B. E. STECHBART

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OF THE SOCIETY OF
MOTION PICTURE ENGINEERS

JULY, 1930

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The Society of Motion Picture Engineers

Its Aims and Accomplishments

The Society was founded in 1916, its purpose as expressed in its constitution being "advancement in the theory and practice of motion picture engineering and the allied arts and sciences, the standardization of the mechanisms and practices employed therein, and the maintenance of a high professional standing among its members."

The Society is composed of the best technical experts in the various research laboratories and other engineering branches of the industry in the country, as well as executives in the manufacturing and producing ends of the business. The commercial interests also are represented by associate membership in the Society.

The Society holds two conventions a year, one in the spring and one in the fall, the meetings being generally of four days' duration each, and being held at various places. At these meetings papers are presented and discussed on all phases of the industry, theoretical, technical, and practical. Demonstrations of new equipment and methods are often given. A wide range of subjects is covered, and many of the authors are the highest authorities in their distinctive lines.

Papers presented at conventions, together with discussions, contributed articles, translations and reprints, abstracts and abridgements, and other material of interest to the motion picture engineer are published in the Journal of the Society.

The publications of the Society constitute the most complete existing technical library for the motion picture industry.

JOURNAL
OF THE SOCIETY OF
MOTION PICTURE ENGINEERS

LOYD A. JONES, EDITOR *pro tem.*

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TECHNICAL ACTIVITIES OF THE ACADEMY OF MOTION PICTURE ARTS AND SCIENCES

IRVING THALBERG*

I. INTRODUCTORY

In the latter part of 1929, the Board of Directors of the Academy of Motion Picture Arts and Sciences, acting at the suggestion of the Producers' Branch, launched two major projects for the general technical benefit of the production industry. The first of these projects was the establishment of a school for the education of studio personnel in the fundamentals of sound recording and reproduction. The second was the organization of a Producers-Technicians Committee for the conduction of a group of new technical activities.

II. ACADEMY SCHOOL IN SOUND RECORDING

The coming of sound, revolutionizing as it did the technic of motion picture production, created a severe production problem in its effect on the studio personnel. The need of internal coöperation on each lot was never greater; yet the possibilities and limitations of the new equipment and technic were alike a mystery to the regular employees, who thus found their hands tied for effective coöperation with one another and with the handful of sound experts.

The traditional policy of the production industry, particularly in technical matters, has always been strongly competitive. The introduction of sound naturally served to bring out more sharply than ever this policy of competition and secrecy. Nevertheless, the internal problem described above was so acute that the producers and technicians of the whole industry decided, through the Academy, on a bold step toward its solution. This step was the creation of the Academy School in Sound Recording.

Determined to make this project perfect in execution, the Academy secured as instructors for the course the cream of the world of sound experts—heads of studio sound departments, crack engineers of

* Metro-Goldwyn-Mayer Studios, Culver City, California. (Read before the Society at Washington.)

the electrical service companies, and leading physicists of the local universities. Ambitious to secure a technical education from this group of authorities, studio employees of all ranks and departments applied for admission to the School. To date a picked lot of this personnel, nine hundred in number, selected by the studios themselves, have attended the courses of lectures, which have been given in six sections.

We feel that we cannot emphasize too greatly how much this project has advanced the general welfare of the industry. It has "sold" the whole industry on the vital principle of coöperative industrial education. It has given the personnel an unparalleled opportunity, which they have seized to the utmost, to do both themselves and the industry a service, not only for today but for the years to come. They have received a technical training not confined to the methods of their own studios, nor to a few narrow principles of application, but embracing the entire known technic of sound pictures from scientific fundamentals to all methods of recording and reproduction. The lectures were held from studio to studio, each section of the class being carefully drawn from the men and women of all studios, ranks, and departments; and this has served to develop in all of them a realization of common interests, and a widespread comradeship. The technical leaders of the industry, too, have been drawn together, by coöperation in administering the course. The monetary value of all these services of the School in contributing to industrial education, coöperation, and morale, is beyond computation.

III. THE PRODUCERS-TECHNICIANS COMMITTEE

Side by side in industrial progress with the creation of the Sound School, that of the Producers-Technicians Committee has already been referred to. It was the purpose of this committee to conduct such specific technical activities as would benefit from coöperative investigation, experimentation, and pooling and distribution of information. In this work the committee had as precedent the broad survey of the problem of incandescent illumination which the Academy (with the coöperation of the American Society of Cinematographers, the Association of Motion Picture Producers, and your Society) conducted in 1928. This survey, as will be remembered, served to advance the technic of production very materially, and did so, moreover, at the most propitious possible time—when sound pictures, which of course promoted the use of incandescents (as being in general more silent than arcs), were springing into life. It thus served to demonstrate to the industry the value of technical coöperation, and particularly the logical function of the Academy in promoting such coöperation.

The Producers-Technicians Committee, created to forward this function, is constituted as follows:

Representing the Producers' Branch:

IRVING G. THALBERG—Metro-Goldwyn-Mayer Studios, *Chairman*
FRED W. BEETSON—Association of Motion Picture Producers
M. C. LEVEE—Paramount Studios
WILLIAM SISTROM—RKO Studios
WALTER L. STERN—Universal Studios
H. KEITH WEEKS—Fox Hills Studios
SOL M. WURTZEL—Fox Studios

Representing the Technicians' Branch:

J. A. BALL—Technicolor Studios
H. G. KNOX—Electrical Research Products, Inc.
FRED PELTON—Metro-Goldwyn-Mayer Studios
GERALD F. RACKETT—Society of Motion Picture Engineers
J. T. REED—United Artists Studios
FREDERICK M. SAMMIS—RCA Photophone Corporation
NUGENT H. SLAUGHTER—Warner Brothers and First National Studios

From the staff of the Academy:

FRANK WOODS, Secretary of the Academy, *Ex-Officio*
LESTER COWAN, Assistant Secretary of the Academy, *Committee Secretary*

IV. INITIAL PROJECTS

The first purpose of the committee was to engage in the investigation of various technical problems which are primarily non-competitive. Six such problems have been taken up: (1) silencing of arc hum; (2) silencing of cameras; (3) acoustic properties of set materials; (4) release print quality; (5) release print standardization; (6) screen illumination. The general procedure in attacking these problems was to appoint a subcommittee for each of them. The subcommittee conducted a thorough survey of existing methods of meeting the problem, conducted tests to determine quantitatively the worth of these various methods, and made final recommendations for their improvement. These activities were conducted with the coöperation of representatives especially appointed by each studio to aid the work. Full publicity was given to all phases of the work by the issuance of progress reports and final reports. The history of each of these projects will now be summarized; the

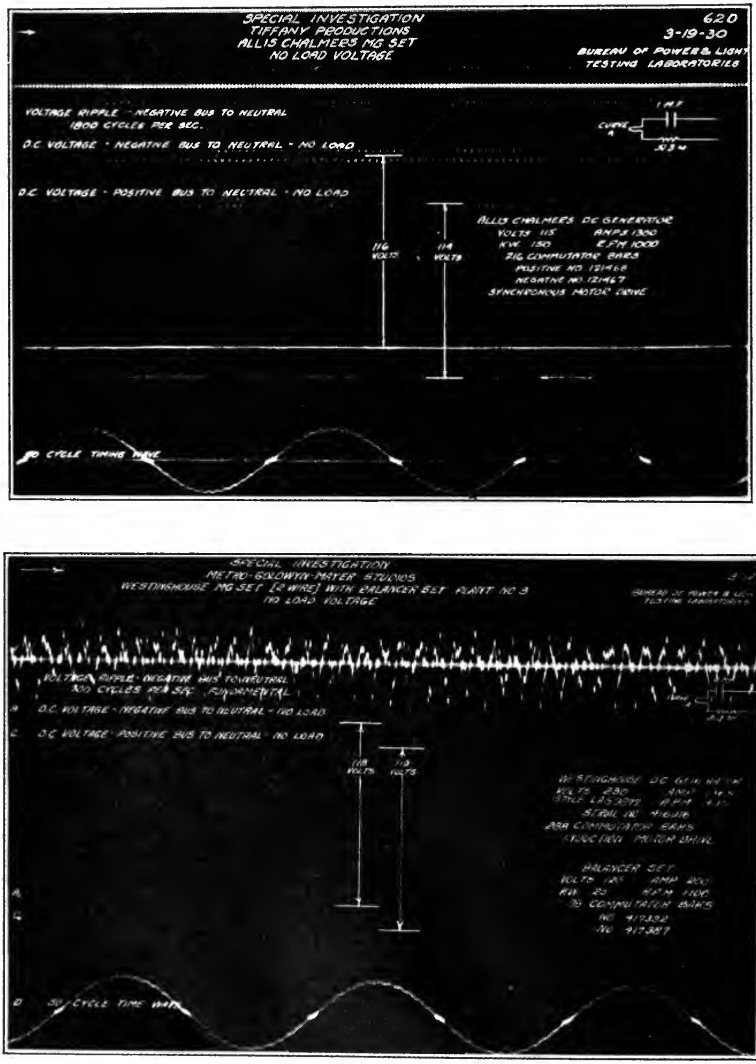


FIG. 1. Oscillograph records of commutator ripple.

full subcommittee reports are available to members of the Society of Motion Picture Engineers or to any other interested parties.

IV-A ARC Silencing.—Mr. L. E. Clark, of Pathé Studios, acted as a subcommittee of one in investigating this problem. The high-frequency hum of arcs, due to the commutator ripple of the d. c. generator, has from the beginning been an obstacle to proper sound recording. Whenever the studios wished to use arcs instead of incandescents, they were forced to use various devices to filter out this

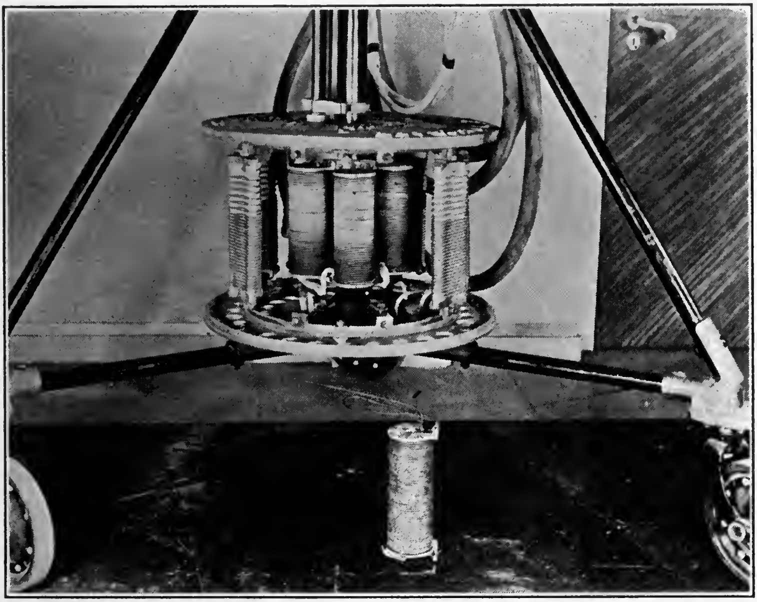


FIG. 2. Inductance coils placed at the arc.

hum; and these devices, as the subcommittee's preliminary survey of them revealed, have varied greatly in design, efficiency, and expense. The next step in the investigation was to obtain oscillograph records of the commutator ripple in each studio generating system (see Fig. 1); these tests were conducted with the coöperation of the Los Angeles Bureau of Power and Light. They revealed that the ripple frequencies ranged, in the various cases, from 750 to 3300 cycles, with a maximum amplitude of 2.7 per cent of the d. c. voltage.

Quantitative tests of the various filtering devices were next begun; but it was soon found that one device, developed by Mr. Walter Quinlan of the Fox Film Corporation (a studio which had great preference for the use of arcs), was apparently sufficient for all studio needs, from the combined standpoints of efficiency and economy.

A filter for such a ripple can be of three sorts: (1) a condenser across the mains; (2) an inductance in the mains; (3) a combination of the two. The first type is in general undesirable because its efficiency varies inversely with the load. The use of a single

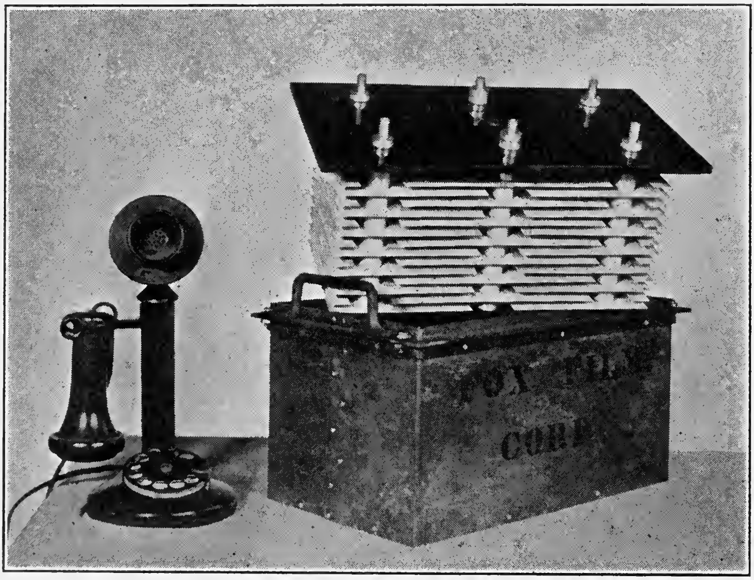


FIG. 3. Electrolytic type of condenser.

large inductance coil is impracticable because of the vast weight required. Small inductance coils placed at the arcs themselves, however, are quite practicable. (See Fig. 2.) They have small weight, volume, and heating loss; and they provide protection at each lamp, which in itself is a long step toward keeping feed-back noise out of the system.

The use of inductive filters alone, however, is not sufficient if efficiency at light as well as heavy loads is desired. It is necessary to use condensers across the mains in combination with such coils.

Mr. Quinlan succeeded in developing, for this purpose, a type of electrolytic condenser (see Fig. 3), of 1000 microfarads capacity, able to withstand 150 volts, able to serve at least ten months when properly cared for, without re-servicing, and cheap in price. (This condenser is described in detail in Mr. Clark's report.) The combination of 2 to 4 such condensers across the generator, and as many 40 ampere coils at each arc as required, serves, at a cost per generator of about $750, to reduce the arc hum about 25 db. which is an ample amount.

FIG. 4. A silencing camera cover.

IV-B Silencing of Cameras.—The problem of silencing the camera was investigated by a subcommittee whose members were Messrs. H. G. Knox, Vice-President of Electrical Research Products, Inc., and Frederick M. Sammis, General Representative of the Pacific Coast for RCA Photophone Corporation. This subcommittee, assisted by studio representatives, first secured complete data on the use in each studio of booths, blankets, blimps, the two principal cameras, motors and covers, drives, and minimum camera-microphone distance. The silencing devices and the cameras themselves were then subjected to quantitative noise tests in the laboratories of Electrical Research Products, Inc. The best devices were then retested, primarily for the purpose of determining what constructional details were inherent in any good device. It was found that the silencing value of the different devices varied tremendously, from 21 to 11 db. for rigid devices, and from 14 to 1 db. for semi-rigid coverings; so, to an even greater extent (20 to 4 db.), did the noise from the uncovered cameras.

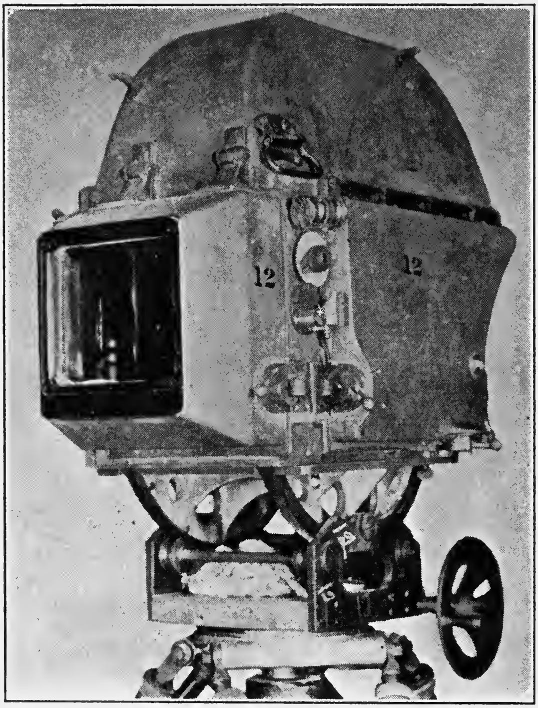


FIG. 5. A silencing camera cover.

The subcommittee then established standards for the desired camera silence, varying from studio close-ups to location work; and prepared a list of the fundamentals which should be embodied in any camera silencing device, together with a list of recommended materials for certain purposes, and photographs (see Figs. 4–6) showing desirable types of construction, some of which types can be embodied in the present silencing devices if desired. As regards the problem of the noisy camera itself, the subcommittee sought the coöperation of Mr. G. A. Mitchell of the Mitchell Camera Corporation. Mr. Mitchell offered to take a noisy camera and overhaul it mechanically; and in doing so he reduced its noise from 18 db. to 12 db., an improvement of 6 db. Mr. Mitchell also tried out a new model silent camera which, in the experimental form sub-

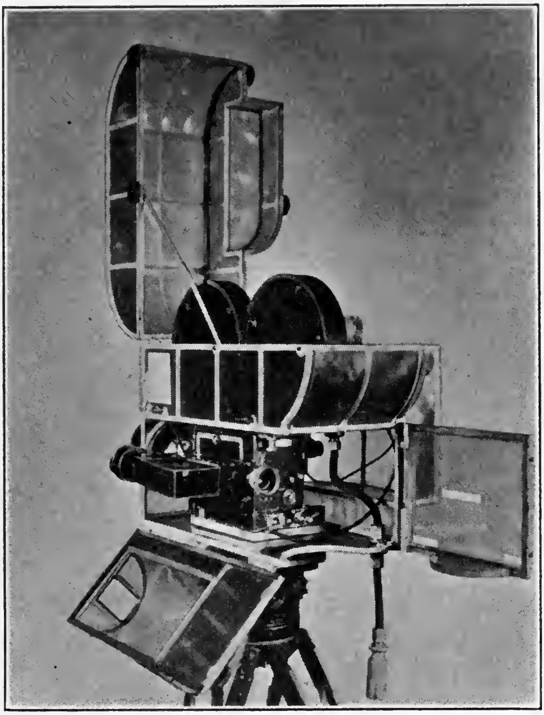


FIG. 6. A silencing camera cover.

mitted, had a noise of only 1 db.—5 db. less than any Mitchell camera previously tested.

A complete report of the subcommittee's work is now in print.

IV-C Set Materials.—A subcommittee, consisting of Mr. J. P. Maxfield and Mr. Ralph Townsend, was appointed to test and classify according to their acoustic properties typical materials commonly used in set construction for sound pictures. The measurements obtained have made available for the first time specialized data of practical application to studio conditions. Absorption coefficients at typical frequencies were obtained for the following materials, erected as in set operation: veneered flats (papered with crepe paper and additionally with hard wall paper); $^7/_{16}$ inch Masonite (papered with crepe paper and additionally painted with flat oil paint); $^7/_{16}$ inch Celotex (papered with crepe paper and also with one coat of water paint); cast plaster on burlap; cast stone on burlap; Zonolite plaster on burlap covered chicken wire (two thicknesses). These ten tests, curves for which have been published in a preliminary report, will be supplemented by four others, the material to be selected after consideration of results of the present tests by the studios.

The subcommittee proposes to continue its work by studying (1) the question of the open ceiling, making reverberation measurements in the studios themselves; (2) the placement of microphones with reference to the focal length of the camera lens; (3) the effect on the absorption-frequency curve of bracing the sets by various spacings of the braces in back of the set material. For the measurements made to date, the material has been rigidly braced for the prevention of resonance.

IV-D Release Print Quality.—Another subcommittee, with Frederick M. Sammis as chairman, has been studying the question of the production of high-quality release prints. The producing industry has heretofore been rather lax as to laying down specifications as to release print quality; and it seemed logical, particularly in view of the more exacting need for high quality imposed by the coming of sound-on-film pictures, that the coöperation between studios, laboratories, and exchanges in this matter be strengthened. It was the first task of the subcommittee to survey the methods in use for the production and inspection of release prints, and to study these methods in the light of the quality of prints produced. The subcommittee has worked out certain standards for processing and inspection, based on the best current practice, and will endeavor to secure the general adoption of these standards. In this, the coöperation of the exchanges and of the service departments of the major electrical companies, is being enlisted. Two releases for educational purposes were planned: the first, which is already available, containing the characteristic annoying sounds resulting from inefficient projection; the second is to contain disturbing noises resulting from improper laboratory procedure or deficiency in handling by exchanges. Exchanges will be urged to make it a practice to maintain the quality in the laboratory print by proper handling in transit, and by periodical cleaning in accordance with accepted specifications.

The final report of the subcommittee will suggest standards of high-quality release print production, including: transit and storage of the negative; construction of laboratory buildings; dustproofing precautions; cleaning of the negative; printing equipment, maintenance, and care thereof; development equipment, and its use and care; assembly; visual and aural inspection of prints; and, as mentioned above, treatment of prints by exchanges.

IV-E Release Print Standards.—As there are at present no standards for the makeup of release prints, the length and divisions of leaders vary with every studio. Exchanges report that theater operators are cutting off leaders, substituting leaders of their own, marking crude visible signals for changeover, *etc.*, the resulting waste of film and mutilation of prints constituting a serious problem.

This problem was dealt with by an active committee from the Academy Technicians' Branch, the Pacific Coast Section of the Society of Motion Picture Engineers, Chapter No. 7 of the American Projection Society, and the American Society of Cinematographers. The members of this committee, which has become a subcommittee of the Producers-Technicians Committee, are: S. J. Twining, *Chairman;* A. J. Guerin, Sidney Burton, N. H. Brower, I. James Wilkinson, Gerald F. Rackett, and Donald Gledhill, *Secretary.*

The group prepared a set of tentative specifications for a standard release print, embodied them in a detailed blueprint, and made up two sample reels to demonstrate them. The subcommittee then met with the appointed representatives of fourteen studios, who considered these specifications favorably, except for a few minor points which will be settled shortly. The revised standards will then be published by the committee.

IV-F Screen Illumination.—Prior to the organization of the Producers-Technicians Committee, there already existed a joint committee of the Pacific Coast Section of the S. M. P. E., the Academy Technicians' Branch, the American Society of Cinematographers, and Chapter No. 7 of the American Projection Society, appointed to deal with the subject of standards for screen illumination. The members of the committee were: Emery Huse, *Chairman;* John O. Aalberg, J. A. Ball, Dr. John T. Frayne, Russell H. McCullough, Peter Mole, John M. Nickolaus, Gerald F. Rackett, Richard Towers, and Sidney J. Twining. This body has continued its work under the auspices of the Producers-Technicians Committee.

