFORD

\* *Treasurer*: M. R. BOYER

† *Governors from the Atlantic Coast Area*:

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\* EARL I. SPONABLE

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† *Governors from the Pacific Coast Area*:

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\*\* PETER MOLE

\* EDWARD M. HONAN

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\* WALLACE V. WOLFE

Officers and Managers of the Atlantic Coast Section for the term beginning January 1, 1945, are:

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\* *Past-Chairman*: ALFRED N. GOLDSMITH

\* *Secretary-Treasurer*: M. W. PALMER

*Managers*: \* E. A. BERTRAM

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\* JAMES FRANK, JR.

\*\* W. H. OFFENHAUSER, JR.

\* J. J. HOPKINS

\*\* H. E. WHITE

Officers and Managers of the Pacific Coast Section for the term beginning January 1, 1945, are:

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\* *Past-Chairman*: CHARLES W. HANDLEY

\* *Secretary-Treasurer*: SIDNEY P. SOLOW

*Managers*: \*\* J. W. BOYLE

\* C. O. SLYFIELD

\*\* F. L. EICH

\* J. R. WHITNEY

\*\* H. W. REMERSCHIED

\* W. R. WILKINSON

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\* Term expires December 31, 1945.

\*\* Term expires December 31, 1946.

† Appointed by Board of Governors to fill unexpired term of Engineering Vice-President.

‡ One additional Governor to be appointed by Board of Governors to fill vacancy in each area.

### BACK ISSUES OF JOURNAL WANTED

The stock of many early issues of the *Transactions* and the *JOURNAL* is being depleted rapidly. The General Office of the Society is unable to supply certain back issues urgently required by the Armed Forces, libraries, and others who have placed orders for complete files of these publications. Therefore, the Board of Governors recently authorized the purchase of such issues of the *Transactions* and *JOURNALS* needed to replenish our stock, a list of which follows:

TRANSACTIONS		JOURNALS		
No.	Date	Vol	No.	Date
1	July, 1916	20	6	June, 1933
2	Oct., 1916	22	1	Jan., 1934
5	Oct., 1917	22	2	Feb., 1934
6	Apr., 1918	22	3	Mar., 1934
7	Nov., 1918	22	4	Apr., 1934
8	Apr., 1919	26	5	May, 1936
9	Oct., 1919	30	1	Jan., 1938
20	Sept., 1924	30	3	Mar., 1938
31	Sept., 1927	30	5	May, 1938
		32	4	Apr., 1939
		34	6	June, 1940

The Society will purchase a quantity of these issues at rates up to 50¢ each, plus postage, depending on the condition of the copy. Please communicate with the General Office, Hotel Pennsylvania, New York 1, N. Y., if you desire to dispose of any of the above issues in your possession.

### PACIFIC COAST SECTION

Local presentation of 3 papers of timely interest, which were delivered before the recent 56th Technical Conference in New York, was arranged for the Pacific Coast Section meeting on November 1. They were "Application of Sound Recording Techniques to Airplane Vibration Analysis," by J. C. Davidson and J. G. Frayne, "An Airplane Vibration Recorder," by J. C. Davidson and G. R. Crane, and "An Airplane Vibration Reproducer," by G. R. Crane, all of Electrical Research Products Division of Western Electric Company, Hollywood.

These papers, which will be published in full in a forthcoming issue of the *JOURNAL*, describe methods and instruments which have been developed for analysis of the various vibration components present in airplane structures. The complex wave forms are recorded on standard motion picture sound negatives during flight. After proper development, these films are analyzed electrically, making possible a complete analysis on the ground, thereby reducing materially the time devoted to flight tests, and simplifying the process of analysis of complex wave forms.

The meeting was held in the Review Room of ERPI in Hollywood.

**PROGRESS MEDAL AND JOURNAL AWARDS**

The 1944 gold Progress Medal of the Society was awarded to Mr. John George Capstaff of the Eastman Kodak Research Laboratories, Rochester, N. Y., in recognition of his pioneer work in the fields of amateur, professional, and color cinematography. The medal was presented by President Herbert Griffin at the Dinner-Dance held on October 17, during the 56th Semi-Annual Technical Conference of the Society in New York. Dr. C. E. K. Mees, Vice-President in charge of Research, Eastman Kodak Company, read the citation reviewing the highlights of Mr. Capstaff's work in these fields.