Minimum standards will be formulated for illumination attainable by the majority of theaters. Because of economic considerations, de luxe houses will exceed these and very small houses will not be able to reach them, but they will be practicable for the great majority of houses. The density of release prints can then be related to this standard.

For preliminary investigation the committee selected six representative local theaters. In each of these the committee measured the illumination produced at the screen, without any film in the projector. It was found, however, that the same print, shown in two theaters in which the length of throw and screen illumination measurements are approximately equal, may look very different. This fact led the committee to further inquiry into the type of light used in the projector. There appeared to be some evidence, for instance, that mirror lamps and high intensity lamps which reflect equal foot candles from the screen when projected through a clear film gate, differ in how much light they put through film. The problem of the quality of the projected picture seems to center on brightness contrast.

In order to simulate actual conditions in future illuminometer measurements, test reels have been made up by Emery Huse, chairman of the group. The first of these consists of four sections in each of which the density is constant (10, 50, 75, and 100 per cent transmission). The second will have four density areas appearing on each frame. Thus, for the first time a scientific method will be available for taking into account the various factors which affect the transmission of pictorial quality to the screen.

V. GENERAL FUNCTIONS

The committee plans, after the present series of investigations have been concluded, to attack other important non-competitive problems. A number of these are now under consideration.

At the beginning of 1930, the Technical Bureau, formerly under the Association of Motion Picture Producers, was transferred to the jurisdiction of the Academy, and thus of the Producers-Technicians

Committee. No attempt has been made to differentiate between the Bureau's activities and the other technical functions of the committee. The Bureau is acting as a place of record and a clearing-house for technical information. As a place of record, its function is to supply the studios with pertinent information on technical problems with which they find themselves confronted. In connection with this function, it has on hand a large library of motion picture books and periodicals, which is being maintained and expanded. As a clearing-house, the Bureau is serving to keep the individual studios abreast of current progress in all technical developments, particularly the investigations conducted by the subcommittees. In addition to publishing progress reports, the committee also circulates the *Academy Technical Digest.* The *Digest,* which was begun in connection with the Academy's Sound School mentioned above, consists of a series of fundamental, yet up-to-date, reviews of the technical knowledge in various fields. Through it, papers of scientific and educational nature, as well as records of individual achievements among the various studios, are distributed directly to the industry.

To take care of several problems of mutual interest, such as that of standardization of camera and projector apertures, as described by the committee's secretary, Lester Cowan, in the January, 1930, number of the JOURNAL; that of standardization of release print leader and changeover cue; and that of screen illumination, the committee has established a degree of contact with exchanges and theaters. It is planned to maintain this contact in so far as it will improve the correlation of theater and studio practices along technical lines.

Finally, the committee is commencing coöperative contacts with the laboratories, factories, and local representatives of equipment manufacturers, and with your Society. The expansion of this activity will serve excellently in interpreting the needs of the producing industry to the manufacturers, and in acquainting the studios with manufacturing developments. The Academy therefore looks forward eagerly to the growth of such coöperation.

DISCUSSION

MR. ROSS: I should like to ask whether a single rectifier is used with each arc lamp.

MR. TOWNSEND: In most cases the checks are put at the bottom of the arc.

MR. ROSS: An automatic inductance of known form could be placed in series with the generator at the generating plant. The electrolytic condenser could also be made automatic and the movable element thereof connected to the moving arm of the automatic inductance in a manner to automatically change the capacity of the circuit simultaneously with changing the impedance thereof. This would remove the inductances and condensers from the studios.

MR. TOWNSEND: That was used originally and given up in favor of the method shown.

MR. TAYLOR: To what extent does the running of this sound school resemble that of a college or university?

MR. TOWNSEND: During the operation of the sound school the members were chosen by the studios. The initiation fee was $10 including tuition to all the lectures and printed matter obtained from them. In some cases the motion picture companies took it on themselves to pay the entrance fees. The men in attendance were from all branches of the industry. Some of the most interested were from the ranks of the directors. The apparatus required for the investigation of the problems was supplied, some from the studios, but a large portion was supplied by Electrical Research Products, Inc. They turned over their laboratories to the Academy and, where they were too limited, we worked at the University of California. In this school, for the first time, people from the competitive laboratories met and discussed their problems. It seems strange to find the competitive spirit as strong here as it is after having lived in that atmosphere out there.

PRESIDENT CRABTREE: Those of us who visited Hollywood two years ago have a clear picture of the Academy. It is very important that there should be the closest coöperation between our Society and the Academy, especially with regard to standardization. Our Standards Committee is studying screen illumination and wide film dimensions as well as nomenclature. The Academy has similar committees, and it would be ridiculous for the Academy to put out one list of nomenclature and our Society another. I have appointed on various committees a member of the Academy, and I should like to see more collaboration, but the world was not made in a day. One of the reasons for the success of the Academy is the fact that it has a number of paid employees. If it had to depend on voluntary help, as the Society of Motion Picture Engineers has to, I am afraid it would not have been able to do the fine things it has done. I think the Academy has set a fine example for us to follow in establishing courses of education. I hope that our Society can get something going along these lines. The best form which this should take has not crystallized in my mind, but I think we should contribute to the industry by assisting in the education of the engineer.

I wish Mr. Townsend to convey to the Academy our thanks for the papers they have sent along, and we send our greetings and best wishes, and the Board is already considering the matter of putting Hollywood on the ballot for the convention next spring. Personally, I am pushing very hard for a spring convention in Hollywood.

MR. TOWNSEND: I was asked by the Academy to urge you to hold the next convention out there.

PRESIDENT CRABTREE: It is a little too warm there in the fall so we will consider very carefully coming next spring.

TALKING PICTURES—THE GREAT INTERNATIONALIST

HAROLD B. FRANKLIN*

The history of the motion picture business is a history of unexpected accomplishment and unrealized opportunity. Its success has ever been greater than anyone expected it would be; its influence has gone far beyond the wildest hope of even its most enthusiastic visionaries. Its success, in short, has been too good to be true.

No one who looked at Fulton's first steamboat dreamed of the North German Lloyd liner, Bremen. Anyone who, after seeing the Wright Brothers when they first flew at Kitty Hawk, would have been wild enough to presage Lindbergh's trip to Paris, would have been put in an asylum.

This modesty of vision has, after all, been true in respect to all great inventions. And the point is, I suppose, merely that the motion picture is no exception.

Like the chorus girl who turned down the gift of a book because "she had a book," there was the film man who came to Seattle in the early 1900's to open a film exchange, but refused to open one when he found there already was a film exchange in that city.

Mitchell Mark, running the famous pioneer Strand Theater in New York City, was very much upset and worried when another picture theater was going to open on Broadway. Marcus Loew, bless his soul, appealed to his friend Zukor not to go ahead with the Rialto Theater because it would put too many seats on Broadway!

Always this lusty youngster cub of an industry has been far, far ahead of the imaginations of its founders and its operators. The most eloquent medium ever discovered for the presentation and exchange of ideas, its precocity has ever been retarded because its eventual accomplishments seemed unbelievable miracles until they actually happened.

The reason for this is that nothing ever existed like it before;

* Fox West Coast Theaters, Los Angeles, California. (Read before the Society at Washington.)

no such power for world-wide education and propaganda. Naturally then, no one could ever dream how far and wide its influence would eventually become.

For years, the silent picture was working a leaven of world-wide propaganda, unnoticed. The internationalism of this influence, though tremendous, was never taken advantage of, not even realized, until long after its results were so obvious as to be daily memoranda.

Take a news weekly shot of Japanese people in bathing, and what do we find?—American one-piece bathing suits. What country is there in the entire world unacquainted with the American Cowboy and the American Indian? Every corner of the globe has learned what Lindbergh looks like.

Perhaps internationalism is too strong a word for all this. An internationalization of appreciation fits it better. The exchange of pictures between countries has for years been acquainting each country with its neighbor's peoples, habits, and clothing, as nothing before in history ever did. To some extent, merchants did finally wake up long after the influence was first felt, to this fact: that trade was no longer following the flag but was following the shadowy legends of the screen instead.

But now we enter a more definite phase. A more acute and a more telling influence is on the way, because talking pictures are here. And this new influence will also go unrealized, and unsung, until long after it starts its miracles.

A talking picture intensifies whatever a silent screen would do. When characters speak from the screen, they become more intimate, more real; speech intensifies Life. No matter how effective your silent sequences might have been, they still were shadows, legends, phantoms. Once they become vocal, however, they become people; they come right off the screen into the laps of the audiences—and whatever their effect was while mute, it trebles, and trebles again, in voice.

There is a belief among all of us that no matter what our differences may be with other people, if we could but sit down and talk with them we could wipe those differences away. We believe this because we know that without a heart to heart exchange of soul, and search of mind, we can never see the other fellow as he actually is, nor can he see us. All of us thought, throughout the Great War, that if we could have but joined our enemy in intimate talk we would no longer be enemies. Speech may have been invented to hide thought, yet no matter how imperfect, there is no understanding without it.

Such a medium for understanding is the talking picture. Peoples of the world will speak to each other for the first time in the whole history of the world. Hopes, customs, traditions, ideals, will be exchanged. Familiarity, sympathy, will come from them. Talking pictures will have the same effect as if nations visited in the homes of other nations. The homely little things that make us human, the breakfast table, the family life, will give each country a chance to see that its neighbor and its enemy are human exactly like itself. The world will receive and maintain an intimacy within itself that has been available hitherto to no entity larger than a village, and the talking picture will do it.

True, this is a long way off; much will have to happen first. Trade embargoes will have to be lowered; languages will have to, and will be, altered, unified. It may be centuries, but the United States of the World is going to come, and when the history of its vivid arrival is written, a talking picture will have, it seems to me, the star role.

If I may be permitted to prognosticate, I think the first step will be a unification by languages. All countries that speak Spanish, for instance, will see the same kind of Spanish motion picture; all countries that speak English, will see the same kind of English motion picture; and so on, throughout all the major languages we have. Long after this unification by languages is accepted, there will begin a gradual breaking down of even those few divisions which will remain due to the language barrier. Then, with the final breaking down of that barrier there will arrive a unification of the world on such a vast and happy scale that the mere prophecy of its coming is enough to stamp me as a wild visionary.

What that language will be, and which civilization will so dominate the world as to dictate its syllables, no man can say. There is no doubt in my own mind that its course of accomplishment will be such as to reiterate the age-old theory of the survival of the fittest.

But people are so curious, so gregarious, so ambitious, and, I am sorry to say, so greedy, that these fundamental human traits will seek and demand what talking pictures will teach them is feasible—a world-wide presentation of the best in everything, a universal understanding, and a cosmic peace.

THE REVOLVING LENS WHEEL PROJECTOR

ARTHUR J. HOLMAN*

The desire to reproduce motion in pictures, for the purpose of study and analysis, is the origin of the great motion picture industry. The stroboscope, as you know, was one of the early and rather crude instruments developed for motion study, and, strange as it may seem, its basic principles are still employed universally wherever motion pictures are shown. I refer particularly to the picking out of portions of a complete action by the shutter mechanism of the motion picture camera, and the presentation, through the medium of an intermittent mechanism, of these same portions of action on the screen of the theater. Such a recording and reproducing system, involving intermittent film movement, must necessarily fall far short of the ideal for the following reasons:

First, the screen illumination is entirely unnatural in that it pulsates rapidly from zero to maximum value.

Second, the maximum light intensity on the screen must be excessive to secure the desired average brightness because of the shutter cut-off.

Third, rapid actions have a jerky appearance, for even persistence of vision, that physiological and fundamental foundation of present-day movies, cannot fill in the action obliterated by the camera shutter.

To eliminate the stroboscopic principles from motion picture presentations and to remove, or at least mitigate, the evils of intermittent illumination, have been the goal and aim of inventors and experimenters for many years, and more ideas have been conceived to this end than most of us are aware of. As is usually the case, however, the most fantastic and utterly impossible optical systems and mechanisms have been promulgated by both novices and those skilled in the art, and the simplest and most logical means has been meticulously avoided, the only apparent reason being that the simple system is considered utterly impossible by those well grounded

* 59 Auburn St., Brookline, Mass. (Read before the Society at Washington.)

in optical theory. But the "impossible" is often the most fruitful ground for research and invention, and the more certain the authorities are that "it can't be done," the more likely are the prospects for discovery. It has ever been thus.

In the language of the Patent Office, this invention relates to that type of projecting apparatus, or camera, wherein the film strip is kept continuously in motion and the effect of said motion is so compensated by means of moving optical rectifying elements as to produce a well-defined image. A complete mental picture of our ideal projector may be gained from the following:

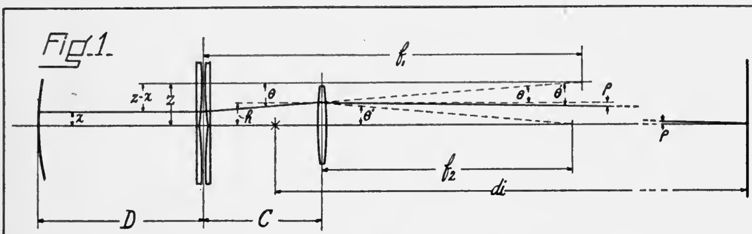
Let us suppose that we have an aperture across which a film strip may be actuated, a light source, and condenser system which will illuminate uniformly the area of this aperture, and an objective system which will distribute light passing through the aperture in such a manner as to produce a uniform illumination over the entire area of a screen. Now suppose that a film strip is moved across the aperture at a uniform linear velocity, and the objective system is so constituted that it will form on the screen a stationary image of each film frame, and will accomplish the transition from frame to frame, as the film advances, through the medium of a dissolving action, without varying the light intensity or interfering with the definition of the resultant screen image. In other words, we wish to provide an optical system capable of producing uniform maximum illumination over the entire surface of a screen, and having the capacity to modify the intensity locally in proportion to the density of the corresponding part of the film frames which are passing continuously over the aperture plate. Measured against such an ideal, the present system of intermittent projection shows up as a poor makeshift.

Much thought has been devoted to solving the problems arising as men have sought to eliminate the intermittent movement and approach more closely to the recognized ideal. Many, many systems have been thought out and tried, and a few very ingenious devices have been constructed, but they have all fallen by the wayside due to inherent mechanical or optical difficulties which make them impractical. Reflecting systems have been used almost exclusively by searchers after the ideal, and one or two of these have been developed to a high state of perfection, but they fail in service because they involve complicated mechanical movements which require cams for their accomplishment; moreover, reflecting surfaces of great optical accuracy are not easy to manufacture or maintain at high efficiency in service. Although spectacle makers have long recognized and used the prismatic power of decentered thin lenses, it has occurred to very few that this principle might offer the easiest approach to the perfect system of recording and reproducing motion in pictures.

The continuous projector we have developed, and which I will now proceed to describe and demonstrate to you, functions entirely and solely because of this inherent characteristic of a thin lens which produces a prismatic or bending action proportional to the decentration. It was discovered nearly thirty years ago that an optical system comprising a stationary lens element and a pair of overlapping revolving lens wheels would produce on a screen a stationary image of pictures on a film strip provided the film strip was continuously moved across the optical axis at a rate properly proportioned to the angular velocity of the revolving lens wheels. Unfortunately, the original inventor, lacking one or more of the three essentials, ability, financial means, or stick-to-it-iveness, not only never solved the problem himself, but left a monument in the Patent Records which has been effective in causing investigators to shun the basic idea long after the expiration of his patent. Our projector embodies the results of a mathematical analysis of the revolving lens wheel system and includes many new and original mechanical and optical features which are essential to the practical application of this system.

As stated previously, our ideal projector consists essentially of a suitable light source, a condenser system, and an objective system, the latter comprising spherical lenses only. The objective system is composed of a stationary front element, comparable to the front element of an ordinary projection lens, and pairs of rear elements which constitute the peripheries of the two revolving lens wheels, these pairs of rear elements replacing the rear element of an ordinary projection lens. The first important feature to be noted is that our objective interposes the same amount of glass between the aperture plate and the screen as does the ordinary projection lens, therefore, its light-transmitting efficiency, with equal lens apertures, should be about the same. Moreover, since the axial spacing and refractive powers of the elements are comparable to those of an ordinary projection lens, there is nothing freakish in the system requiring special optical treatment. The problem, as far as the objective is concerned, is, therefore, reduced to a mathematical analysis which will supply the data required for a proper design of the lens wheels and the stationary front element.

The perfect system would consist of a stationary front element and a continuous procession of identical rear elements, all equally spaced and moving downward at a constant linear velocity over a straight path at right angles to the axis of the stationary element. But such an optical rectifying system lies in the realms beyond the range of our mechanical ability; therefore, we must substitute for the perfect, some mechanical arrangement which is practical and which may be so designed as to approach as closely to perfection as we may desire. Since rotation at uniform angular velocity is a movement well within our mechanical ability to produce, and since



$$\tan\theta = \frac{z-x}{f_1}, \quad \tan\theta' = \frac{h}{f_2}, \quad \tan\rho = \frac{h}{di} \text{ (approx.)},$$

$$\rho = \theta' - \theta, \quad h = x + \frac{C}{f_1}(z-x).$$

FIG. 1. Diagram of objective system, showing position of lens sectors at the instant when two film frames are each supplying equal illumination to the screen.

this movement alone is sufficient for our requirements, we have chosen, in the present machine, to use a pair of overlapping revolving lens wheels. Two lens wheels are used to secure the balancing effect of one wheel upon the other, which eliminates all lateral variations and thus permits a very close approach to the theoretically perfect, with wheels of relatively small diameter.

In Fig. 1 is illustrated that position of the lens wheel elements and the film frames which provides the conditions easiest to analyze mathematically. It is to be noted that the edge of a lens sector is on the axis of the stationary element, and, if the screen image is in frame, the line between film frames will also lie on the axis. Tracing the ray, parallel to the axis, which passes through the center of the film frame at the height, x, above the axis, through the elements of the objective to the center of the screen, provides the basic equations for an elementary mathematical analysis. When these equations are solved for values of C, D, and f, with the aid of known mathematical relations, the three general equations of the decentered objective system are obtained. These general equations furnish the means for studying the system and predicting the performance characteristics of new designs. They are the tools which the designer may use with assurance. They enable him to know the results without constructing the system, and thus put his work on a scientific basis. Omitting the derivation, I will give the final equations:

$$C = \frac{di.f_2}{di.f_2} - f_1 \frac{x}{z - x} \quad \ldots\ldots\ldots\ldots\ldots (1)$$

$$D = f_1 \frac{x}{z} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

$$f = f_2 \frac{z - x}{z} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

wherein (see Fig. 1),

C—is the axial distance from the optical center of the stationary element to the vertical plane midway between co-acting lens sectors.

D—is the axial distance from the film strip to the vertical plane midway between co-acting lens sectors.

f—is the focal length of the objective system.

di—is the axial distance from the screen to the equivalent center of the objective system.

f_1—is the focal length of a pair of co-acting lens sectors.

f_2—is the focal length of the stationary element.

x—is the distance from the center of a film frame to the axis. (In Fig. 1 it is equal to one-half the distance between centers of adjacent film frames.)

z—is the distance from the optical center of a lens sector to the horizontal plane through the axis of the stationary element. (In Fig. 1, it is equal to the distance from the optical center to the radial edge of a lens sector.)

Although these simple equations are not exact, due to the elimination of very small complex terms during the analysis, they give values of C, D, and f, which are correct within one-quarter of one per cent.

Variation in film shrinkage has always been a serious problem to the designer of continuous projectors, but with the above equations one can easily figure out the proportionality of the adjustments required in the values of C and D. Our machine is equipped with a hand adjustment which automatically maintains the correct ratio of C to D by moving the aperture plate and front element of the objective along the axis simultaneously, thus easily accommodating the optical system to any variations in film shrinkage.

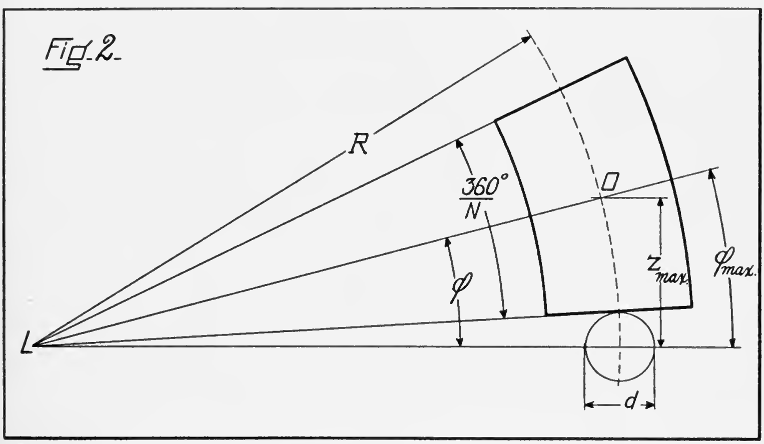


FIG. 2. Diagram showing extremity of active zone of a lens sector.

The factor, z, which appears in each of the general equations, requires further study, for therein is contained the measure of just how closely the revolving lens wheel system may be made to approach the accuracy of the perfect system. In Fig. 2 is shown a lens wheel sector with its radial edge tangent to the circle representing the cross-section of the condenser beam at the vertical plane midway between co-acting lens sectors. L is the center of the lens wheel; O is the optical center of the lens sector; R is the radius of the circle whereon the optical centers of the lens wheel sectors are positioned; ϕ is the angle formed at the center of the lens wheel between a radius through the optical center of a lens sector and a radius through the axis of the stationary element; d is the diameter of the circular cross-section of the condenser beam; N is the number of lens sectors per wheel. In the position shown in Fig. 2, the lens sector is just about to enter the light beam, and, from this instant until it has passed entirely through the beam to a position in which the upper radial edge is tangent to the lower portion of the circle, the lens sector is in the active zone. The maximum values of ϕ and z, which occur at the extremes of the active zone, are designated as $\phi_{max.}$ and $z_{max.}$.

As previously stated, the use of two lens wheels eliminates all lateral variations, therefore we are concerned only with variations in the vertical component of the downward movement of the optical center of the lens sector. Since $z = R \sin\phi$, it is evident that z cannot vary directly as ϕ unless $R = \textit{infinity}$, or $\phi = 0$. However, if $\phi_{max.}$ is kept within certain limits, the variation in $\frac{\sin\phi}{\phi}$, over the active range of a lens sector, will be negligible, and within these limits there is a wide choice in lens wheel diameter and in the number of sectors per wheel. But the variation in $\frac{\sin\phi}{\phi}$, from $\phi_{max.}$ to $\phi = 0$, measures the nearness of approach to the ideal, and governs the residual periodic variations; therefore, it has received prolonged and careful study and its effects have been analyzed minutely. It was at one time considered a serious factor because of its apparent relation to the focal length of the objective system, as shown in general equation (3), but its influence in this respect has been entirely overcome by improvements in the design of the stationary element, the curvatures of the components of which are extremely important in this connection.

The only residual error in the objective system caused by variation in $\frac{\sin\phi}{\phi}$, is that represented by a periodic rise and fall of the entire screen image which takes place during each picture cycle. In the present machine, this error causes a total vertical movement of approximately one-eighth inch in a picture twelve feet wide, and is invisible because it takes place twenty-four times per second at normal projection speed. The method of calculating this error, which I worked out originally in January, 1923, is very interesting but somewhat lengthy, so I will not include it in this paper. It will be sufficient to state that this error is inversely proportional to the square of the number of lens sectors per wheel, and, with a sixteen-sector lens wheel, the maximum departure of the equivalent center of the complete objective system from its theoretically correct position amounts to 0.000,920,99 inch. This factor, multiplied by the magnification ratio, gives the total vertical displacement of the screen image caused by the variation in $\frac{\sin\phi}{\phi}$.

In order that the objective system may function properly, it is necessary to provide a condenser system which will illuminate the entire aperture uniformly, and will produce a beam having a circular cross-section of small diameter at the plane midway between co-acting lens sectors. In the interest of economy, it is also essential

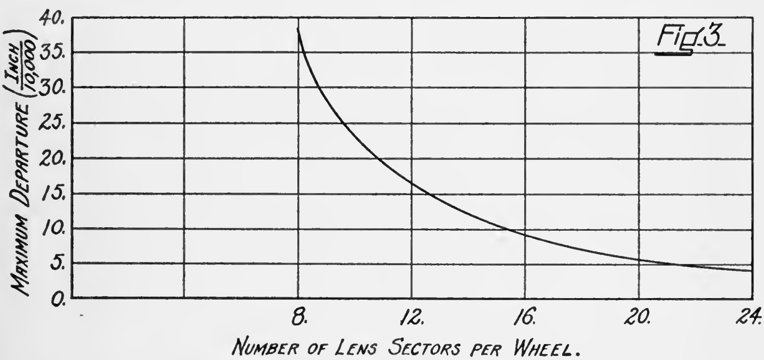


FIG. 3. Curve showing the relation between the number of lens sectors per wheel and the maximum departure of the equivalent center of the objective system from its theoretically correct position.

that the cross-section of the condenser beam, in the plane of the gate, be of such shape and proportions that the maximum amount of light may be transmitted through the elongated aperture. To accomplish these ends, I have long been using a cylindrical surface in the main condenser and a complementary sphero-cylindrical gate lens which is mounted in close proximity to the film strip. The first-mentioned cylindrical element provides a vertically elongated spot at the gate, having the form of an ellipse and fitting closely to the contour of the elongated aperture. The sphero-cylindrical gate lens remolds the condenser beam so that it becomes circular in cross-section as it enters the objective system. The projector is now equipped with a low intensity reflector lamp having a standard reflector and a condenser which was standard before I reground and polished the flat surface to cylindrical form.

Having designed an objective system approaching the ideal in accuracy, and having provided a condenser system fulfilling all the requirements, the mechanical problems involved in operating the lens wheels and film strip in proper relation, remain to be solved.

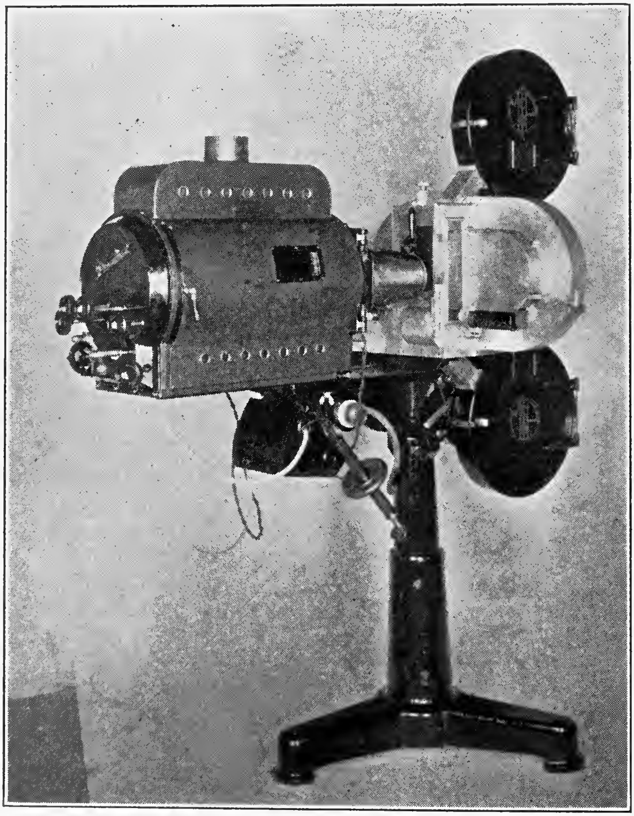


FIG. 4. Rear-right side view of complete projector.

As a first consideration, the mechanism must be easily adjustable to meet the requirements of the optical system in regard to film shrinkage, and a framing adjustment must be provided. Moreover, the lens wheels must operate in exact synchronism and the film strip must be actuated across the aperture plate at a uniform velocity exactly proportional to the angular velocity of the lens wheels. The steadiness, definition, and pleasing qualities of the projected image depend almost entirely on the accuracy with which these functions are performed.

Unsteadiness in the projected image has been my most serious problem in connection with this work, and since it has been elimi-

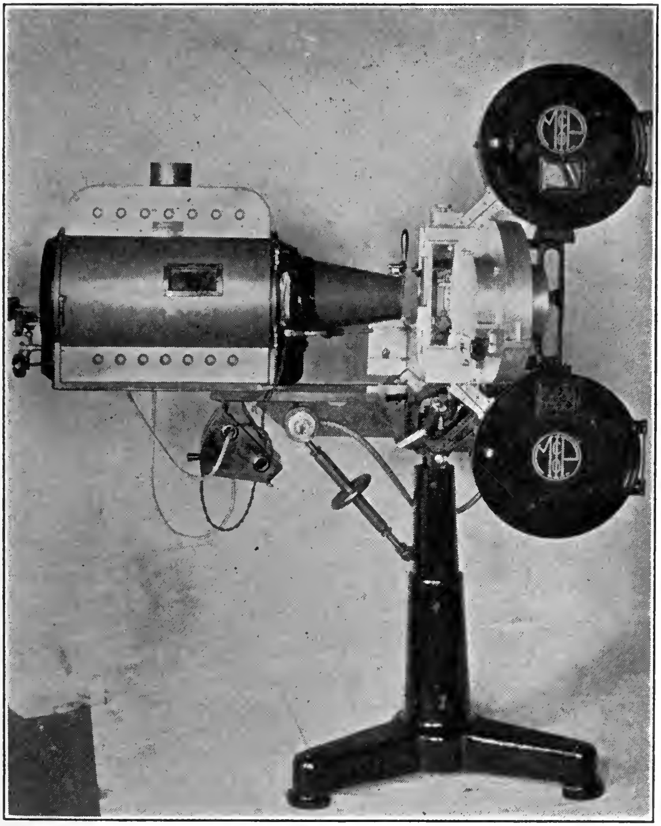


FIG. 5. Right side view of complete projector.

nated by the installation of precise gears, it is not difficult to show that the trouble has been mechanical rather than optical. A better understanding of the nature and cause of unsteadiness in the projected image may be had from the following analogy:

Let us think for the moment of the screen image as being supported in a state of equilibrium by three elastic ribbons, one being attached at each of the top corners and the third being attached at the middle of the bottom edge. We must think of the image as being rigid but having no weight, and moving as a whole if any change occurs in the tension of the supporting elastic ribbons. The tension of each of the top elastic ribbons, in our analogy, is to be

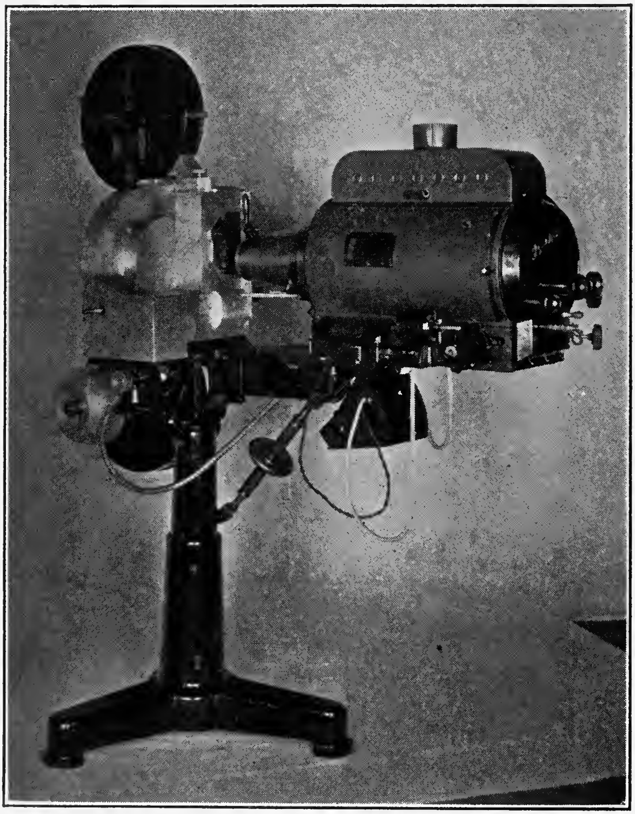


FIG. 6. Rear-left side view of complete projector.

likened to the angular velocity of one of the lens wheels, and the tension in the bottom elastic ribbon compares with the velocity of the film strip across the aperture plate. Any change in the tension of one or more of our imaginary elastic ribbons, unless accompanied by a proportional simultaneous change in all three, will cause a displacement of our imaginary rigid image. In like manner, our real projected image is in suspension, and any change in the angular velocity of a lens wheel, or in the linear velocity of the film strip, unless accompanied by a proportional simultaneous change in velocity of all three elements, will produce a displacement of our real projected image.

Inasmuch as perfect things are seldom if ever made, and never can be made in quantities, and since no means, other than gears, are available by which the lens wheels and film strip may be actuated,

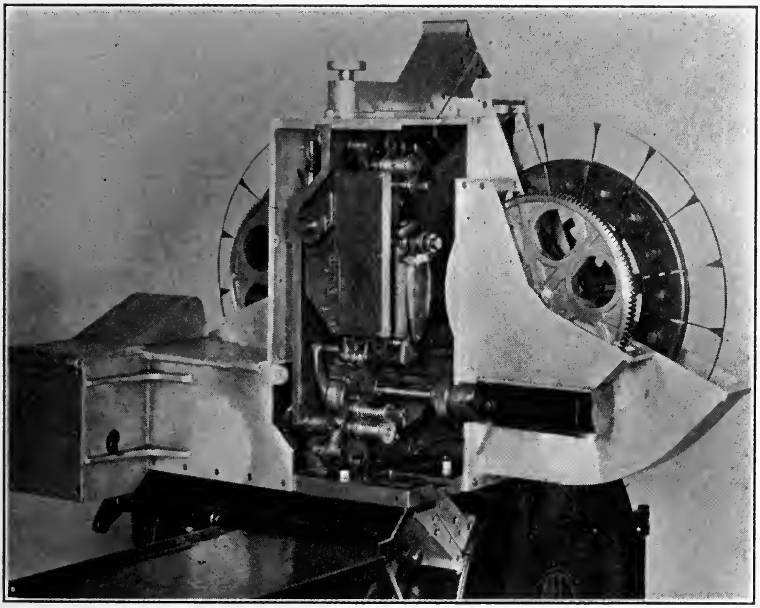


FIG. 7. Rear-right side view of mechanism with door and cover plates removed.

it is evident that the more simple the gear train the less difficult will be the commercial production of the mechanisms. The present model, designed in 1926, can be considerably simplified in this respect, and some idea of the improvement may be gained from the following comparison.

This model has two worms and two worm-wheels between the lens wheel shafts; the new model will have but two gears between these shafts; therefore the probability of errors in synchronization of the lens wheels, with gears of equal accuracy, is one-half. This model has seven gears between each lens wheel shaft and the aperture film sprocket; the new design, providing the same flexibility for framing and adjustment of the optical system, requires but two gears between the aperture sprocket and a lens wheel shaft. It is evident, therefore, that the new gear train, with gears having an accuracy of the order of those in this machine, will have at least a five-to-one advantage over the present arrangement, in the matter of steadiness. Moreover, the new gear train is far less expensive to manufacture.

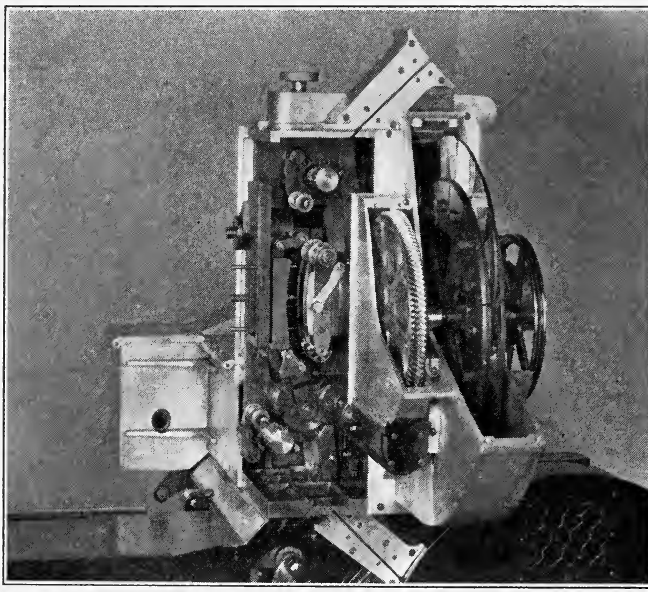


FIG. 8. Right side view of mechanism with door and cover plates removed, showing gate open for threading.

I have purposely avoided any reference to the accuracy required in the construction of the lens wheels, as that subject is fully covered in an article which appeared in the June issue of the JOURNAL (p. 623). It will be sufficient for the present to state that the manufacture of lens wheels, by the usual methods of lens manufacture, would be difficult, costly, and generally unsatisfactory. To meet the new requirement for quantity production of first quality and exactly matched lenses, an entirely new method of grinding and polishing has been developed. A special optical instrument has also been devised for exactly positioning the lens sectors on the lens wheels. With this new equipment it is not difficult to obtain the desired accuracy in the lens wheels and they can be produced commercially at a surprisingly low cost.

Thus far, I have described only the essential features of the revolving lens wheel projector. The fact that the film strip moves across the aperture at a uniform rate has many advantages, and one

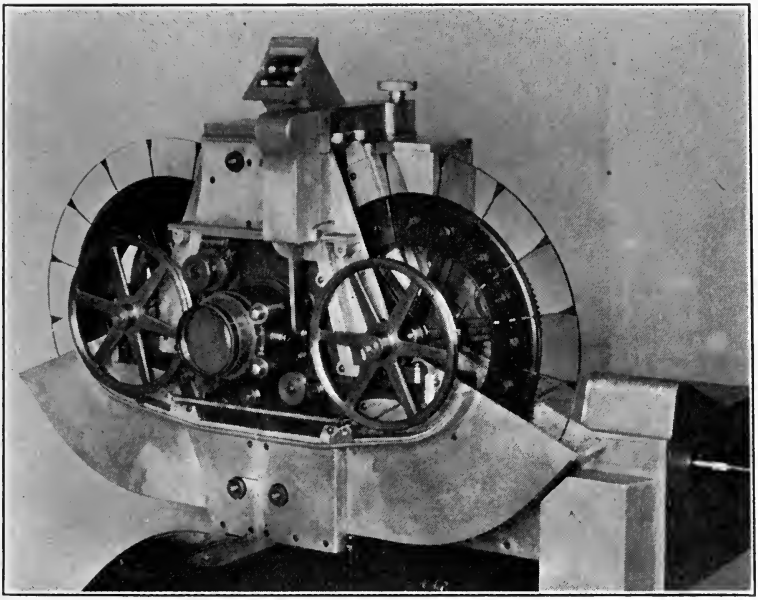


FIG. 9. Front-left side view of mechanism with cover plates removed, showing lens wheels, brake wheels, balanced drag mechanism, and mount for front element of objective.

of these is the ability to actuate a sprocket, located just above the aperture, by the movement of the film strip. This film actuated sprocket operates an automatic fire-shutter control mechanism. With the fire shutter thus controlled by the movement of the film strip across the aperture plate, its response is sure and instantaneous in case of film breakage at the aperture, or slowing down of projection below the predetermined minimum rate. The projectionist has no control over the action of this fire shutter, nor does he need it, since the shutter cannot close unless there is imminent danger of igniting the film. Another advantage of a continuously moving film strip is that the tension shoes can function perfectly with very little pressure, because there is no effect equivalent to the "over shooting," which produces unsteadiness in intermittent projection unless the spring tension is considerable. Since there is no periodic "breaking from rest" under heavy tension, there is very little strain on the film strip in continuous projection, and "green" prints, direct

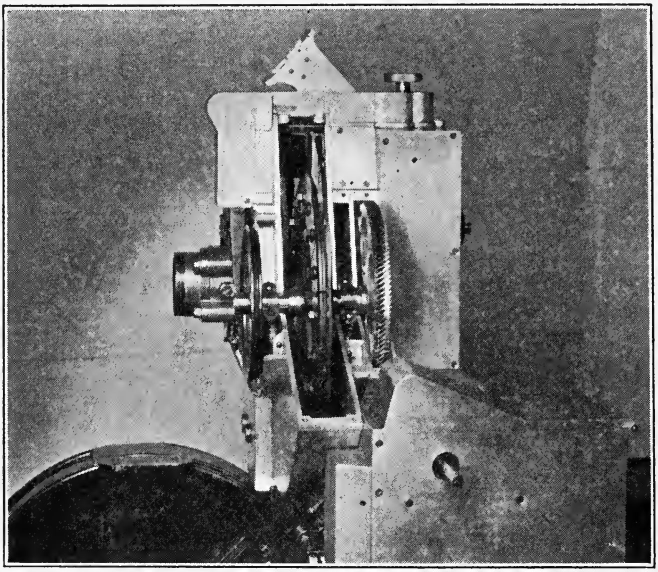


FIG. 10. Left side view of mechanism with cover plates removed, showing lens wheel shaft assembly and bearings.

from laboratory processing, may be run without waxing or other lubrication. In fact, prints may be projected hundreds of times without showing any appreciable wear and without accumulating scratches and dirt over the photographic areas. This is an important advantage, especially in the projection of sound-on-film prints.

Having removed from the projector mechanism the principal causes and sources of wear and damage to the film strip, effort was next directed toward improving the film take-up device with a view to eliminating damage to film from this source. It is pretty generally known that much damage may be done to film during the rewinding operation, and the reason is apparent from an examination of the wound film when the take-up reel is removed from the lower magazine.

The ordinary take-up drive is a constant torque affair and is adjusted so that the initial winding on the take-up reel will not be sufficiently tight to cause damage to the film perforations on the lower or "hold back" sprocket. With this adjustment of the driving torque, the tension on the film strip, during the initial take-up when the wound diameter is small, will be considerably more than is necessary to produce a solidly wound mass, but, as the diameter of the wound mass increases, the film tension decreases, and, generally speaking, the outer layers of film, to a depth of one to three inches depending on the torque adjustment, are wound rather loosely. When the reel containing the film, which has been wound at a progressively decreasing tension, is put on the rewinder and the end of the film is attached to the empty reel and the motor is started with a jerk, it is not difficult to understand that film will be drawn from the reel before the reel begins to rotate, and there will be a progressively decreasing amount of slippage between film layers, from the outer layer down to that inner layer which has been wound at a sufficient tension to balance the pull of the power-driven reel on the rewinder. If the brake on the reel being rewound has not been released, the conditions will be aggravated and the slippage between film layers will go deeper into the reel. The film, in passing through a projector, collects dust, dirt, bits of emulsion, and other grit, which adhere to its surfaces, and when, in the rewinding operation, these surfaces slip over each other under pressure, the conditions are ideal for the most effective abrading. The film damage which shows up as "rain" and is most prevalent toward the end of a reel, is generally caused in this manner.

It is interesting to observe that the advent of sound-on-film prints has drawn more attention to the take-up conditions, and the improvement thus far made has taken the form of new type reels with larger diameter hubs and of more sturdy construction. These new reels, incidentally, cost several times as much as the better grade reels of a few years ago.

Our projector is equipped with a take-up control which may be adjusted to give a practically constant winding tension on the film for all diameters of the wound mass, and it will operate equally well with an old-fashioned reel having a two-inch diameter hub, or with one of the new type reels. This take-up control is a variable torque device, the pressure between the friction drive members being varied by centrifugal force through the medium of a system of balanced springs. At the higher reel speeds, during the initial take-up when the wound mass is of small diameter, centrifugal force acts to reduce the driving torque, thus preventing excessive film tension. As the reel speed decreases, centrifugal force is reduced and the balanced spring system acts to increase the pressure between the friction drive members, thereby increasing the driving torque and maintaining full tension on the film. Adjustments are provided by means of which the film tension may be regulated for three stages of the take-up operation, namely, empty reel, half-full reel, and full reel. With this device the film is wound on the take-up reel under practically constant tension; therefore it acts as a solid mass and is not subject to damage during the rewinding operation.

Continuous projectors which accomplish the transition from frame to frame through the medium of a dissolving action without the interposition of a shutter effect, must be provided with an aperture which is at least two film frames in height; therefore some means must be associated with the projector to prevent the appearance of images above and below the one centered on the screen. It has been common practice to use a mask, placed several feet ahead of the projector, for this purpose, but such a device, while effective, is nevertheless wasteful as it absorbs images which may be redirected to the screen. Our projector, when used with the customary mask, is equal in light-transmitting efficiency to the best intermittent projector equipped with the best large aperture projection lens. This has been proven to the entire satisfaction of representatives of projector manufacturers in recent tests. When our projector is used in association with an optical economizer having the capacity to redirect the extra images to the surface of the screen in such a manner that they may register with each other and with the image already on the screen, the light-transmitting efficiency is more than doubled.