The 1944 Journal Award, given annually for the most outstanding paper originally published in the JOURNAL for the preceding year, was made to Messrs. J. I. Crabtree, G. T. Eaton, and L. E. Muehler for their paper, "The Removal of Hypo and Silver Salts from Photographic Materials as Affected by the Composition of the Processing Solutions," published in the July, 1943, issue. Certificates were presented by Mr. Griffin following the reading of a citation sketching the careers of the authors by Mr. Glenn E. Matthews.

Honorable mention for general excellence was given to Messrs. C. E. Ives and E. W. Jensen for their paper, "The Effect of Developer Agitation on Density Uniformity and Rate of Development," published in February, 1943.

The address made by Mr. Griffin during these proceedings, as well as the citations and remarks of recipients of the awards, will be published in the January, 1945, JOURNAL.



**JOURNAL**  
OF THE SOCIETY OF  
**MOTION PICTURE ENGINEERS**



**AUTHOR AND CLASSIFIED  
INDEXES**

**VOLUME 43  
JUNE-DECEMBER, 1944**

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5451 Marathon St.  
Hollywood 38, Calif.

BARTON KREUZER, *Vice-Chairman*  
RCA Victor Division  
Radio Corp. of America  
Camden, N. J.

F. T. BOWDITCH  
G. A. CHAMBERS  
F. L. EICH  
R. E. FARNHAM  
J. L. FORREST  
JAMES FRANK, JR.

J. G. FRAYNE  
C. R. KEITH  
E. W. KELLOGG  
G. E. MATTHEWS  
P. A. MCGUIRE

H. W. MOYSE  
W. H. OFFENHAUSER, JR.  
V. C. SHANER  
S. P. SOLOW  
D. R. WHITE  
W. V. WOLFE

\* Advisory Member.

## COMMITTEES OF THE SOCIETY

**PRESERVATION OF FILM.**—To survey the field for methods of storing and preserving motion picture film in an endeavor to bring before the Society any information on current or future practice, and also to continually review this field for possibilities of standardization of any specific procedure.

J. G. BRADLEY, *Chairman*  
The National Archives  
Washington 25, D. C.

J. E. ABBOTT  
J. I. CRABTREE  
A. S. DICKINSON

J. L. FORREST  
C. L. GREGORY

\*W. F. KELLEY  
TERRY RAMSAYE  
V. B. SEASE

**PROCESS PHOTOGRAPHY.**—To survey the field of process photography in an endeavor to bring before the Society any information on current or future practice, and also to continually review this field for possibilities of standardization of any specific procedure.

WILLIAM THOMAS, *Chairman*  
851 Monterey Rd.  
Glendale, Calif.

F. R. ABBOTT  
A. H. BOLT

\*F. M. FALGE  
C. W. HANDLEY  
W. C. HOCH

GROVER LAUBE  
G. H. WORRALL

**PROGRESS.**—To prepare an annual report on progress in the motion picture industry.

G. A. CHAMBERS, *Chairman*  
Naval Air Station, PSL  
Anacostia, D. C.

F. T. BOWDITCH  
G. L. DIMMICK

J. A. DUBRAY  
M. S. LESHING

G. E. MATTHEWS  
D. R. WHITE

**PROGRESS MEDAL AWARD.**—To recommend to the Board of Governors a candidate who by his inventions, research or development has contributed in a significant manner to the advancement of motion picture technology, and is deemed worthy of receiving the Progress Medal Award of the Society.

J. I. CRABTREE, *Chairman*  
Research Laboratory  
Eastman Kodak Co.  
Rochester 4, N. Y.

O. B. DEPUE  
G. E. MATTHEWS

J. A. MAURER  
L. L. RYDER

**PUBLICITY.**—To assist the Convention Vice-President in the release of publicity material concerning the Society's semi-annual technical conventions.

\*JULIUS HABER, *Chairman*  
RCA Victor Division  
Radio Corp. of America  
Camden, N. J.

G. A. CHAMBERS  
C. R. DAILY

\*HAROLD DESFOR

G. R. GIROUX  
P. A. MCGUIRE

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\* Advisory Member.

## COMMITTEES OF THE SOCIETY

**SOUND.**—To survey the field of motion picture sound recording and reproducing in an endeavor to bring before the Society any information on current or future practice, and also to continually review this field for possibilities of standardization of any specific procedure.