In this connection another very interesting development is made possible. In the revolving lens wheel projector, which provides a dissolving action occupying a large portion of the picture cycle, the aperture is about three frames high; therefore, with the aid of an optical economizer, it is perfectly possible to produce on the screen a continuous dissolving action involving three separate film frames at all times. This represents the ideal condition for a three-color system of natural color projection according to the additive method. The individual film frames are not required to carry the full color values, as the natural colors are produced on the surface of the screen by the mixing of the three primary color values supplied by three successive film frames. According to this method of natural color projection, the prints are made in black and white, in the usual manner, from a negative exposed in a color camera equipped with a three-color filter wheel. Filters are necessary to bring out the colors in projection, but these will be applied direct to the positive print in the form of red, yellow, and blue tints over successive film frames, the red tint being applied over those frames printed from the negative frames originally exposed through a red filter, *etc.* This system of natural color projection will be relatively inexpensive and will have the same resolving power as black and white prints.

Although the basic idea is that of the old Kinemacolor process, it must be understood that the conditions, with a continuous projector producing a dissolving action involving three film frames at all times, are entirely different from the old Kinemacolor conditions, and, therefore, vastly different results are to be expected. The question of excessive color fringe due to motion, has been suggested as a possible serious fault, but an analysis of the intensity of illumination would indicate that color fringing may not be a serious factor. When it is remembered that no shutter is used in the projector it is evident that the maximum light intensity on the screen is probably only slightly in excess of fifty per cent of that required with an intermittent projector. Moreover, since the screen illumination is being supplied from three film frames simultaneously, it is apparent that each frame is supplying only its proportion of the total illumination; hence, it would appear that the color fringe, especially on subjects not composed entirely of one of the primary colors, would not be of sufficient intensity to be objectionable. This system of natural color projection has real possibilities, especially in connection with sound-on-film subjects, and we expect shortly to be able to demonstrate its superiority.

Continuous projection will be especially helpful in connection with the presentation of sound-on-film subjects. This is apparent when one recalls that the film strip must move across the aperture plate at a uniform linear velocity to satisfy the requirements for steadiness in the projected image. Since this is true, there is no necessity for a sound pick-up attachment to be used with the projector mechanism. The sound pick-up can be built into the aperture unit of our projector in such a manner as to add no complications to the present extremely simple threading arrangement. No extra sprockets or idlers are required. Moreover, the film-feeding mechanism may be designed so that it will successfully handle a film strip having standard perforations along one edge only, thus providing room on a 35 mm. width strip for the standard silent film frame and a sound track at least fifty per cent wider than is now used on 35 mm. film. Thus, an opportunity is offered to restore the old silent picture proportions and provide an improved sound track without departing from the standard 35 mm. width.

The usefulness of the revolving lens wheel projector is not confined to any particular size film frame. A design may be worked out for double-width film or for 16 mm. film and such designs will possess all the advantages enumerated herein. As a matter of fact the system is especially suitable for double-width film because it simplifies the optical problems and, due to its two-to-one advantage in light-transmitting efficiency, eliminates the difficulties experienced in getting sufficient illumination for wide film presentations by the intermittent system.

The story of the usefulness of the revolving lens wheel is not complete without a reference to its application to photography. As stated in the introduction, the true appearance of motion cannot be reproduced from a film depicting only fragments of the original movements. Hence, it is logical to believe that action, as recorded by a continuous camera having no shutter effect, may be reproduced in the most realistic manner by a continuous projector using prints from a negative exposed in such a camera. We are now investigating these possibilities.

DISCUSSION

MR. PALMER: I would like to inquire regarding the stability of the lens setting under operating conditions, that is when it is subjected to temperature variation, vibration, and varying wear.

MR. HOLMAN: With regard to the stability of the system as affected by wear and shock, I can say that this set of lenses was set originally in April, 1927, and has not been shifted since. I have taken the projector to New York on two occasions in the back of my old Buick and brought it here in the same manner. When I tried it out this morning it worked as well as it did in Boston a few days ago. Temperature is not a factor because a lot of glass is exposed to the beam and therefore the lens wheels do not heat up much. This mechanism was built in 1926 and nothing has been done to the bearings since the machine was completed. The wear to date is equivalent to nine months' steady service in the theater.

MR. EDWARDS: I should like to ask what speed the projector operated at in this demonstration.

MR. HOLMAN: The projection was at the rate of about 80 feet a minute.

MR. DUBRAY: What provision is made for shrinkage accommodation?

MR. HOLMAN: Film shrinkage is a problem in the design of any continuous projector, with which I have dealt at length in the paper. Previous systems have had a real tussle with this problem. In mirror and prism systems it is difficult to deal with, but in the revolving lens wheel system the solution is simple. The lens wheels are not adjustable along the optical axis of the machine. The front element is adjustable axially, as is also the aperture unit. These parts are slidably supported on pins and the two are moved to compensate for film shrinkage. It is a very simple matter to design lever arms having the proper ratio to allow for compensation for film shrinkage. The set-up here does not differ much from what I have had in Boston. The throw is somewhat longer and the pitch angle is greater, but, as regards shrinkage adjustment, there is no difficulty; it merely means taking hold of, and turning a hand adjusting wheel. The operator really doesn't realize what is happening when adjusting for shrinkage; he is changing the position of the front element and the projector aperture plate with respect to the lens wheels. This changes the back focus because the aperture unit moves away from or toward the revolving lens wheels; however, the corresponding movement of the front objective with respect to the revolving lens wheels also varies the equivalent focal length of the system simultaneously.

MR. SHAPIRO: Has Mr. Holman any figures as to the light efficiency of his projector as compared with the intermittent type with the same source of light?

MR. HOLMAN: I am sorry to say I have never measured the light intensity on the screen. We ran comparison tests a month or so ago with a Simplex equipped with the Ross lens, and the conclusion was reached that there was no difference in screen illumination with the two machines under the same conditions; *i. e.*, equal arc amperage, lens opening, *etc.* These tests were made using a mask such as I have here today. It is possible, however, to put on the screen the light now lost on the two fiber sheets forming the mask, by using an optical economizer, and under these conditions the light transmitting power of the system is about double that of the ordinary intermittent machine.

MR. ROBIN: Is the relative speed of the wheels half the angular velocity of the film? What means besides the brake has been provided for wear or backlash in order that the two optical elements will register in optical centers at the same moment on the optical axis?

MR. HOLMAN: In regard to the speed of the wheels with respect to the film, that has puzzled lots of people. There is no definite prescribed relation except that one lens sector cross the optical axis in the time required for one film frame to cross the axis. The relative velocity in this machine can be figured out. The optical diameter on which the lens sector centers are set is 12 inches, and there are 16 lenses on the wheel, so you can figure out the ratio of movement of film and lenses. There is an opinion abroad that the ratio must be one to one—that the lens sector must be the same height as the film frame, but this is incorrect.

In regard to wear, it is to be noted that normal wear in gears and bearings is not a serious factor unless it is uneven or excessive in amount, because all parts are operating under a uniform and constant load. The sprocket overcomes a uniform film drag and the lens wheels operate against a uniform brake load.

MR. RICHARDSON: I should like to ask whether we could at some future time run sharp black and white film through the machine?

MR. HOLMAN: We should be glad to, if another showing can be arranged. I can assure you that there is no difficulty in securing sharp definition.

MR. FINN: I should like to know whether any provision is made for precise adjustment in film splicing.

MR. HOLMAN: There is no precise adjustment required in making film splices. The sprocket actuating the film across the aperture plate is a standard Simplex intermittent sprocket and it is positioned $2^1/_4$ inches below the optical axis. If the splice is good enough to run over the sprocket, there will be no appreciable jump in the picture.

MR. GOLDEN: Is there any additional time required for re-threading in the case of breakage?

MR. HOLMAN: Threading is about the same as in other machines but the mechanism is open and large and there is no main shaft in the way, so that there is plenty of room. There is the usual top sprocket feeding the top loop, an aperture unit sprocket, and the bottom or hold-back sprocket. Most projectionists find our mechanism easier than any other to get into.

A MICROPHONE BOOM

ELMER C. RICHARDSON*

When sound motion pictures were first produced in the Hollywood studios, the sets were small, and no great difficulties were encountered in concealing microphones within the set, so that sound could be satisfactorily picked up.

As the sets became larger it became necessary to use a plurality of microphones, and to fade from one circuit to another as the actors moved about. This operation of fading from one microphone to another contributed to errors in recording which while excusable a year ago would be highly criticized today.

To obviate the use of plural microphones several devices were used. For instance, a microphone was sometimes suspended from the ceiling by means of a cord and moved about with a long pole, an operation quite obviously called "fishing." Some studios had their property departments construct supporting arms or booms which would facilitate the quick placement of microphones. Most of these pieces of equipment were hurriedly made and crudely constructed and none too satisfactory in their operation.

The Metro-Goldwyn-Mayer Studios, after some experimentation with a microphone boom of this type, designed and built a boom of the type illustrated in Fig. 1, which operated quite satisfactorily. This boom consisted of a substantial base supporting a vertical column which in turn supported a lever arm having an adjustable portion which could be extended or retracted at will by operating a cable drum by means of a crank from the floor. The underbalanced portion of the boom and the weight of the microphone was counterbalanced by a fixed counterweight and the boom operated upon its vertical and transverse axes by an operating lever, as shown in the illustration.

While there are some sound engineers who object to the use of moving microphones, many of the best technicians are convinced

* Mole-Richardson, Inc., Hollywood, California. (Read before the Society at Washington.)

that the inherent limitations of the microphone can be overcome by silently moving the microphone to maintain it in a proper relation to the sound source, and by properly manipulating the fader.

FIG. 1. Microphone boom designed by Metro-Goldwyn-Mayer.

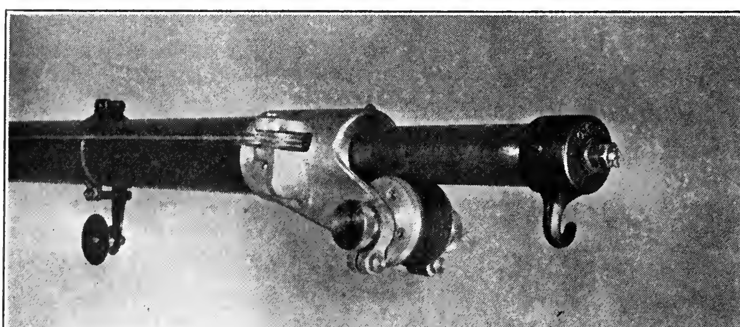


FIG. 2. Extension tube carrier, Type M-R 103-103A.

As is true with many of our problems, the general principle involved in this design is simple; the real problem, however, was to construct this piece of apparatus so it would operate with a degree of silence which would in no wise interfere with sound recording.

In the type illustrated, the sliding tube was operated by two leather-faced friction rollers, which were rotated by a cable which was wound over a capstan sheave. The whole apparatus worked quite silently, but there still remained a slight snapping sound as the wires of the cable changed their position on this capstan. To overcome this difficulty, another type of extension tube carrier was designed. (Illustrated in Fig. 2.) In this case, the extension tube rolls in and out of the fixed tube, supported on a leather-faced

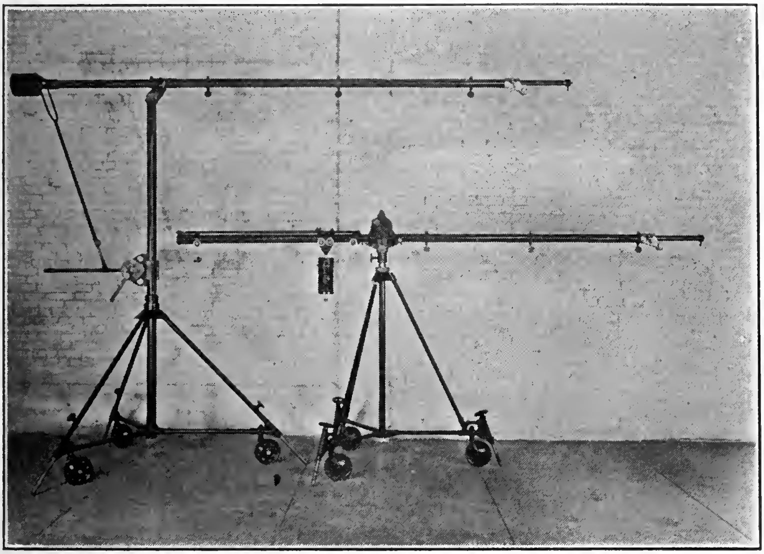


FIG. 3. Microphone boom, Type M-R 103-103A.

roller having an eccentric adjustment for centering purposes, but instead of being moved by friction it is moved by a direct pull from a cable attached to the rear portion of the sliding member and operating in the annular space between the stationary and sliding tubes. This cable passes back to a simple sheave supported at the fulcrum point of the fixed tube and down to the operating drum. It is wound around the operating drum several turns and passes around another simple sheave at the fulcrum point, returning through a sheave in the rear of the fixed tube, and is rigidly fastened to the sliding member. This construction gives a positive motion to the sliding tube with a construction which introduced no serious problems of extraneous noise. This type of boom (M-R 103) is illustrated in Fig. 3.

A number of ingenious suspensions for the microphones have been worked out, such as hanging the microphone on rubber suspension loops and mounting upon sponge rubber shock absorbing mechanisms. One of the most successful mountings was worked out in the Pathé Studios by suspending the microphone from the center of a rubber diaphragm about six inches in diameter. By means

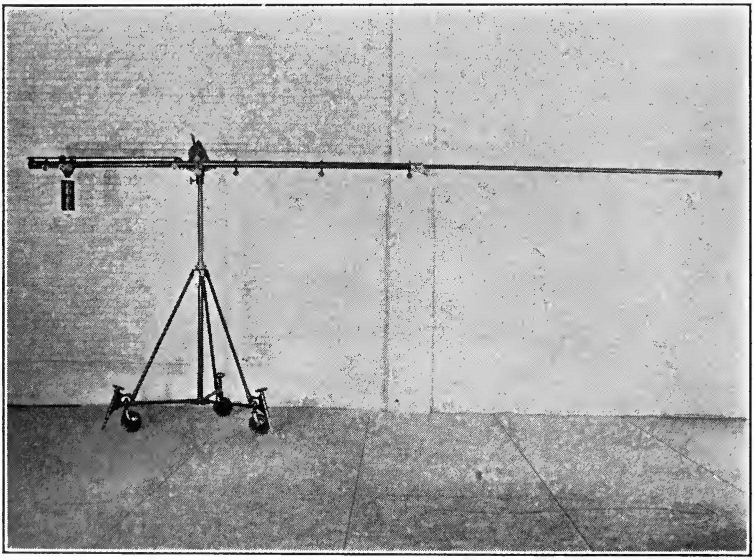


FIG. 4. Microphone boom, Type M-R 103-A (extended).

of these various rubber suspensions all "telegraphed" sounds were withheld from the pickup circuit.

Since the microphones have certain directional characteristics many of the studios have taken advantage of this and constructed suspensions which allow the microphone to be faced at will by the operator. In this way, for instance, if a conversation is being carried on between two persons, the microphone may be faced from one to the other, giving better recording results than would be the case if the microphone were held in a constant position.

Practically every major studio on the West Coast, and some of the studios in New York, have been using these booms with good success.

A demand arose for an automatically counter-balanced microphone boom which could be operated from the top of a camera booth. To meet this situation, the M-R Type 103-A boom was developed. The same principles of design for moving the telescoping portion have been incorporated in this boom as in the Type M-R 103, but the counterpoise is mounted on a carriage which slides on the rear portion of the fixed tube supported by leather-faced rollers and operated by means of a sheave system working on the principle of a double block and fall. The counterpoise moves outward one foot when the sliding tube and microphone are extended three feet. This gives the advantage of always maintaining the boom in a state of balance, and by underslinging the boom from its fulcrum bearing the boom will always return to a horizontal position when it is released.

This boom is mounted on a tripod which may be elevated (see Fig. 4), and has a number of advantages which have been well accepted by the studio operating personnel.

It does not matter whether or not one objects to the use of the moving microphones (other technicians are probably more familiar with the pros and cons of that subject), the fact remains that microphones must be placed. In the Hollywood studios, a picture of any size is carrying an overhead charge of from ten thousand dollars a day up. Every minute gained in the production time is money saved. If you have ever observed sound operators trying to place microphones by means of rope suspensions, fishing, *etc.*, it is quite obvious that a device such as has here been described has a very definite place in sound motion picture production.

TILT HEADS AND ROLLING TRIPODS FOR CAMERA BLIMPS

ELMER C. RICHARDSON*

Though there has been considerable progress made in silencing the movements in motion picture cameras, there are not at present available many cameras sufficiently silent, so that they may be used without the additional sound-proofing of a camera booth, or with what we term a "blimp" or "bungalow" camera housing.

Sooner or later camera manufacturers are going to offer the industry a camera so silent that it can be used with every facility which cameras previously used in silent pictures; however, at present the sound departments of most studios are resorting to the use of blimps as the best means to meet the present situation.

There has been a lot of experimentation with these sound-proof devices. For instance, some blimps have consisted of a simple padding or quilted cover attached to the camera by means of snaps or zippers. These sound-proofings are popularly called "horse-blankets." Other blimps have been constructed of plywood or masonite cases, lined with sponge, rubber, felt, and many other insulating materials.

When the writer left the West Coast, the most popular "blimps" were of a construction embodying an aluminum external housing, lined with insulating felt and in some cases with lead. I believe another paper has been written with respect to these developments.

At first these blimps were mounted on ordinary camera tripods, and in the case of the horse-blankets the addition of the sound-proofing, which did not add much weight, did not present a serious problem. These heavier "blimps" which are now looked upon with favor, weigh approximately 260 pounds with the loaded camera, and are too heavy to be supported by either a standard tripod or a standard tilt head.

To meet this situation, there has been introduced a rolling tripod,

* Mole-Richardson, Inc., Hollywood, California. (Read before the Society at Washington.)

which in combination with a special tilt head, as shown in Fig. 1, gives the cinematographer almost the same latitude with the heavy blimp and camera that he formerly had in the days of silent pictures.

As you will note in the illustration, the tripod is mounted on rubber-tired casters, which may be locked into line for "perambulator" shots, or left free as desired. At the supporting points leveling screws are provided with which the tripod and camera may be lifted

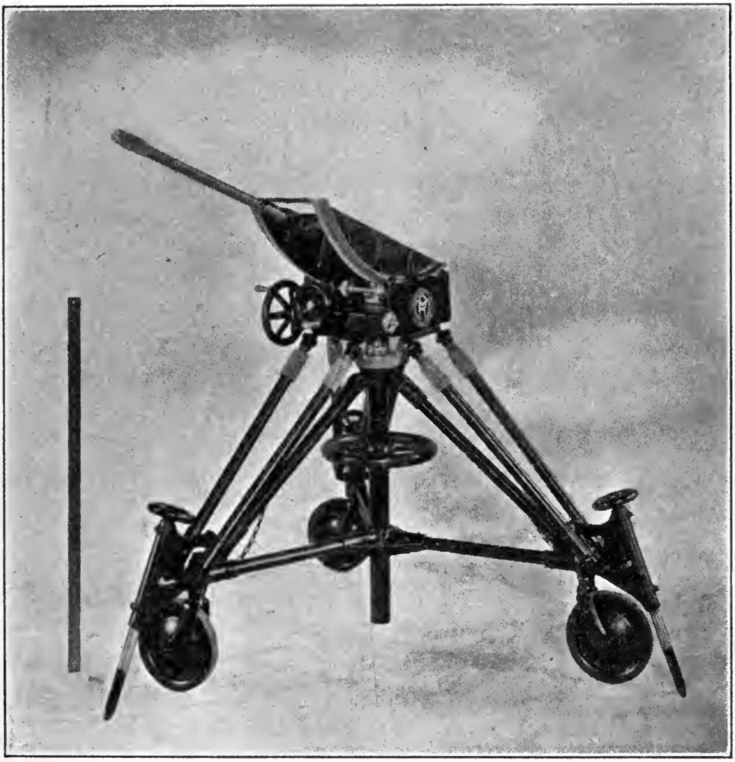


FIG. 1. Rolling tripod, low position.

off of the casters and leveled. These leveling screws were given an angular inclination which has provided a very rigid support.

The tilt head is supported upon a central telescoping tube system, and by means of a hand-wheel may be elevated or lowered. Fig. 1 shows the tripod in the low position and Fig. 2 in the high position. Supplementary telescoping struts extend from the base to the tilt head, which may be locked by means of clamping sleeves.

Mounted upon this supporting structure is a tilt head which is better illustrated by the detail in Fig. 3.

As you will note, the blimp is mounted upon a table, which in turn rolls upon rails which are sectors of a circle, the radius of which centers at a point coinciding approximately with the center of gravity

FIG. 2. Rolling tripod, high position.

of the blimp. By this method of support, the blimp and camera are in equilibrium in all positions of tilt.

When free tilt is desired, the knurled clutch knob shown under the table is shifted to the right, which disengages the tilt worm reduction gear and spur gear drive to the gear sectors on the table. If the blimp and camera are to be operated by the control wheel,

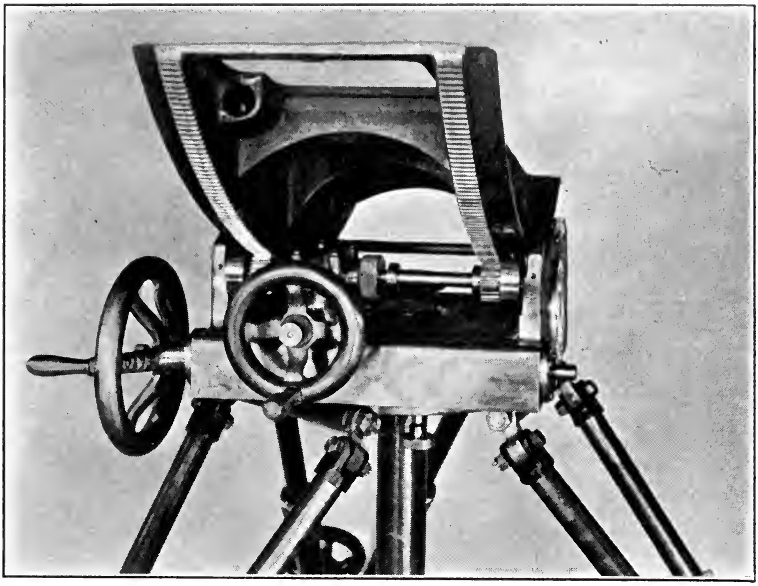


FIG. 3. Detail of tilt head.

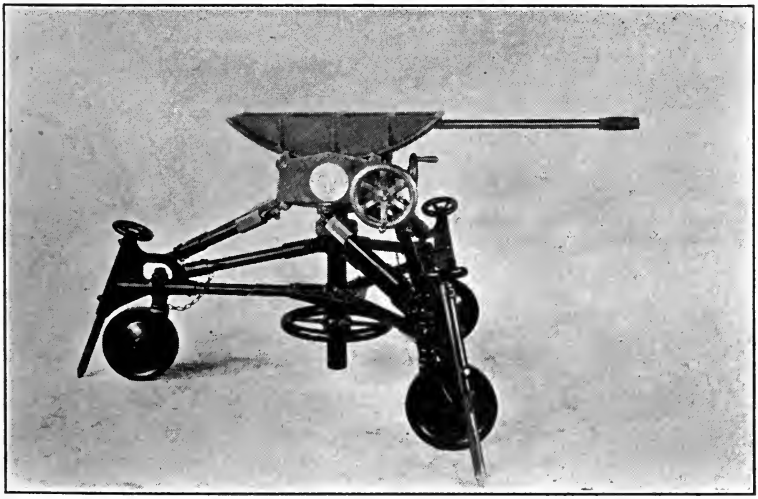


FIG. 4. Auxiliary low tripod.

the clutch is shifted to the left, connecting the worm reduction gear to the spur gear driving shaft.

The panning movement may be mechanically operated by the hand wheel on the left, as illustrated in Fig. 3. By withdrawing the locking plunger under the support plate, the panning action is made free. It will be noted that the hand-wheel controlling the passing movement may be moved to the right hand shaft extension, if desired.

By liberal use of ball and roller bearings, friction has been re-

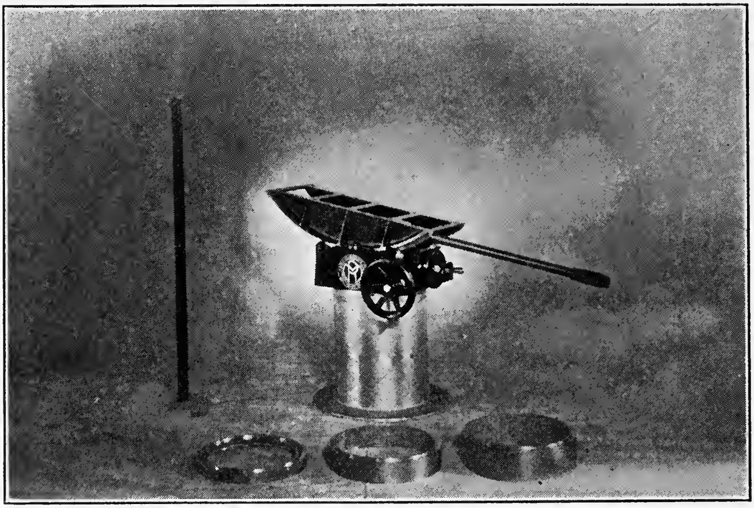


FIG. 5. High-hat unit showing adjustable section.

duced to the minimum—a very essential feature in handling a camera when covering action.

In addition to the standard tripod, shown in Fig. 1, which supports the camera at a lens height of from $70^1/_2$ inches high position to $48^1/_2$ inches low position, an additional low tripod may be used when it is desired to operate from below 48 inches lens height. (See Fig. 4.) The low position of this auxiliary tripod is $37^1/_2$ inches. If it is desired to operate at a still lower position, the tilt head may be mounted on a sectional high-hat, illustrated in Fig. 5, by adjusting the sections of which the camera may be lowered an inch at a time to a lens height of 20 inches from the floor.

By the use of these several units the camera may be operated at any desired height.

Experience has shown that 90 per cent of production photography may be made with the standard tripod.

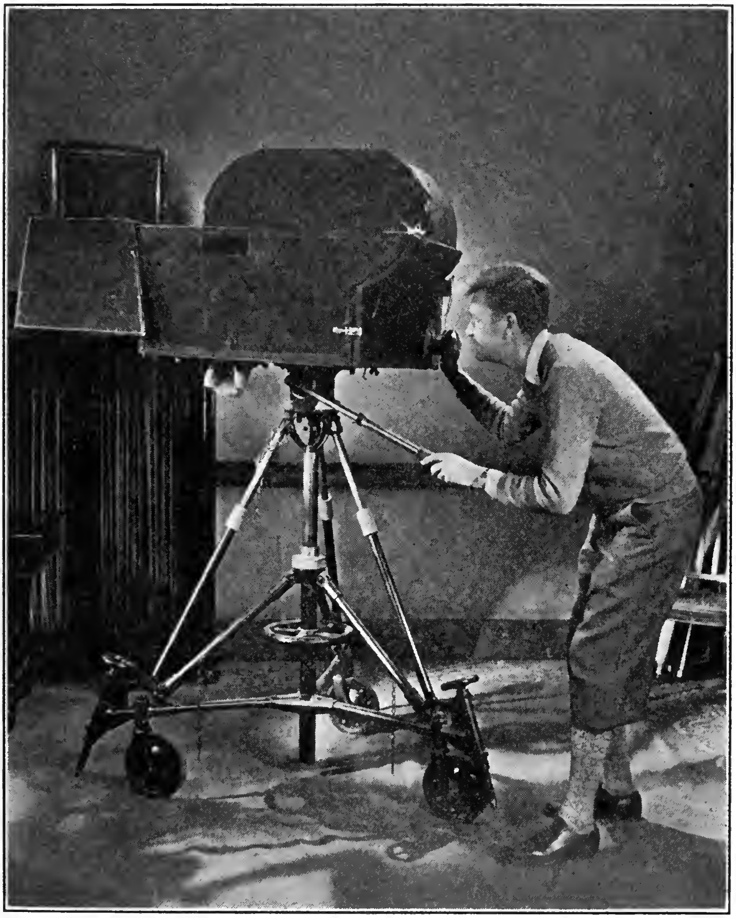


FIG. 6. Rolling tripod modified for lighter blimps.

For use with the type of blimps which are light enough to operate from a standard camera base, another type of rolling tripod of modified design (see Fig. 6) is available. This piece of equipment has proved popular in such studios as use these—may we call them—medium weight blimps.

Every change of production procedure has presented its problems. The camera booth was the first solution to the problem of silencing camera noise. The blimp has been a modification and its use has made necessary the equipment herewith described.

Until suitable silent cameras are available in quantity to meet the needs of the studios, it will probably be that blimps of some type will most ably meet the situation.

VOLUME CONTROL BY THE SQUEEZE TRACK

WESLEY C. MILLER*

The proper regulation of volume or apparent loudness is essential to good reproduction of sound. This is particularly true when the sound forms a part of a sound picture, as the success of the latter in producing an illusion of reality is greatly affected by sound volume. If the recording has been well done, and if the theater apparatus is in good condition, the picture may still be poorly shown if the sound volume is improperly handled. This is clearly a matter of showmanship, and must be studied as such. The definition of suitable volume is simple. It is the volume at which the desired illusion is obtained. The illusion of reality which results from such a combination of sound and scene is such that little imagination is required to think of the scene as being real. The attainment of this result is the goal of all sound picture productions.

In real life our personal and inherited experience produces the effect more or less automatically. Involuntarily, we correlate the impressions we receive—and equally involuntarily, we adjust ourselves to the natural distortions in every-day phenomena. However, an artificial device, such as a recording and reproducing system accompanied by a motion picture, has no such involuntary reactions. It has certain potentialities which may produce amazingly good results, but it must be guided throughout every step or some form of distortion will appear. If we are to show to our audiences a product which will, without effort on their part, give the illusion we plan, this guidance must come from both producer and exhibitor. The studio must anticipate the problems of the theater, and the latter must endeavor to exhibit the product in a manner approaching that designed by the producer. This combination alone will result in a high average success in terms of audience appreciation.

Technical perfection may be analyzed in terms of scientific laws which are common property. There is general agreement on the

* Metro-Goldwyn-Mayer Studios, Culver City, California. (Read before the Society at Washington.)

fundamentals, but due to the newness of sound reproduction on its present scale there is a tremendous lack of understanding of some of the details. This is naturally less apparent in the studios and among the producers, as they are closer together geographically, and as they were the first to have to meet the problems of the new business. Largely through their own initiative and by their own analysis of the situation, they are for the moment in the position of being able to help the exhibitor to get the results both desire—to please the audience. Among other things, they are trying to do this by the expedient of making proper sound reproduction as nearly automatic as possible.

Sound volume is definitely interrelated with frequency response of records and apparatus, theater and studio acoustics, sound perspective, personal desires, and a multitude of other factors. Eliminating all of these for the purpose of the present discussion, volume control presents a particular problem. The total range of volume to which we are accustomed in real life is tremendous, and quite beyond the possibilities of any known commercial reproducing device. Fortunately, this is not an impossible limitation. In the first place, we shall probably never wish to reproduce in a theater the loudest sounds we can feel or hear, as they would be uncomfortable to an audience. Similarly, the lowest sounds we reproduce must be loud enough to be somewhat audible over the theater noise—breathing, rustling of clothes, and general movement. Consequently the total range to be accommodated is reduced to a point where it is entirely practicable to take care of it.

This range, however, still exceeds the capabilities of the record itself. In recording we have two definite limits—an upper limit represented by the overload point of the recording device and medium, and a lower, which is the inevitable surface noise in a record of any kind. Exceeding the upper limit introduces disagreeable distortion without noticeably louder apparent volume. Going below the lower limit results in a loss of part of the record by the masking effect of the surface noise. Every sound recording technician is continually making use of various devices to get the most effective results from this limited recording volume range.

Fortunately there is available a means of somewhat extending this range in reproduction, through the medium of adjustable amplification of the record. By means of this we may amplify some parts of the record more than others, and produce the effect of an over-all range greater than the recording range proper. Even this available increase is limited, as too much additional amplification brings forth other troubles from excessive surface noise, machine noise, and perhaps amplifier or other system overloads. Judiciously used, this factor of additional adjustable amplification is a means of greatly enhancing the effectiveness of the reproduction.

In recording we plan to make use of this extension when necessary. Ordinarily the attempt is made to have a record run without such a change, and the great majority of records fall in this class. But when we do have to use the additional amplification in the reproduction, the operator must know when to use it, and, more important, must use it. Therein lies a weakness which has resulted in many a poor reproduction.

The theater operator has at his command some form of volume control—a fader or similar device. If cues are furnished with the picture he can control the volume by following these cues with the fader, but if the fader is in the projection booth he has no way of checking the resulting effect in the house, unless by reports from an observer. Fair results may be obtained by such a mechanical method. However, the average operator in a booth has plenty to do during the showing of a picture—changing reels, watching lamp adjustment, *etc.* The result is that his attention to the fader must suffer.

In certain cases the Metro-Goldwyn-Mayer organization has advocated the use of a fader installed in the auditorium and operated by a special operator, who is then in a position to know exactly how the picture sounds and to regulate the sound accordingly. This has produced excellent results but it has certain disadvantages, not the least of which, from the theater standpoint, is the requirement of an additional operator who must necessarily be something of a sound expert and artist, in addition to his other attainments.

These are real problems to both producer and exhibitor in the face of an annual release of some hundred million or more feet of pictures each year, involving thousands of the theaters. With them in mind the Metro-Goldwyn-Mayer sound organization has evolved a means of practically automatic volume control for variable density film release, which has been very effective in practice. From the appearance of the sound track which it uses the name of "squeeze track" has come into use.

It is a well known fact that the sound volume resulting from a given variable density sound track record varies as the track width changes. This feature is used for volume control. Due to the width of the reproducing aperture, the effective normal track width is 0.080 inch. Reducing this width to 0.020 inch gives a reduction in volume of 12 db. Moreover, the surface noise to signal ratio reduces in practically the same ratio, that is, the effective surface noise is reduced in proportion to the sound on the record. If, then, we make our average volume track 0.040 inch wide by matting out half of the regular track, we may, by varying the width of the mat, get an increase or decrease of 6 db. by making the track 0.080 inch or 0.020 inch wide, respectively. This is the principle of the Metro-Goldwyn-Mayer "squeeze track."

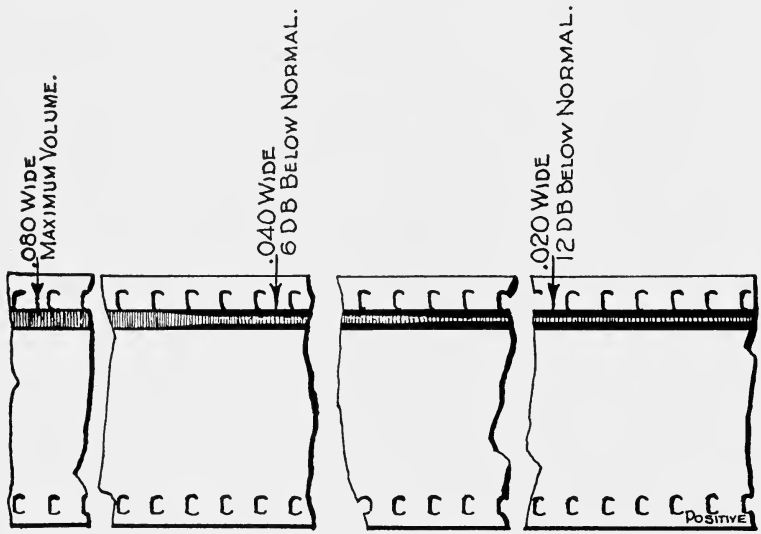


Figure illustrating the principle of the "squeeze track."

In practice, recording is done as usual and the attempt made to keep the recorded level as nearly uniform as is consistent with the desired effects. If, through some error of judgment, or because of the nature of the scene, a change in fader setting becomes necessary, the mat width in the release print is changed in the proper direction to produce the desired result. Inasmuch as the normal track will produce but half the volume of an unsqueezed track it is of course necessary to run the theater fader 6 db. higher than normal, but this imposes no hardship.

In operation each reel is handled as a separate unit, and the volume adjustments throughout the reel length are adjusted to keep within the limitations of recording volume range and squeeze mat range. Many reels require no squeeze mat because the range in them is such that the normal recording range is sufficient. In the theater then if the operator adjusts any part of a given reel to the proper volume level the remainder of the reel is automatically right. In other words, if he sets the fader right for the beginning of the reel, the rest takes care of itself—one fader cue per reel.

Some judgment must still be used by the operator or an apparent necessity for cues results. In the studio the right balance is established between the loud and soft parts of the reel. If now the operator runs the soft parts, such as low dialog, at too great a level, the loud parts will run much too loud and must apparently be cued down. There is a tendency in most theaters to run the dialog abnormally loud, so that in making the mat this must be taken into account. The result is that we often find ourselves in possession of a usable volume range which is too great for theater use. This paradox will correct itself as time goes on, and as a better understanding of proper volume is gained by the operator.

In the accompanying figure is shown a short section of sound track with a rapid change from full volume down to minimum volume. This rapid transition is shown for illustration only, as the changes are much more rapid than practice demands, although they are entirely practical if such rapid changes are required. It will be noticed that the sound track appears between two mats. Consideration of the reproducing apparatus will show the reason. The lateral adjustment of the apparatus may not be quite correct, but the relation between track and black area will still not be varied. This is of course essential. It is expected that the apparatus will be in adjustment, but this method of applying the squeeze mat offsets slight adjustment irregularities.

The production of the squeeze mat on release prints may be accomplished in several ways, modification of printer apertures and double printing with a negative mat being the most readily applicable to present commercial practice. Projection printing methods also offer possibilities. Each of these has been tried and satisfactory results obtained. The production of the original matrix or mat is also something of a problem, but suitable automatic control devices have been developed which work admirably. Later publication of their details is contemplated.

This type of volume control has been in use for several months wherever the volume requirements have been such as to require it. Comments from the field have been uniformly favorable, especially since the operation of the device has become better understood by operators. Fader cue sheets still accompany each picture, but disregard of the instructions which they contain has had a less deleterious effect than in the past. If any part of a reel is set to give the right volume the rest is automatically correct. If the volume is set for dialog the high spots are found to be colored as they were designed to be. The adoption of the device has enabled the producer to more nearly obtain in the theater the result which he put into the picture, and his average of technical and artistic success has improved. The operator is relieved of the difficult problem of constantly watching the fader cues. The net result has been a very gratifying advance in the production of the much sought after illusion which the audience can enjoy and will appreciate.

DISCUSSION

MR. SHEA: Is the method suggested applicable only to variable density recording?

MR. RICHARDSON: The squeeze track method is only applicable to variable density.

Means are being developed to put the control in the viewing rooms, so that as the director and his musical directors are studying their production they can fade and adjust the sound levels to suit their own ideals.

MR. EVANS: In connection with the work we have been doing in the Standards Committee on wide film, we propose a 250 mil sound track. The principal arguments for this are that by widening the sound track you improve the ratio of signal to sound track ground noise. This squeeze track method, it would seem, goes in the wrong direction.

MR. RICHARDSON: We realize that a scratch on this track will produce worse results than one on the full width. Beautiful productions, however, are often ruined by poor control in the theater. You have the two horn dilemma and the squeeze track seems the best way out.

MR. ROSS: Supplementing the reply to the question raised whether this system is limited to the variable density system, I wish to state that the sound volume level of the variable area system can be varied by variably light fogging the sound track. In fact the variable density sound track may also be variably light fogged to accomplish the same result as squeezing the track.

MR. COFFMAN: Contrary to Mr. Evans' belief, it seems to me that the wide sound track is needed to make this system fully effective. With 250 mils, you can squeeze it to a greater degree than you can in the present size print, and you will have more control than the 12 db. of the present system.

MR. TOWNSEND: Speaking of control with variable area sound track, it may be of interest to point out that there is in operation an automatic system of regulating the sound track on variable area film. Two productions made with this method are about to be released. The process is very simple. It is done automatically at the time of recording. Without modulation, there is no sound track whatever. As the modulation increases to any magnitude, the sound track automatically appears even up to the full width of a wide film sound track, which is 250 mils.

MR. ROSS: I should like to state as a matter of interest that a new company has recently introduced a system of automatic control for motion picture theaters which dispenses with the services of a projectionist. Part of this system includes automatic sound volume level control. A microphone is placed in the auditorium which controls the fader in the horn circuits.

MR. MAURER: As a slight contribution to this general discussion, those of you who will remember one of the figures in my paper (*J. Soc. Mot. Pict. Eng.*, June (1930), p. 640) will recall that if you start with a negative of relatively low density and overprint it, the volume level drops rapidly, but the ratio of signal to ground noise remains the same. Also there is practically no change in quality. Starting with a negative of density about 0.8 and working through the range of exposure in which the resolving power is best, one can get a ten to twelve decibel range of volume control without change of quality simply by varying the printer lights in printing the sound track. This has not been put into practice, but it could be handled readily on the basis of facts already available.

THE MEASUREMENT OF LIGHT VALVE RESONANCE BY THE ABSORPTION METHOD

O. O. CECCARINI*

In investigating the behavior of electro-mechanical systems the method which invariably seems to be readily applicable is that of measuring the effect by a disturbance of known character and magnitude applied to the system. Sometimes it is far more simple and economical, especially when we are concerned only with qualitative measurements, to observe not the final effect but the reaction of the system to the flow of energy supplied by the source.

In sound recording on film the light valve plays a very important role, and to its correct adjustment depends largely the uniformity and quality of results. Below resonance, the light valve is a constant amplitude device, but not at resonance nor beyond resonance. It is therefore necessary that its resonant frequency be well outside the useful range. In addition, the sensitivity of the light valve is very much dependent on the tension with which the ribbons are stretched, as an excessive tension, and therefore a high tuning point, lowers the valve response to an appreciable extent. It is therefore very essential that the frequency of resonance be carefully determined, and kept within certain limits to insure uniformity.

Let us review briefly the various steps in recording sound on film. Sound waves converted into electric waves by the condenser transmitter, are amplified to a sufficient amount and fed to the light valve.

The Western Electric film recorder, as familiar to many, consists of an exciting lamp, condenser, light valve as part of an electromagnet, optical system, film, sprocket, photo-electric cell, and amplifier for monitoring. Other mechanical parts do not concern us here.

If, instead of the electric waves from the amplifying system, we supply the light valve with constant volume from a variable oscillator and connect a volume indicator at the output of the photo-electric

* Metro-Goldwyn-Mayer Studios, Culver City, California. (Read before the Society at Washington.)

cell monitoring amplifier, we will be able then to detect any change in response in the light valve for any frequency within the range of the oscillator. As we enter the resonance range the light valve becomes more and more sensitive, and will vibrate at far greater amplitude than at any other value of the frequency. Our volume indicator will therefore show greater response, and any change in the mode of vibration of the light valve will be faithfully interpreted by the volume indicator.

This is the most obvious method for tuning and checking the tuning point of the light valve, and the method adopted by the Western Electric from the very beginning and prescribed to the various studios using Western Electric apparatus. There is nothing wrong with this method except that it involves tying up a film recording machine, a very costly piece of apparatus. Also it is difficult to arrange the apparatus in one place, and therefore it cannot be readily called a one man job.

Bell System engineers realized the disadvantages of the arrangement and proceeded in designing the light valve tuning unit, which is now supplied as regular equipment and contains in miniature practically all of the above apparatus.

This unit has undoubtedly greatly facilitated the task of keeping the valves in proper shape, but the writer does not agree that it constitutes the most economical arrangement which engineering ingenuity can produce, especially when there are other phenomena directly linked with the operation of the light valve which can be utilized for the purpose, such as, for instance, the reactive voltage, or counter emf., generated by the motion of the light valve ribbons in a magnetic field. This particular phenomenon is of a fundamental nature and well known to any student of engineering and physics.

The counter emf. set up in a conductor is proportional to the rate at which the conductor cuts the magnetic field. The equilibrium position assumed by the system for a given value of the driving current is dependent upon the value of the current, the exciting field, the elasticity, the mass, and the dissipative constants of the electro-mechanical system. It is easy to see how a change in any of the constants would change the equilibrium position. At resonance the elasticity neutralizes the effect of the mass and the valve tends to vibrate at much greater amplitude. This greater amplitude in turn means greater counter emf., which, being entirely opposite to the driving voltage and current, tends to limit the latter and a new equilibrium position is reached by the system at which the driving current is appreciably less than for a non-resonant condition.

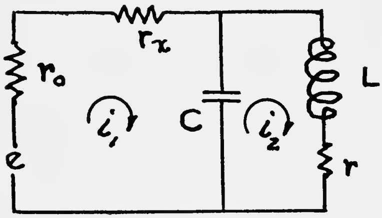


FIG. 1.

For the electrical engineer the system can be represented by the circuit of Fig. 1, in which a source of voltage drives a current through a parallel circuit of constants, r, L, C, supposed to represent the light valve vibrating in a magnetic field. The resistance, r_o, is that of the source, and r_x is that of a measuring instrument.