W. V. WOLFE, *Chairman*  
515 N. Alta Drive  
Beverly Hills, Calif.

C. R. KEITH, *Vice-Chairman*  
195 Broadway  
New York 7, N. Y.

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D. J. BLOOMBERG  
B. B. BROWN  
F. E. CAHILL, JR.  
C. R. DAILY  
L. T. GOLDSMITH

E. H. HANSEN  
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G. T. LORANCE  
J. A. MAURER  
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W. A. MUELLER  
HARRY RUBIN  
G. E. SAWYER  
S. P. SOLOW  
F. R. WILSON  
\*E. C. ZRENNER

**STANDARDS.**—To survey the various fields or branches of the motion picture industry in an endeavor to bring before the Society any information on current or future practice or methods that would lead to possibilities of standardization of any specific procedure.

F. T. BOWDITCH, *Chairman*  
Box 6087  
Cleveland 1, Ohio

J. M. ANDREAS  
P. H. ARNOLD  
HERBERT BARNETT  
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E. K. CARVER  
H. B. CUTHBERTSON  
L. W. DAVEE  
J. A. DUBRAY  
A. F. EDOUART

J. L. FORREST  
A. N. GOLDSMITH  
L. T. GOLDSMITH  
IRL GOSHAW  
HERBERT GRIFFIN  
A. C. HARDY  
D. B. JOY  
C. R. KEITH  
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W. B. RAYTON  
HARRY RUBIN  
L. T. SACHTLEBEN  
OTTO SANDVIK  
LLOYD THOMPSON  
J. F. VAN LEUVEN  
H. E. WHITE  
A. G. ZIMMERMAN

**STUDIO LIGHTING.**—To survey the field of motion picture studio lighting in an endeavor to bring before the Society any information on current or future practice, and also to continually review this field for possibilities of standardization of any specific procedure.

C. W. HANDLEY, *Chairman*  
1960 West 84th St.  
Los Angeles 44, Calif.

J. W. BOYLE  
H. J. CHANON

R. E. FARNHAM

KARL FREUND  
W. W. LOZIER

**TECHNICAL NEWS.**—To survey the fields of production, distribution, and exhibition of motion pictures, and allied industries, to obtain technical news items for publication in the JOURNAL.

A. C. BLANEY, *Chairman*  
1016 N. Sycamore St.  
Hollywood 38, Calif.

J. W. BOYLE  
J. I. CRABTREE  
A. M. GUNDELFINGER

C. W. HANDLEY  
EMERY HUSE  
H. R. LUBCKE

K. F. MORGAN  
H. W. REMERSHIED  
WILLIAM THOMAS

## COMMITTEES OF THE SOCIETY

**TELEVISION.**—Technical consideration of the uses of motion picture television service; technical consideration of the phases of television which affect origination, transmission, distribution, and reproduction of theater television.

P. C. GOLDMARK, *Chairman*  
485 Madison Ave.  
New York 22, N. Y.

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E. D. COOK	A. G. JENSEN	*PAUL RAIBOURN
C. E. DEAN	P. J. LARSEN	OTTO SANDVIK
A. N. GOLDSMITH	C. C. LARSON	R. E. SHELBY
T. T. GOLDSMITH	NATHAN LEVINSON	E. I. SPONABLE
HERBERT GRIFFIN	H. R. LUBCKE	H. E. WHITE

**TEST FILM QUALITY.**—To supervise the quality of prints of test films prepared by the Society.

F. R. WILSON

C. F. HORSTMAN

**THEATER ENGINEERING.**—The Committee on Theater Engineering comprises the membership of the four subcommittees listed below and is under the general chairmanship of DR. ALFRED N. GOLDSMITH, 597 Fifth Ave., New York 17, N. Y.

**Subcommittee on Film Projection Practice.**—To make recommendations and prepare specifications for the operation, maintenance, and servicing of motion picture projection equipment, projection rooms, film storage facilities, and stage arrangements as they affect screen dimensions, placement, and the maintenance of loudspeakers.