The voltage equation for the system in symbolic form can be written down at once:

$$e = \dot{i}_1 \left[r_o + r_x + \frac{1}{pC} - \frac{1}{p^2C^2\left(r + pL + \frac{1}{pC}\right)} \right] \quad \ldots (1)$$

and for unity emf. the value of the driving current becomes:

$$\dot{i}_1 = \frac{P^2C^2\left(r + pL + \frac{1}{pC}\right)}{\left(r_o + r_x + \frac{1}{pC}\right)p^2C^2\left(r + pL + \frac{1}{pC}\right) - 1} \quad \ldots (2)$$

At resonance we have the condition:

$$pL + \frac{1}{pC} = o \quad \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

and,

$$\dot{i}_1 = \frac{p^2C^2r}{\left(r_o + r_x + \frac{1}{pC}\right)p^2C^2r - 1} \quad \ldots\ldots\ldots\ldots (4)$$

We could perhaps see a little more readily what happens at resonance if we would assume the valve free from dissipative constants. In other words, $r = o$. It is readily seen, from equation (4), that $\dot{i}_1$ becomes o. We would say then that the counter emf. is equal in magnitude and opposite to the driving voltage across the valve.

This condition is never realized in practice, but the driving current always becomes appreciably less, and the drop can be readily measured. Our measuring instrument would then indicate a dip at resonance instead of the peak shown by the volume indicator with the Western Electric method.

It is interesting to note here that the only equipment necessary to tune a light valve by means of what we can call the absorption method is a variable oscillator, a suitable thermocouple in series with the valve, a microammeter to measure the voltage developed by the couple and an electromagnet with an exciting coil of the

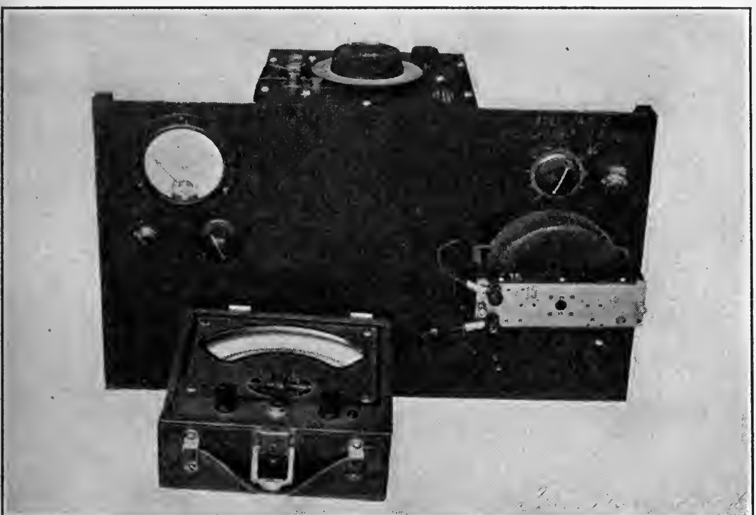


FIG. 2. Laboratory model of resonance measuring instrument.

form used in the film recording machine, but very much simpler since no light passage through it is necessary.

From the foregoing it is quite evident that the absorption method is simpler and quicker in operation than the other method. Another point of great advantage is that it is not necessary for the operator to know the principle and details of the tuning outfit, because the number of operations necessary can be reduced to a single switch to energize the oscillator, another switch to turn on the exciting current for the electromagnet and 180 degrees rotation of the condenser dial to cover the entire frequency range from 4800 to 10,000 cycles.

The included photograph (Fig. 2) shows the first model made up at Metro-Goldwyn-Mayer Studios. This model has been continuously in service for the past eighteen months. The photograph for the model made up for use with movietone trucks for location work is also given (Fig. 3).

The following is a brief description of the variable oscillator:

In order to cover the greatest possible range with the minimum amount of variable capacity, it is necessary to operate the oscillating coil very close to its natural period. Instead of designing a coil

FIG. 3. Portable model for use with trucks in the field.

especially for the purpose, the writer chooses to make use of the Western Electric 91-A retardation coil. This coil has two windings, each of which has a natural period slightly above 5000 cycles. In order to bring the upper frequency range above 10,000 cycles two 91-A coils are connected as shown in Fig. 4.

The resistance, R_o, of the order of 20,000 ohms is inserted in series with the grid coil to prevent the system oscillating on the grid side. Fig. 5 gives the complete schematic arrangement of the oscillator amplifier and valve measuring circuit.

It will be noticed in the above arrangement that no "C" battery is used for the oscillator grid, nor for the amplifier grid. The reason for this is that the distortion caused by the oscillator tube is com-

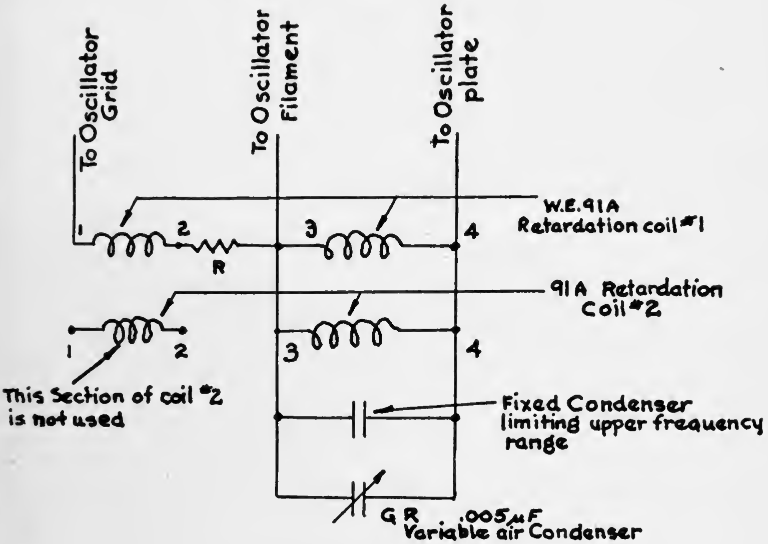


FIG. 4. Arrangement of oscillating circuit.

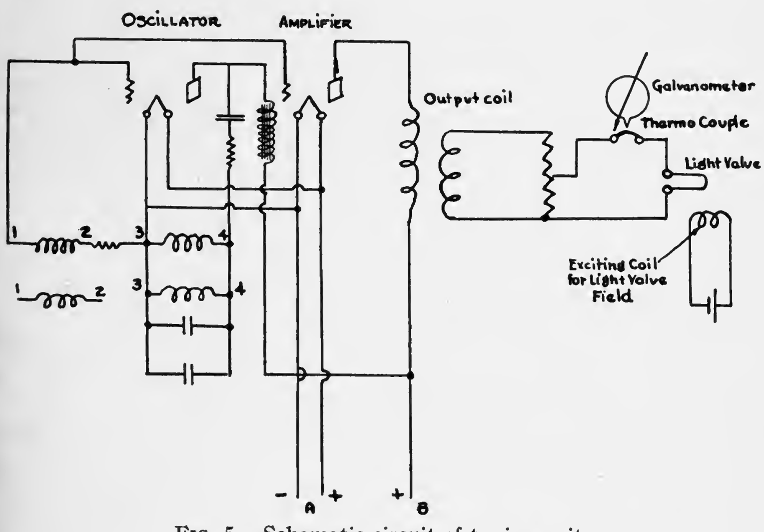


FIG. 5. Schematic circuit of tuning unit.

pensated by that of the amplifier, and the resulting wave at the output of the amplifier is exceedingly pure. This balancing effect is true only with vacuum tubes of a certain type and characteristic, and not general. Caution must therefore be exercised.

The thermocouple which has been found most convenient for the purpose is the Western Electric type 22-E, having a heater resistance of approximately 40 ohms, and for a galvanometer the Weston model 322 (200 microamperes, 10 ohms) is eminently satis-

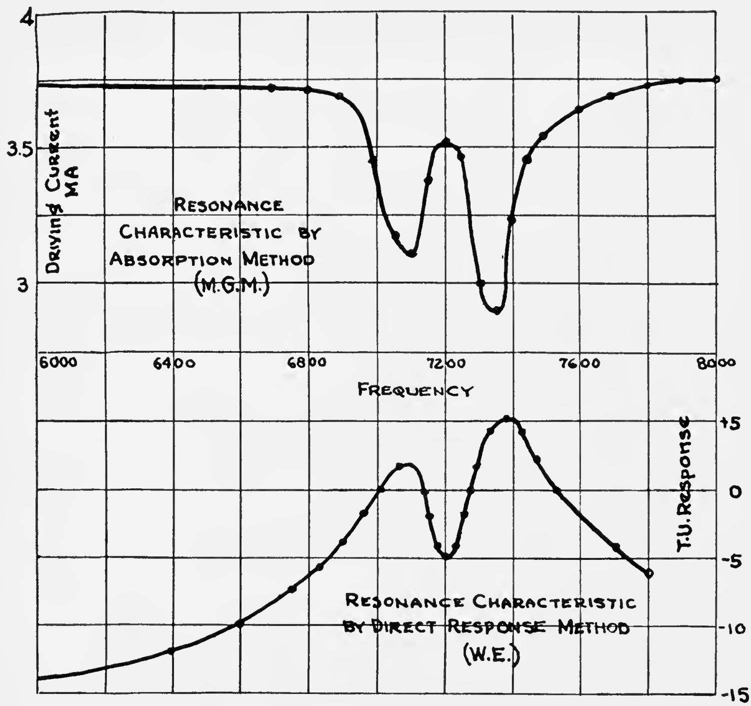


FIG. 6. Comparison of resonance determination by two methods.

factory, although a more economical type, such as the General Radio pointer type galvanometer (10 ohms, 150 or 160 microamperes) is quite satisfactory.

It must be pointed out here that calibration of the thermocouple and galvanometer is not necessary unless quantitative data are required, which is seldom the case. For illustrative purposes, Fig. 6 gives the resonance response characteristic of a typical light valve, both by the absorption method and by the direct response method. It will be noticed that the two characteristics are strictly related to each other.

In concluding, the writer believes to have satisfactorily proved the advantages of the absorption method for tuning light valves, especially with regard to simplicity and economy of apparatus involved.

A little consideration will readily bring in evidence of the fact that this method measures strictly the "admittance function" of the electro-mechanical system, and therefore it can be also applied to the investigation of the performance of loud speakers, condenser transmitters, and other electro-dynamical apparatus involving the motion of conductors in electromagnetic or electrostatic fields.

PROGRESS IN THE MOTION PICTURE INDUSTRY*

The most significant events of progress for the fall and winter of 1929–30 have been the increased production of feature pictures combining sound and color, and the marked improvement in sound quality and in picture artistry. The technical quality of color pictures, however, still leaves much to be desired and further improvements must be made before the full benefit of color will be realized.

Production of pictures on film wider than 35 mm. has not gone ahead as rapidly as predicted chiefly because of the lack of an agreement on a definite standard for such film. Pending an agreement, the majority of the producers are marking time, thus indicating their willingness to collaborate in adopting a standard. Widths of 70 mm. and 65 mm. are most favored. A subcommittee of the Standards Committee of this Society, consisting of the chief engineers of all the leading producing organizations, is working on this important problem.

Sound recording studios are working on smoother production schedules as the problem of recording has become more a matter of routine. Production programs for feature sound pictures are in progress in England, France, and Germany. The trend in new construction is toward larger sound stages which can be divided up or opened out as required. Most of the tricks of the silent picture, fades, dissolves, double exposure, *etc.*, have been worked out by cameramen while under the pressure of actual production. Valuable surveys are being made more deliberately relative to causes of camera noise, silencing of arcs, release print specification, screen illumination, and set acoustics.

A census made in Hollywood during January, 1930, indicated that about 40 per cent of the leading studios were using arcs for 50 per cent or more of their productions. One of the leading color picture processes was stated to favor arc illumination. Incandescent lamps, however, have continued to find general favor and improvements in their design and installation have been noted.

* May, 1930—Report of the Progress Committee. (Read before the Society at Washington.)

The problem of acoustics of studios and auditoriums is being investigated very thoroughly. Results of a survey of more than 1500 theaters have been reported. Engineering measurements indicate that the increased acoustic power available with electrical amplifying currents introduces new factors for which quantitative data are not yet available.

Improvements have been noted in cameras, printers, processing machines, and projectors. Attention is being given to the important problem of film storage as processing laboratories appreciate the seriousness of the danger involved. The increased hazards resulting from the use of high intensity arcs for sound film projection have been reduced materially by the introduction of rear shutter projector assemblies.

Motion pictures in sound are beginning to be used in conjunction with education, business, medicine, and for legal records. The availability of portable recording and reproducing equipment and a general lowering of costs of other sound equipment no doubt have encouraged this development.

No significant improvements have been noted in stereoscopic cinematography but methods of television continue to develop. One type of television receiver utilizes a fluorescing screen within a cathode ray tube which permits a reduction in the number of images per second without noticeable flicker. Technical difficulties of television may take years for their solution, however, especially with wireless transmission and reception for pictures.

Acknowledgment.—It was considered desirable, because of the growth of our Society abroad, to invite several members and others doing motion picture work in foreign countries to assist in the work of the Progress Committee. The assistance rendered by these foreign members and friends has been very valuable. Two of them made such interesting and comprehensive reports that their papers have been recommended for publication in our JOURNAL. They represent reviews of cinematographic progress in France and Austria, respectively. Excellent reports have also been received from England, Germany, Switzerland, and Australia.

Acknowledgment is also made to Dr. J. B. DeLee and the Fox Film Corporation for the loan of a sound film of an obstetrical operation, and to Frank Woods, N. D. Golden, and L. Trotti, for the use of copies of publications of their respective organizations. A number of interesting films, particularly newsreels of outstanding events

of the past six months, have been lent for showing by the Fox Film Corporation, Universal Pictures Corporation, and the Paramount-Famous-Lasky Corporation. H. Rosenberger has contributed a film which includes two examples of his remarkable photomicrographic work on living cell tissues. Sound picture records of several of the world's leading scientists have been made available through the courtesy of the General Electric Company.

Helpful data have also been received from the following: L. P. Clerc, H. Griffin, W. H. Peck, G. K. Rudolph, and V. Zworykin.

Respectfully submitted,

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SUBJECT CLASSIFICATION

I. PRODUCTION

A. Films and Emulsions

1. New Materials
2. Manufacture
3. Miscellaneous

B. Studio and Location

1. General
2. Studio Construction
3. Lenses and Shutters
4. Cameras and Accessories
5. Exposure and Exposure Meters
6. Studio Illumination
7. Make-Up, Actors, and Direction Technic
8. Trick Work and Special Process Photography
9. Methods of Recording Sound

C. Laboratory Practice

1. Equipment
2. Photographic Chemicals and Solutions
3. Printing Machines and Methods
4. Editing and Splicing
5. Titles
6. After Treatment, Cleaning, Reclaiming, and Storage

II. DISTRIBUTION

III. EXHIBITION

A. General Projection Equipment

1. Projectors and Projection
2. Sound Picture Reproduction
3. Projector Lenses, Shutters, and Light Sources
4. Fire Protection

B. Special Projection Methods

1. Portable Projectors
2. Stereoscopic Projection
3. Continuous or Non-intermittent Projection

C. Theater Design and Installation

1. Screens
2. Theater Illumination
3. Theater Acoustics and Construction

IV. APPLICATIONS OF MOTION PICTURES

A. Education, Business, and Legal Records

B. Medical Films, Radiography, and Photomicrography

C. Telephotography and Television

D. General Recording, Miscellaneous Uses

V. COLOR PHOTOGRAPHY

A. General

B. Additive Processes

C. Subtractive Processes

VI. AMATEUR CINEMATOGRAPHY

A. General Equipment and Uses

1. Cameras
2. Projectors
3. Accessories
4. Scenarios
5. Films and Film Processes

B. Color Processes

VII. STATISTICS, PUBLICATIONS, AND NEW BOOKS

I. PRODUCTION

A. Films and Emulsions

Increased interest has been noted in the past six months in the subject of wide films. Of the widths proposed, 70 mm. and 65 mm. appear to have received the most consideration. The producing organizations fully appreciate the importance of the engineering problems involved in the introduction of wide film and are postponing definite action pending a decision of the subcommittee of the Standards Committee of this Society, the personnel of which includes engineers from all the producers. A limited amount of production, however, has been undertaken on film 70 mm. wide. A feature, *Happy Days*, and a newsreel were shown as a regular program, opening March 14th, at the Roxy Theater on a screen $41^1/_2$ feet by 22 feet.[1] Several other theaters are also equipped to handle this type of film and at least four feature pictures are said to be in progress.

The optical problems arising in the development of wide film have been considered by Rayton.[2] Howell and Dubray[3] discussed practical and artistic elements bearing on the selection of wide film standards. They proposed a three to five ratio of height to width, placement of the sound record to occur outside the sprocket holes, and rounded corners for the perforations. Jones[4] made an exhaustive analysis of the sizes of the paintings of one of the old masters, Rubens, and tabulated the rectangular proportions for different forms of composition. A rectangle having a width to height ratio of 1.618 is considered by many artists to be one of the best shapes for a pictorial composition. Gregory[5] has written on the early history of wide films.

Sound motion pictures in color have come into still greater use and are regarded by several authorities as the most outstanding development of the year. Five processes have been exploited and the entry of a sixth process, both on standard 35 mm. film and wide film, has been announced.[6] Definite advances in optical systems, processing methods, and the experience that follows production problems on a large scale have all contributed to a substantial improvement in the quality of color pictures.

The bulk of the raw film being used is coated on nitrate stock although the hazard resulting from improper and careless storage of this stock has been demonstrated forcibly by the results of a number of serious film fires during the year which destroyed many valuable negatives. A large English firm manufacturing a non-inflammable support is reported to have found difficulties in applying emulsions to the base and has decided to sell the uncoated product on the open market.[7] A raw film factory with a daily production capacity of sixty thousand meters is reported to be in operation in Tiflis, Russia.[8]

About the usual large number of patents have been issued relating to cellulose acetate compositions, indicating continued attention of the manufacturers to this important development. In view of the limited interest in the details of these, reference to the patent numbers has been omitted from this report. The references can easily be found by consulting the issues of the *Monthly Abstract Bulletin*, published by the Kodak Research Laboratories. A few patents have appeared dealing with methods and machinery used for roll coating of film support.[9] Protection has been granted the idea of incorporating a light sensitive material in a cellulose xanthate or viscose film base.[10]

Patents of interest dealing with emulsion manufacture describe a device for double coating a film support, the incorporation of a hygroscopic substance in an emulsion to accelerate subsequent development with gases or vapors, a process for coating an emulsion to equal thickness on uneven bases, and the addition of protein substances to emulsions to enhance sensitivity.[11]

Of particular interest is a German patent which disclosed a process of light sensitive emulsion manufactured without the use of silver salts.[12] Certain compounds capable of undergoing stereo-isomeric changes under light action are mixed with gelatin, collodion, or cellophane, and coated as a photographic layer. If one of the stereo-isomers is colored and the other is colorless, an image is produced immediately on exposure.

The addition of a sound record on motion picture film in conjunction with the picture has increased the necessity for a more thorough understanding of the characteristics of film. Toward this end, Schmidt[13] has contributed a paper discussing the photographic relations of density, transparency, and contrast of negative and positive films having variable density sound records. At the Toronto meeting, Jones and Sandvik[14] dealt with the photographic characteristics of sound recording film giving the results of practical tests on several different emulsions. Sensitometric characteristics, resolving power, contraction, and growth of images were discussed. Conklin[15] has described the use of a set of transparencies which may be superimposed on a sensitometric (H. & D.) curve for rapid determination of the characteristics of the emulsion under investigation.

Patents relating to sound film emulsions dealt, among others, with the following methods: The preparation of a tinted film having a narrow uncolored strip along one side on which the sound record may be printed; several patents by Gaumont cover their method of making sound records reproducible only by ultra-violet radiation.[16]

The importance of pitch measurement in film perforation has been treated by Carson[17] in the JOURNAL of this Society. Several patents[18] have been taken out on methods of reënforcing the edges of film strips, on anti-static layers in film, and on edge printing.

B. Studio and Location

The major portion of the motion picture studios in the United States had been equipped for sound recording by the end of 1929 and new studios built by the leading producers. The trend is toward large sound-proof structures that may be opened into one another for large exteriors, long shots, and reviews. Two huge sound stages have been completed in Hollywood recently by two producers. One of these stages is 150 feet wide by 500 feet long and five stories high; it is divided into four parts and when opened will house a set occupying 75,000 square feet. Overhead monorail systems facilitate the movement of sets.[19] The other stage has been conceived on equally gigantic proportions and comprises a theater auditorium capable of seating 1500 persons and a section which is also designed as a theater stage; in size, 75 feet deep, 80 feet wide, and 120 feet high. This stage has been designed particularly for the production of lavish spectacles. It is equipped with a steel curtain weighing 65 tons, and each of its 12 floor sections is fitted with a hydraulic lift. A vertical steel track, 65 feet high, permits camera shots in synchronism with the rising stage and curtain.[20]

In order to standardize the quality of motion pictures and to eliminate matter from scenarios which would prove objectionable to the public, the Association of Motion Picture Producers and the Hays organization drew up and approved a production code.[21] In the immediate practical field, Pfitzner has considered the economics of studio management.[22] The requirements for the ideal sound studios have been discussed by Schultz.[23] The increased use made of incandescent lights has necessitated the installation of refrigeration plants in studios in connection with ventilation systems.[24] Ground vibration noises are claimed to be minimized by the use of "floating floors" resting on a base of sound absorbing material and not connected to the outside walls.[25]

A description has been published of a new sound studio located at Wembly, England.[26] Its largest stage is 120 feet by 90 feet in size. Floors are laid on felt runners with a layer of plastic bitumen under the boards. A novel feature of this studio is a tank fitted with a camera booth permitting underwater photography. The four new German studios at Neubabelsberg have been built in the form of a cross, all recording and monitoring being done at the center.[27] A number of French studios are now producing sound pictures according to reports from France, notably those located at Joinville, Epinay, and Paris. One French studio operating at Courbevoce was destroyed by fire early in February.

New studios have been reported under construction near Moscow by Danashew who stated that the largest containing 5 stages would have 175,000 cubic meters of space.[28]

Lenses and Shutters.—The characteristics of a new *f*/2.7 80 mm. lens for soft focus effects were tested by Emmermann and Seeber[29] both for arc and incandescent lighting. Noulet[30] has described two methods for introducing aberration in lenses. The introduction of color motion pictures has made greater demands on the performance of lenses, particularly in the photographing of long shots. A novel lens device for securing wider pictures without the use of wide film is of interest.[31] It consists of two lenses held in a mount which screws onto the front of the camera. A lateral compression of the image is produced so that nearly three times as much image is included in the normal frame. The picture is then expanded to three times normal width on projection.

Patents dealing with lenses and shutters[32] have been noted relating to a method of producing relief effects by alternate exposures through a system of lenses and mirrors, a device for prevention of the picture getting off center, and an apparatus for simultaneously taking details of foreground and background. In the last named patent this is accomplished by oscillating mirrors placed behind a dual objective system in the camera.

Cameras and Accessories.—Stull[33] described changes made in the

Mitchell camera to adapt it for use with 70 mm. film. The shutter size is doubled, and the gears are cut differently to adapt them to the pitch of the perforations which is stated to be 0.231 inch for 70 mm. film.

The French camera, "Eclair," was described by Eveleigh.[34] Its features are: lightness, a six lens turret, a direct vision tube sight, and an automatic fade. A new model of the Askania camera appeared which is equipped for single, normal, and ultra-rapid exposures.[35] The Castagna camera, manufactured in Vienna, is housed completely in an all metal case (Fig. 1). It is fitted with a four

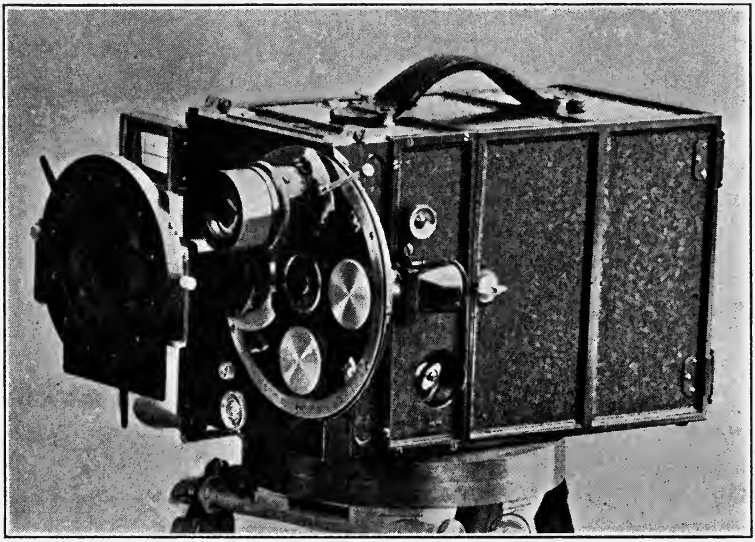

FIG. 1. Castagna motion picture camera (Vienna, Austria). Reproduced by courtesy of Dr. P. Schrott, Vienna, Austria.

lens turret, and the front may be swung open providing easy access to the gate. The shutter design is novel in that a fade may be adjusted to a definite number of crank turns from a minimum sector opening of 5 degrees to a maximum of 180 degrees.

Fear[36] designed a silent high speed movement for Bell and Howell, and Mitchell cameras. Pilot pins, accurately fitted, lock the film while the shutter is open and an eccentric has been substituted for a cam for moving the film. More recently, the same inventor introduced a completely new silent camera which is stated to be adaptable quickly to color motion pictures, sound-on-film photography, and wide picture photography either on wide film or by the Fear process which rotates the images through an angle of 90 degrees, placing the frames longitudinally on 35 mm. film.[37]

According to a well-known motion picture director, the use of synchronous electrical camera drives, necessitated by simultaneous longshot and close-up exposures in sound motion picture work, has freed first cameramen from actual cranking and given them more time to consider pictorial composition.[38] Cowan[39] reported on a survey of camera and projection apertures in relation to sound-on-film pictures. A joint committee of the Society of Motion Picture Engineers, the Academy of Motion Picture Arts and Sciences, the American Society of Cinematographers, and the American Projection Society prepared a resolution on recommended practice for cameramen and projectionists. This resolution was recommended as standard practice by the Standards Committee of the Society of Motion Picture Engineers at the Toronto meeting in October, 1929. Essentially the resolution suggested that a rectangle 0.620 inch by 0.835 inch be marked on the ground glass of cameras and that an aperture size of 0.600 inch by 0.800 inch be adopted for sound-on-film projection.

Accounts have been published of cameramen's experiences in frigid countries, notably of the troubles encountered by Rear Admiral Byrd's Antarctic expedition.[40] Spring-driven cameras failed at −20°F. Lieberenz[41] was able to keep such cameras in operation even at −40°F. by cleaning the mechanism with gasoline and lubricating with a mixture of kerosene and bone oil.

A viewing device known as the "Orthoviseur" was announced for use on Debrie cameras.[42] It is used for determining the field angle and focus of the particular objective to be used on the camera, namely, 35 mm., 50 mm., 75 mm., and 100 mm. An erect image is produced about 9 cm. by 12 cm. in size and not reversed left and right. A focussing lens giving an enlarged view on the focussing screen has also been made available for the Debrie camera. Smack[43] described the construction and properties of flexible drive shafts for motor-driven cameras. Chutes fitted between the sprocket and magazine assist in minimizing film buckling troubles, according to Henri-Robert.[44] Jonson[45] described a buckle-proof magazine designed for Mitchell cameras.

The added weight of sound-proof housings has resulted in the design of stronger tripods. One of these called a "camera dolly" is constructed of telescoping steel parts attached to a triangular rubber tired traveling support.[46] Types of equipment and methods used for still photography in German studios were described by Lichtenstein.[47] The use of an amateur motion camera was considered valuable by a Hollywood cameraman as an inexpensive means for making trial shots on sets.[48]

Many improvements have been noted in camera design as shown by the large number of patents[49] issued which, besides the usual modifications in claw pull-downs, shutters, magazines, *etc.*, deal with the use of derivatives of cellulose, such as acetyl cellulose for the manufacture of film spools; the obtaining of relief effects by movement of a camera round an eliptical or oval path during exposure; and electrical tension regulation for delivery or take-up reels.

Time-Lapse and Ultra-Speed Cameras.—An ultra-rapid camera known as the "Trommelapparat" employs a high frequency 30,000 volt arc for illumination intermittently flashed on the subject by means of a rotating sector. The film is wound on the inside of a cylinder which accommodates 100 turns of 40 frames each. Four thousand normal frames may be exposed per second, or 8000 and 16,000 half or quarter normal frames, respectively, per second.[50]

Only two patents appeared dealing with improvements in motion study cameras.[51]

Exposure and Exposure Meters.—A cameraman[52] recounted some of his experiences in making satisfactory exposures in the tropics. Yellow filters and panchromatic film were employed, exposures being made between 7:00 and 11:00 A.M. each day. Emmermann[53] described the properties of silk screens used before the camera lens for the production of diffused negatives. A light intensity meter used for the determination of the light values on motion picture sets, as well as light measurements in connection with printers and screen illumination, was described by McCoy.[54] The meter consists of a shielded photo-electric cell with a range of sensitivity of 100 to 3000 foot candles, having a broad response covering the visible spectrum. A patent was issued relating to the design of an actinometer of the rotating wedge type.[55]

Studio Illumination.—A survey of incandescent lighting in the United States, Germany, and England was published by Eveleigh.[56] Two sizes of spotlights available in Germany permit variation of the spot diameter and utilize a front ground glass plate for obtaining uniform diffuse illumination.[57] Descriptions were published also of searchlights, floodlights, "spots," overhead banks, and broadsides manufactured by a German firm particularly for use in the production of sound films.[58]

In order to decrease the heat given off by high intensity illuminants, such as used for lighting sets for sound and color motion pictures, Gordon[59] has proposed an experimental design of a water cell surrounding the lamp. Such a cell dissipates 75 per cent of the total watts input and results in only about 7 per cent light loss. Although it seemed that the practical limit of incandescent lamps had been reached several years ago when a 30 kilowatt lamp was announced, lighting engineers showed this was not the case, for a 50 kilowatt lamp was made available during the fall of 1929.[60] According to recent reports from Hollywood studios thirty-six inch reflectors have been found to give maximum effectiveness with 10 kilowatt incandescent lamps. The small light units, 1, $1^1/_2$, and 5 kilowatts, found most extensive employment in studios early in 1930. Portable dimmers, used individually or in connected units of two or three, found useful application for sunrise or sunset effects. Each unit handles 20 kilowatts. (Fig. 2.)

A joint committee of the Producers and Technicians branches of the Academy of Motion Picture Arts and Sciences reported on an investigation of arc lighting in fifteen Hollywood studios.[61] In 60 per cent of the studios, arcs were being used for less than 10 per cent of the lighting; in 35 per cent, arcs were used for 25 to 50 per cent; and in only one studio were they employed almost exclusively. Sun arcs and spots were finding more extensive application. Three types of filters were in use: (*a*) individual choke coils for each lamp unit, (*b*) choke coils for each group of lamps, and (*c*) the use of a large electrolytic capacity across the generator windings. The investigation is being continued with plans for making oscillograph records of the commutator ripple at each studio. Buck and Albert[62] presented a paper on the subject of elimination of commutator ripple at the last meeting of the Society.

Descriptions have appeared in several foreign journals of new styles of illuminants, particularly several designs of the Osram Nitrophot which is said to be especially adaptable for use with panchromatic film.[63] Controversies have raged abroad, as in this country, on the relative merits of arc and incandescent lighting. It seems to be generally agreed that arcs possess many more merits to recommend their employment than when panchromatic film first came into extensive use in 1928.[64]

According to Clerc,[65] reflectors dyed with rhodamine and emitting fluorescent red light proved inadequate and too unstable as a practical means for supplying the red rays deficient in mercury vapor lamps. Combinations of tungsten and mercury vapor lamps in the ratio of 1125 watts or 750 watts of tungsten to 400 watts of mercury both give satisfactory rendering on panchromatic film without a filter.

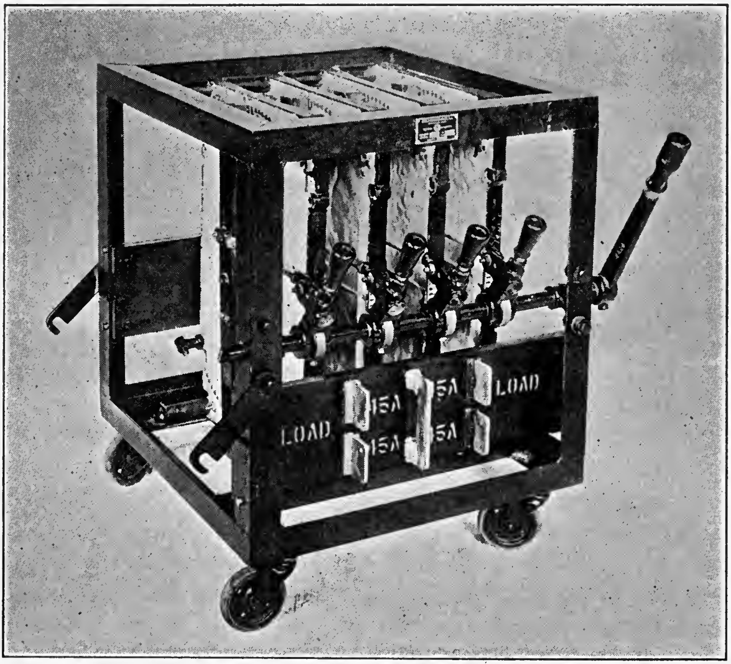

FIG. 2. Portable dimmer used to create "sunset" or "sunrise" effects. Reproduced by courtesy of P. Mole, Hollywood, Calif.

Abadie[66] reported before the cinematographic section of the French Photographic Society on some interesting experiments with gaseous illuminants. Mercury and neon could not be used effectively in the same tube to give a white light, but when their combined light was supplemented with that from vaporized antimony and arsenic, a good white light was produced for the photography of colored objects. A lamp had been produced which contained neon gas and a cadmium-bismuth alloy at the cathode. Upon heating, the cadmium was vaporized and its arc gave a light of desirable spectral distribution. Two new glow lamps were announced for variable density sound recording.

Benford[67] presented useful data at the Toronto meeting on the radiation characteristics of two mercury arcs. A carbon arc lamp with a chromium plated copper reflector was claimed to give an increased illumination efficiency over other lamps of similar wattage.[68]

Make-Up, Actors, and Direction Technic.—A make-up test program by the American Society of Cinematographers was expanded to include color pictures and wide film. A new series of powders and greases was developed which photograph exactly as they appear to the eye.[69] A leading comedy actor reviewed some of his experiences in making his first talking picture which was first produced as a silent picture. Greater ingenuity was required in introducing the sound but at least 50 per cent more laughs were stated to have been added.[70] By studying each spoken word of the English version of the picture *Lummox*, a director so directed a German speaking cast that their voices were adapted to the lip action of the production. Voices were made to appear to come off the screen when expressions could not be made to fit a lip movement.[71]

Trick Work and Special Process Photography.—According to Stull[72] most of the well-known trick effects of the silent picture, such as the fade-out, fade-in, lap dissolve, and double exposure, have been worked out for sound-on-disk and sound-on-film methods. The details of these problems were solved by the cameramen during actual pressure of production. Hutchins[73] dealt mathematically with the problem of dimensional analysis as an aid to miniature cinematography and showed how, by the application of simple physical laws, illusions may be produced which appear real even to the trained mind.

Coissac[74] described equipment for making animated drawings and an elaborately designed machine printer for making enlargements, reduction prints, fades, double exposures, *etc.* The printer is built on a rigid steel support which insures freedom from vibration. Lightning effects may be produced, according to Seeber[75] by photographing a white wall upon which zig-zag line figures are intermittently projected by flashing arc lamps behind special tin masks.

Patent protection[76] was granted several applicants who disclosed, among others: methods for making anaglyphs, a process for obtaining composite pictures, a method for the synchronizing of sound with animated cartoons, and the production of grotesque motion pictures by photographing a checkered screen.

Sound Recording.—Historical summaries[77] of the development of the sound film industry have been published by Gaumont and by Rider. It is of interest that the first patent for an electrical "pickup" was issued to Gaumont. Messter[78] has also reported on his trials with synchronization of sound and picture started 30 years ago.

Production programs for sound pictures continued to expand during the fall of 1929 and early part of 1930. European studios which were slower than the American studios in adopting sound, announced their plans for feature pictures in sound late in 1929. One German producer planned an American "invasion" by announcing the making of English versions of twenty feature pictures.[79] Bohm and Noack have each made analyses of the situation in Germany during 1929, the latter reviewing the patent difficulties.[80]

Several French studios have commenced sound productions on a large scale, a number of them by the RCA variable area process. Société Gaumont which, until quite recently, recorded on the full width of a separate film by the Danish Peterson-Poulson method, has adopted fixed density recording in the margin of a separate film. This record is printed subsequently on the border of the film bearing the positive image.

In its latest large installation at Epinay, the firm Tobis is reported to have given up the system of employing a camera booth for sound taking and, like many American studios, has adopted sound-proof housings for their cameras. A fixed central station in communication with the different sound stages receives by wire the current from the microphone. In the Cinevox process, recording is accomplished with a glow lamp, according to a variation of the DeForest method.

Soviet engineers have worked out their own systems of sound recording and reproducing for use in the Russian studios and theaters. One studio in Leningrad and one in Moscow are reported to be making short subjects.[81]

Great interest was shown in the sound school sponsored by the Academy of Motion Picture Arts and Sciences and, with the completion of the fifth and sixth sections, more than 900 studio workers had taken the course.[82] The lectures presented by various authorities before this school were assembled and published as a Technical

Digest. Plans were announced for an actor's school under the supervision of the same organization with the aim of giving actors the essential facts to assist them in working naturally before the microphone.[83]

During the winter of 1929–30, a few grand opera stars were prevailed upon to "star" in sound pictures. In March the first screen opera, *Pagliacci*, was produced, sung entirely in Italian.[84] A talking newsreel* was introduced during December, 1929, which had novelty in that it was made without sound in the field but had the sound added later in the form of a reporter's running comments on the scenes depicted.[85] The problems and troubles of the news cameraman had been increased with the advent of sound, for dexterity, skill, and ingenuity were all necessary in securing good placement of the microphone.[86] Recent improvements in the design of compact equipment have decreased some of these burdens. One outfit for complete recording, exclusive of the camera, could be packed completely in two cases, weighing 70 pounds.[87]

A general review of the problems of sound recording has been published by Eisenberg.[88] Too ready acceptance by studios of certain practices of sound recording is unwise, according to Coffman,[89] as the industry is still in a plastic state and mistakes might easily be converted to production traditions. One of his warnings about too much mixing has already been justified as it is reported that some of the studios have eliminated this position. Maxfield[90] has analyzed the problem of acoustic control for talking motion pictures.

Mechanisms for synchronizing sound film cameras have been described by Friess,[91] one promising type employing a magnetic interlocking device to overcome certain disadvantages of synchronous motors.

The Debrie camera has been fitted with a sound-proof housing consisting of a box, containing the motor drive encased under the camera, and a cover on a vertical track which may be lowered or raised quickly by the movement of a hand lever. All controls are accessible from outside the case when it is closed. The merits of 16 different types of camera silencing housings used in Hollywood have been tested by a joint committee representing the producers and technicians.[92] Most housings were found to absorb more high

* A sound motion picture illustrating the talking newsreel was shown during presentation of this report through the courtesy of Universal Pictures Corporation, N. Y.

than low frequencies. Motors should be mounted inside the housing but improvements are needed in methods of coupling the motor to the camera.

Descriptions of types of German portable sound recording trucks have been published.[93] Portable mixing booths mounted on pneumatic tires are reported to be in use.[94]

Data have been given on the frequency ranges of phonograph records showing that reproduction is satisfactory for frequencies from 50 to 10,000 per second.[95] Knowles[96] believes that film recording offers more advantages than disk recording. A synthetic resin coated on a heavy paper base offers a light, economical, and unbreakable material for the manufacture of disk records.[97]

Borchardt[98] has dealt with the properties of microphones and Eveleigh[99] has given an historical review of the development of microphones. Extreme accuracy is needed in the manufacture of microphones according to an article describing their construction.[100] Booms for holding the microphone over the actors have undergone material development and several ingenious devices are available for handling microphones on the set.[101] The booms are operated easily by means of telescoping arms which permit operation over comparatively large areas.

Recording and reproducing lights for variable width sound record films have been improved and standardized. A 4 ampere, 5 volt, single axial filament in a pear shaped bulb is used for recording as well as a 6 ampere, 5 volt double axial filament type. For reproduction, a $7^1/_2$ ampere, 10 volt single transverse filament is used with a cylindrical bulb. The Aeo light for variable density recording has been improved for effective illumination and life. An optical system has replaced the slit. For Grandeur pictures on 70 mm. film a new optical system was designed.

Palmer[102] has published details of a device for printing the footage numbers on the sound record while it is being exposed in the camera. These numbers correspond with those on the picture negative and facilitate matching the two negatives for printing.

Gaumont[103] has suggested leaving room between the picture and the perforations on both sides of a film for two sound records as might be required if right and left side microphones and reproducers were employed for simulating binaural hearing. The two sound tracks might also be used for non-synchronized speech in various languages.

A modification of the Poulson magnetized wire recording method uses film base impregnated with colloidal particles of an alloy of nickel, cobalt, and iron as the magnetically susceptible recording material. The film possesses a slight lavender tint when so treated.[104] The process can be used for amateur standard reversal film or the record can be impressed by induction during making of the positive.

Another novel recording process is that suggested by Madelar by which a groove is recorded on the film support by means of a diamond stylus.[105]

Improvements in methods of sound recording have resulted in a large number of patents,[106] especially in Great Britain, of which the following may be described briefly: a sound record having varying dielectric characteristics which vary the condenser assembly capacity; in recording by means of the Kerr cell, a means for controlling the light reaching the sensitized surface is provided so that it will be restricted to wave-lengths substantially equally affected by the cell; the use of a tapered quartz glass, connected to the light source of the last element of an optical system, to make "direct impingement" of the sound influenced beam of light on the sensitized support; the enclosure of a camera for sound recording within a chamber which is a vacuum or which contains a rarefied atmosphere.

C. *Laboratory Practice*

Production demands necessitated expansion of several Hollywood laboratories.[107] Germany has about twenty-five film processing laboratories with a combined capacity of approximately two million meters of positive film monthly.[108] There are approximately 150 laboratories for film development in the United States, but the bulk of the film is being processed in about 5 per cent of these laboratories. According to Hubbard[109] there are six different types of negatives which the processing laboratory is required to handle, as necessitated by disk, and sound-on-film methods. A summary is given of modern versus older methods of processing.

Machine development has been adopted universally in this country, chiefly as a result of the introduction of sound pictures. A Los Angeles firm has designed new small tanks and a relatively inexpensive machine. The tanks are arranged horizontally one above the other and are about 50 feet long with a drying compartment placed above the tanks. Several rolls of film may be processed simultaneously.

Inspection projectors in processing laboratories have not as yet been fitted with sound testing equipment but the need for such installations is becoming apparent.

Equipment.—Rack and reel methods are still in use in the processing plants in Australia, of which there are about twenty. A more modern laboratory under technical control is being constructed to be ready about June 1st.

Conklin described a densitometer constructed from a Martens photometer.[110] A compact developing tank for motion picture film consists of special reels around which the film is wound and a vertical "ring cylinder" composed of two concentric vertical cylinders.[111] Wolter described a small metal cylinder for use in developing test exposure strips on location.[112] Patent protection[113] was granted on devices for automatic inspection of motion picture film during processing, means for handling wet film on sprockets, drying equipment, development of picture area and sound track (on the same film) separately, and improvements in apparatus for the development of film by ammonia gas.

Photographic Chemicals and Solutions.—Much attention has been given the composition and properties of the photographic solutions used for film development in recent years, particularly since the general adoption of sound and color pictures. Developer characteristics are continually changing and a test suggested by Dundon, Brown, and Capstaff[114] is of interest, therefore, for it offers a rapid means for determining the degree of exhaustion of a developer. A two-solution developing procedure, whereby overexposed negatives are immersed in a 5 per cent carbonate solution following development, has been suggested by Forstmann and Lux[115] as a means of avoiding blocked highlights. Hamer[116] concluded that the use of a desensitizer in the form of a preliminary bath is preferable to adding it to the developer.

Fine grain developer formulas for negative development as recommended by three manufacturers have been discussed by Heering.[117] A symposium on fixation was conducted by the Royal Photographic Society during 1929, papers being presented by Renwick and by Baines.[118] The use of a solution of mercuric chloride and potassium bromide was shown by Crabtree and Ross[119] to be capable of detecting 0.05 milligram of sodium thiosulfate (crystal) in motion picture film.