L. B. ISAAC, *Chairman*  
M. D. O'BRIEN, *Secretary*  
1540 Broadway  
New York 19, N. Y.

HENRY ANDERSON	J. K. ELDERKIN	*J. H. LITTENBERG
T. C. BARROWS	JAMES FRANK, JR.	E. R. MORIN
H. D. BEHR	R. R. FRENCH	J. R. PRATER
M. F. BENNETT	E. R. GEIB	HARRY RUBIN
KARL BRENKERT	ADOLPH GOODMAN	J. J. SEFING
F. E. CAHILL, JR.	HERBERT GRIFFIN	R. O. WALKER
C. C. DASH	SYLVAN HARRIS	V. A. WELMAN
L. W. DAVEE	J. J. HOPKINS	H. E. WHITE
A. S. DICKINSON	C. F. HORSTMAN	A. T. WILLIAMS
	I. JACOBSEN	

**Subcommittee on Television Projection Practice.**—To make recommendations and prepare specifications for the construction, installation, maintenance, and servicing of equipment for projecting television pictures in the theater, as well as the projection room arrangements necessary for such equipment, and such picture-dimensional and screen-characteristic matters as may be involved in theater television presentation.

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HERBERT BARNETT	J. J. HOPKINS	A. J. RADEMACHER
T. C. BARROWS	C. F. HORSTMAN	HARRY RUBIN
M. F. BENNETT	C. R. KEITH	A. G. SMITH
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L. W. DAVEE	P. J. LARSEN	*FRANK SUTTON
JAMES FRANK, JR.	*J. H. LITTENBERG	V. A. WELMAN
	J. A. MAURER	

\* Advisory Member.

## COMMITTEES OF THE SOCIETY

**Subcommittee on Screen Brightness.**—To make recommendations, prepare specifications and test methods for determining and standardizing the brightness of the motion picture screen image at various parts of the screen, and for specific means or devices in the projection room adapted to the control or improvement of screen brightness.

F. E. CARLSON, *Chairman*  
Nela Park  
Cleveland 12, Ohio

HERBERT BARNETT  
E. R. GEIB  
SYLVAN HARRIS

W. F. LITTLE  
W. B. RAYTON

C. M. TUTTLE  
H. E. WHITE  
A. T. WILLIAMS

**Subcommittee on Theater Engineering, Construction, and Operation.**—To deal with the technical methods and equipment of motion picture theaters in relation to their contribution for the physical comfort and safety of patrons so far as can be enhanced by correct theater design, construction, and operation of equipment.

HENRY ANDERSON, *Chairman*  
1501 Broadway  
New York 18, N. Y.

(Committee under Organization)

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# NEW SMPE TEST FILMS AVAILABLE

Test films prepared under the supervision of the Projection Practice Committee of the Society of Motion Picture Engineers have been remade with new titles, new test targets, and fuller explanations for their use. These films are now available to theaters, review rooms, exchanges, laboratories, etc., for testing the performance of projectors. Both the SMPE 35-mm and 16-mm Visual Test Films have been completely remade. The 16-mm Sound Test Film negative has been rerecorded from the 35-mm Sound Test Film, with new titles added to both films.

Only complete reels, as described below, are available (not short sections or single frequencies). The prices given include shipping charges to all points within the United States. Delivery is approximately 2 weeks after receipt of orders.

**35-MM SOUND FILM:** Approximately 500 ft long, consisting of recordings of several speaking voices, piano, and orchestra; buzz-track; fixed frequencies for focusing sound optical system; fixed frequencies at constant level, for determining reproducer characteristics, frequency range, flutter, sound-track adjustment, 60- or 96-cycle modulation, etc.

The recorded frequency range of the voice and music extends to 10,000 cps; the constant-amplitude frequencies are in 15 steps from 50 cps to 10,000 cps. Price \$37.50 each.

**35-MM VISUAL FILM:** Approximately 500 ft long, consisting of special targets with the aid of which travel-ghost, marginal and radial lens aberrations, definition, picture jump, and film weave may be detected and corrected. Price \$37.50 each.

**16-MM SOUND FILM:** Approximately 400 ft long, consisting of recordings of several speaking voices, piano, and orchestra; buzz-track; fixed frequencies for focusing sound optical system; fixed frequencies at constant level, for determining reproducer characteristics, frequency range, flutter, sound-track adjustment, 60- or 96-cycle modulation, etc.

The recorded frequency range of the voice and music extends to 6000 cps; the constant-amplitude frequencies are in 11 steps from 50 cps to 6000 cps. Price \$25.00 each.

**16-MM VISUAL FILM:** An optical reduction of the 35-Mm Visual Test Film, identical as to contents and approximately 225 ft long. Price \$25.00 each.

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