Printing Machines and Methods.—Printing machinery is being redesigned rapidly for better quality and more rapid production of sound-on-film prints. One manufacturer of printing equipment has brought out a single operation printer, and another manufacturer is reported to be working on a new model. A new combination printing device has been described by Goff[120] which permits both optical and continuous printing as well as trick work. It is adaptable either to 16 mm. or to 35 mm. film, has a curved gate, a variable aperture plate, and the pressure plate is recessed and blackened. The Debrie "Matipo" printer was remodeled to adapt it for printing sound and picture records simultaneously.[121] A new continuous printer designed by Lawley is available on the British market. A novel feature is that only one tooth of the driving sprocket is in contact with the film while it passes the exposure aperture. The light intensity is magnetically controlled and the printing speed is 90 feet per minute.[122] Wolter[123] has described a German reduction printer in which a violet filter is employed between the light source and the 35 mm. film. A sensitometric device known as a "gammeter" permits the correct printing exposure for a given negative to be found by visual inspection.[124]

One of several problems connected with the reproduction of sound has been the proper control of sound level in the theater. Much use and some abuse of fader control have resulted from efforts to correct for volume variations resulting from recording sound at different levels and which were not entirely smoothed out by re-recording. One studio has devised a "squeeze track" for the purpose of adjusting differences in sound level. This consists in blocking out part of the sound track by exposing it before development to a negative consisting of a black line of varying width from zero to the full track width. The positive sound track thus becomes a record of varying width contained between two black lines filling up the remaining space of the track on each side of the track itself which is in the center of the space.

Patents related to printing processes[125] disclosed, among others, the following methods: (*a*) a means of printing two rows of pictures on the same face of a film by printing, first, from every alternate frame of a negative and, subsequently, printing from the remaining frames; (*b*) synchronization of a positive film and a gramophone by printing markings between the pictures which bear a relationship to divisions on a counter geared with the gramophone; and (*c*) the use of an illuminating system for rapid printing which comprises an extended light source and a quartz block having curved sides which, by internal reflection, concentrate the light on a single printing point.

Editing and Splicing.—A patch made of film support, 0.003 inch thick, was proposed by Crabtree and Ives[126] as a uniform and satisfactory method of blocking out splices on sound film. Equipment for cutting has been developed on a basis of the needs experienced for sound pictures and many of the make-shift devices are giving way to commercial products embodying the necessary features for handling sound films. Three designs of "Moviolas" are available for sound film editing: (*a*) a sound picture synchronizer for use with records on separate films, (*b*) a disk reproducer, and (*c*) an apparatus for use when sound and picture are on the same film. In the last named device, the film movement is continuous; a rotary shutter turns inside a cylindrical lamp housing around which the film passes.[127]

Richardson[128] has described a reduced speed motor driven rewinder devised by Slagle and Seckel which rewinds at 60 to 90 feet per minute. An automatic rewinding device described by Engelmann[129] in 1928, but not mentioned in previous reports, is of interest since the reels lie in a horizontal position. More recently the same author has given details of an expanding case for film rolls permitting quick removal or replacement.[130] Patent protection has been requested for a method of editing pictures and sound records, the latter being recorded magnetically on a steel wire.[131] Several other patents are recorded which relate to improvements in splicing apparatus.[132]

Titles.—With the expanding use of sound film, the necessity for titles and titling machines has diminished considerably, although for silent releases and for non-theatrical films, titles still find an important application. A double titling machine made in Germany uses vapor arc lamps and has a capacity of 8000 meters per eight hours.[133] Another German device for title making employs a projection lamp with a 235 mm. triple condenser for illumination of transparent titles.[134] Three patents were issued pertaining to methods of preparing title copy for photographing.[135]

After Treatment, Cleaning, Reclaiming, and Storage.—A comprehensive discourse was published by Wiegleb[136] on methods of sulfide toning which included a review of all articles and patents with references. The chemistry of many selenium compounds and their suitability for toning purposes was treated by Sedlaczek.[137] Directions for the use of a dye mordanting formula containing copper sulfocyanide were published by Namias.[138]

Sound record prints may be lubricated satisfactorily, according to Crabtree, Sandvik, and Ives,[139] by applying a thin coating of a solution of paraffin wax in carbon tetrachloride along the edges of the film in the perforation area. Film will have a minimum tendency to accumulate scratches, dirt, and finger marks, which in turn cause ground noise, if edge waxed and buffed after applying a 1 per cent solution of cantol wax to the entire emulsion surface. A description has been published of a film cleaning and treating machine which processes 2000 meters of film per hour.[140]

Several processes[141] for film preservation have been exploited for which various claims are stated, such as increasing the flexibility of the film, reducing its tendency to become scratched or buckled, and generally increasing its useful life. Another process is particularly recommended for revivifying old films by a method of cleaning, brushing, and resurfacing with a chemical treatment to eliminate scratches and abrasions. No technical details have been published on the chemicals employed.

One patent of three issued, dealing with cleaning and conditioning processes, describes a method for the treatment of a sound record to eliminate "parasitic noise" during reproduction.[142]

As a result of a serious studio fire in the East and a laboratory fire on the West Coast during 1929, a great deal of pressure was brought to bear on all laboratories to increase their safeguards for fire prevention. Even before the two fires, however, a committee of representatives from all laboratories was appointed by Mr. Will Hays to work with the National Board of Fire Underwriters to revise the code of recommended practice for laboratory requirements. This committee has not completed its investigation but is expected to report within the next few months.

The characteristics of nitrocellulose films which may undergo flameless combustion at 150°C. have been discussed by a well-known Federal chemist.[143] Contact with an electric lamp, a heated steam coil, a hot wire, or a burning cigarette may ignite such film. Directions for the construction of storage vaults for safe storage of this material have been published by Brown.[144] A German film safe is composed of a series of sliding drawers which may be stacked on top of each other and side by side in sections.[145] Additional containers for film reels have been patented.[146]

II. DISTRIBUTION

Impending adoption of wide film introduces problems for the film exchanges, since the larger reels will require larger shipping cans and will cost more to ship because of their increased weight. An average reel of 70 mm. film weighs 34 pounds and rewinding is a man-sized job, requiring care to prevent cinching or tearing of the film.[147]

Some idea of the extent of the distribution of ordinary and sound prints may be gained from a statement that one of the large producers delivers on an average 155 sound prints compared with 75 silent prints. Some "star" pictures may run as high as 280 prints. The life of an average sound print is 50 to 75 days; that of a silent print 90 to 120 days.[148]

A summary of the packing regulations for shipment of film over the German governmental railways has been printed.[149]

III. EXHIBITION

A. *General Projection Equipment*

Projectors and Projection.—Fox and Richardson[150] have commented on the projection equipment used for showing 70 mm. film. The projector is built more sturdily than older projectors and is equipped with a rotating shutter between the light source and the film aperture. Maintenance of uniform screen illumination is found to be a delicate job at the Roxy where 150 amperes are required for the long throw.[151]

An attachment weighing less than 100 pounds has been announced for installation on a universal projector base for the showing of a film 56 mm. wide, giving a picture ratio of 1:2 for projection on screens 24 feet wide.[152]

A new model Simplex projector,[153] as well as a new assembly for older models, was announced in 1929 which incorporates as a special feature a rear shutter between the lamp house and the gate. The shutter blades are set at a slight angle to create a current of air on the gate which is claimed to lower the temperature of the gate considerably, to reduce to a minimum the tendency for film buckle, and to lower the general fire hazard. Some other features of the new model as claimed are easy and rapid change-over from disk to sound-on-film, and means for maintaining accurate focus and centering of the picture.[154]

Hardy[155] applied the results of a consideration of the conservation of energy principle to a discussion of the optics of motion picture projectors. Jahn[156] has given interesting data on transformers for use with motion picture projectors. A cue meter, consisting of a dial attached by a flexible shaft to the shutter shaft on the projector, has found practical use and eliminates the need of a long written cue sheet. The dial is graduated in feet and is traversed by two hands, geared ten to one.[157] Descriptions have been given by Lassally[158] of two Berlin theater projection rooms, in one of which are installed two non-intermittent projectors. A projector is available for projection of Ozophane film which is 0.02 mm. thick. It employs a claw pull-down movement and 750 runs were made successfully at a speed of 25 frames per second.[159]

Improvements in pressure plates, claw pull-downs, change-over devices, automatic rewinds on the projector, take-up fittings, sprockets, *etc.*, comprise the essential features of many patents related to projection mechanisms.[160]

Sound Picture Reproduction.—During the winter of 1929–30, sound motion pictures became such an integral and vital part of regular theater exhibition programs that their discussion is included at this point under general rather than special projection equipment, as in past reports. The problem of equipping many thousands of theaters for sound reproduction during the comparatively short period of a year and a half was a serious and gigantic task both from the engineering as well as the economic standpoint. The economic problem, according to Franklin,[161] has been a particularly serious one for the small exhibitor, for, while the large houses could eliminate their symphony orchestras and introduce a saving, the small house had only a small investment in its orchestra in comparison with the cost of installation of reproduction equipment. A lowering of costs on such equipment alleviated this situation to a certain extent. In the meantime, many small exhibitors installed inferior low-priced equipment with a resulting lowering of the quality of sound reproduction and an inevitable falling-off of box office receipts. On the other hand, the steady improvement in sound reproduction quality noted in the better equipped theaters stimulated public appreciation and, according to a report by Hays, resulted during 1929 in an increased attendance of 15 per cent or 15,000,000 persons per week in the United States.[162]

The advent of the sound picture apparently offered the producers a plausible excuse for the removal of concert orchestras which many of them believed had been appreciated only by an aesthetic minority. Surprisingly few complaints from theater goers and no noticeable loss of revenue apparently substantiated this opinion.

Schools for theater projectionists have been established to acquaint them with the handling of sound equipment and elaborate servicing staffs have been formed for the assistance of the theater. Numerous practical articles have been written on analysis of sound reproduction troubles, such as care of equipment, location of electrical supply generators relative to the loud speakers, causes of hum sounds in reproducers, acoustic nature of draperies and seats in the auditorium, *etc.*[163]

A survey of the literature indicates that considerable attention has been paid to the problem of theater acoustics during the early months of 1930 as the importance of this problem was fully realized. Of interest to the theater patron is Marrisson's[164] method for estimating by ear, frequencies from approximately 50 to 4000 cycles. Norris[165] has described an electrical instrument called an "acoustimeter" for measuring sound intensities.

Sound picture projection apparatus is in active use on trans-Atlantic liners, in a Chicago hotel dining room, and even in railway cars. A successful showing on a Union Pacific trans-continental train was arranged during the fall of 1929.[166] A Delaware corporation has been formed to promote a fleet of specially designed railway coaches as the first unit of a projected nation-wide system of mobile sound theaters to present pictures in small villages.[167] The first theater for the exclusive showing of sound newsreels opened early in November, 1929, running a continuous show from 10:00 A.M. to midnight.[168]

A description has been given of the Tobis projection equipment which is used in Germany and France.[169] The sound record is of variable density type. Loud speakers are mounted in sets of six, on each side of the screen. Five of each set are of the electro-static and one of the electro-dynamic type. Various projectors available in Germany have been described by Fischer[170] and by Pander.[171]

The adoption of a standard projection aperture for sound-on-film prints of 0.600 by 0.800 inch is of importance as noted previously in this report.[39] It was proposed by a joint committee of technicians and engineers and represents a forward step toward better screening of sound pictures. Microphone installations connected with the loud speakers on the stage have been made available for theater managers' offices to permit the manager to give personal announcements about coming programs, sport events, and elections, as well as to assist in the prevention of panics in case of fire.[172]

Several articles have been written on that important subject of volume control, so vital to the interest of the theater patron.[173] A special fader installation operated from the orchestra floor of a New York theater has proven an effective means of controlling sound volume during the showing of the picture, *Rio Rita*.[174] The proper location of horns and other types of loud speakers is still somewhat of an open question.[175] Analyses of types of loud speakers have been made by Vogt,[176] and by Blattner and Bostwick.[177] An audible frequency selector has been designed for use in the projection room which it is claimed permits the projectionist to accentuate, attenuate, or eliminate certain frequencies delivered to the amplifier.[178]

Details have been published on the technical characteristics of all the sound reproducing equipment on the French market.[179] The only French process which is complete from the taking to the production end is that of Gaumont. Their projector, known as "L'Ideal Sonore," uses a selenium cell illuminated with a 220 watt lamp, for sound-on-film reproduction, and is also equipped with a synchronized disk for records. A special amplifier for the selenium cell is provided, located on the projector, and a three stage audio amplifier delivering a telephonic power of 150 watts which may be located anywhere desired.

Dunoyer[180] has reviewed the characteristics of photo-electric cells with especial mention of a cell manufactured in France. Nason[181] has dealt with the design of audio frequency apparatus in a series of three articles. Electro-magnetic pickups were discussed by Crouse,[182] and Hatschek[183] treated the subject of amplifiers and hook-ups to minimize distortion.

Additional installations have been made in theaters to make sound pictures audible for deaf patrons. The equipment consists of a network tapping the sound energy in the reproducing system with a separate amplifier capable of supplying sufficient power for thirty headsets.[184]

The number of available types of turntable reproducers continued to increase monthly for each one of which certain meritorious claims were advanced.[185]

Various improvements in sound reproduction equipment have been patented[136] relating to synchronization of disk records with pictures, constant speed control of film projector mechanisms, tension regulators, *etc.* Two other patents are interesting because of their novelty: (*a*) Broadcast sounds are synchronized with cinematographic films, illustrating the subject broadcast and projected in one or more theaters, by the aid of duplicate strips, on which the speech and music are marked so the projectionist, by means of his copy strip and speed regulator, can adjust the projector to synchronize with the received sounds.[187] (*b*) Motion pictures have been reproduced on metal film, and projected by reflected light. The sound track is produced either photographically, mechanically, or magnetically.[188]

Projector Lenses, Shutters, and Light Sources.—Improved efficiency has been claimed for a projector shutter which consists of three cutout disks on separate shafts.[189] The center of the lens is uncovered first and covered last. A number of patents[190] have been issued both here and abroad on improvements in lenses and shutters.

The introduction of sound and color pictures has resulted in increased amperage for screen illumination with greater accompanying trouble from heat on the gate aperture. This excess heat causes the film to buckle and increases the fire hazard. To overcome these difficulties the manufacturers of the Simplex projector designed a rear shutter assembly for use on existing projectors which, it is claimed, effectively reduces the heat incident on the gate from a 170 ampere high intensity arc more than 65 per cent.[153]

A 500 watt lamp for general studio illumination and a projector incandescent lamp have been announced in France which are silvered on one-half of the bulb interior as a means of increasing their efficiency.[191] Naumann[192] studied the light distribution over the face of a condensing mirror in relation to each part of the picture area. In another paper the same author gave results of tests with a novel photographic set-up which indicated that the mirror arc under average working conditions gives unequal illumination of the center and edge of the film aperture.[193]

A unique generator known as the Rosenberg cross-field generator is being marketed by an Austrian firm located in Vienna (Fig. 3). An arc, such as that in a projector, may be connected directly to the generator and the voltage and current are self regulating. Two of the four commutator brushes are short circuited. When the outer circuit is closed, a magnetic field and an armature field result in the same direction, but opposed, the former increasing slowly, the latter rapidly. The resulting field strength then becomes weaker, the potential at the brushes grows less, and the current is lowered.

A new high intensity arc was designed which is especially suitable for the projection of wide film.[194] Joy and Downes[195] presented a useful paper at the Toronto meeting on the characteristics of high intensity arcs. Only three patents dealing with projector light sources have been noted since the last report.[196]

Fire Protection.—Ignition tests were conducted by the Los Angeles Bureau of Standards and Research on several different motion pic-

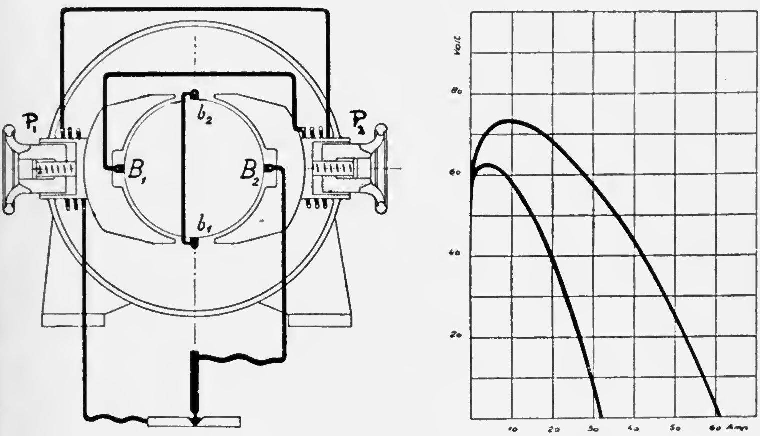

FIG. 3. Diagram (left) of Rosenberg cross-field generator and curve (right) showing effect on voltage of increasing the amperage. Reproduced by courtesy of Dr. P. Schrott, Vienna, Austria.

ture films; the lowest ignition temperature found was 250°F.[197] Cabourn[198] reviewed various methods for minimizing fire risks during projection. A non-inflammable substitute for nitrate film is considered the real solution. Alteration of projector design so that the shutter would operate between the lamp house and the gate is strongly advocated for reducing the heat reaching the film. This scheme is incorporated in the new projector design previously noted under the section on *Projectors and Projection.* In case of a film fire, one type of fire extinguisher releases a gas from outlets in the projector which smothers the fire.[199]

The importance of the question of fire prevention is indicated by the number of patents which have been issued dealing with automatic means for closing apertures, operating dousers, disconnecting electrical lighting circuits, prevention of burning of the film in case of breakage, *etc.*[200]

B. Special Projection Equipment

Portable Projectors.—A new sound-on-film portable projector equipment made by RCA was announced in October, 1929.[201] The projector and sound reproducer is housed in a metal cabinet 24 inches square and 12 inches wide mounted on four telescopic legs. The magazines are attached to the outside of the housing. The amplifier is housed in a separate metal cabinet and permits volume control in graded steps of 2 TU from zero to maximum volume. Accommodation is made in the amplifier for a second projector to permit smooth change-over. The speaker is an electro-dynamic moving coil cone type. The equipment takes about an hour to assemble.

Further details have been made available on the portable sound equipment supplied by Western Electric.[202] The delivery and take-up reels are included on the same shaft inside the projector case. A 60 foot throw is possible giving a picture 7 feet by 8 feet in size.

Dahlgreen[203] has given data on a German projector of the suitcase type as "Kinobox C." Light is reflected from a mirror set at an angle of 45 degrees to the film plane and the rotating shutter is positioned between the light source and the film. Descriptions have also been published of two other portable projectors of German manufacture, the "Grawor" and the "Matador."[204] A window display projector uses 35 mm. film and projects pictures 9 inches by 12 inches, which remain 7 to 12 seconds on the screen.[205] The Kohm advertising projector uses a loop of 16 mm. film, 120 meters long.[206]

In the "Speico" automatic projector, the lamp house, motor drive, gate, and lens system are mounted on a horizontal box holding the film which feeds from the center and rewinds from the outside of the roll. The film edges rest on a number of threaded metal cylinders arranged radially around the center of the magazine. One of these cylinders is connected to each of the extremities of a vertical drum for guiding the film from its entrance to its exit from the case and to keep a constant length of film outside of it. Upper and lower sprockets, ventilation of the film, and the lantern, and a humidifying device are features of this projector.[207]

A few patents have been issued concerned with improvements in projector design, methods of utilizing an endless strip of film, *etc.*[208]

Stereoscopic Projection.—Barth[209] prepared a review of the systems for the production of stereoscopic motion pictures. A device for which claims of relief effects were made was demonstrated in Hollywood in November.[210] A standard camera and regular film stock were used. Another apparatus was demonstrated also on the Coast which was patented in 1915 but was perfected mechanically only recently. Bi-lensed optical systems are avoided and individual viewing frames are said to be unnecessary. Alternate frames are photographed from laterally varying positions (angles), the optical center of the lens representing the pivotal point. A train of motor-driven gears and cams are built into the tripod head.[211] Only two patents were noted dealing with devices for obtaining relief effects.[212]

Non-intermittent Projection.—In one type of continuous projector supplied by an English firm, a ring of lenses rotates in the place usually occupied by the rotary shutter. The speed of rotation of each lens corresponds to the rate of travel of the film in the gate in such a way that each lens is maintained central with its appropriate film picture which is thus projected stationary on the screen.[213]

Another non-intermittent type of projector, also manufactured in England, was designed so that the film passes upward through the gate which accommodates two picture frames. Moving parallel with the film and at equal speed is a continuous band of 14 lenses arranged in a channel shaped like the letter **"D"** the flat side of which is nearest the gate. Two images, or one complete image with parts of two others, are available which, by means of a master lens and an ordinary projector lens, are superimposed on the screen.[214]

A continuous projector designed by a Frenchman, M. R. Huc, has several novel aspects to recommend its consideration. Film is passed on a curved track in the form of a part cylinder before a light aperture somewhat higher than that of a single frame. An image is projected onto a mirror in the center of the cylinder and set at an angle of 45 degrees to the light path. The mirror turns at a speed one-half that of the moving film through a slight arc and then returns to the original position while a shutter cuts off the light momentarily. A stationary image is projected on a screen placed at right angles to the original light source. Means are provided for framing a single picture on the screen.

A projector with continuous movement and using unperforated film on Ozaphane stock has been demonstrated in Paris.[215]

The interest shown in design of non-intermittent projector devices is indicated by the comparatively large number of patents which have been taken out on such equipment.[216]

C. *Theater Design and Installation*

Screens.—Larger screens are generally being installed for standard projection, the size most used in the larger houses on the Coast being 18 feet by 24 feet. Certain producers are planning installation of large screens for the showing of wide films.

A mechanical device operated from the projection booth permits masking the screen to any size needed in three seconds.[217] A sound screen is constructed entirely of asbestos.[218] Another sound screen is made with a glass beaded surface.[219] The screen is fire-proof, may be washed, and rolled up. A screen used by the Film Guild Cinema is stated to be made up with laminated gold and other metals as well as pigments. Arc amperage is said to be lowered 50 per cent by its use.[220]

Some of the ideas patented relating to projection screens are the following: a screen surface comprising agglomerated microscopic spheroidal particles of a considerable range in size; screens having mica dust or finely ground quartz on their display surface, a daylight screen which includes the use of a rayon screen before the regular screen, the former stopping the light falling angularly on the screen; a screen comprising a thin sheet of water dropped through space from a suitable container, *etc.*[221]

Theater Illumination.—Paints which fluoresce strongly under ultraviolet radiation have been used to paint costumes and scenery for the production of startling effects.[222] Types of batten spotlights available in Great Britain for stage illumination have been described.[223] Electrically interlocked motors form the connecting link between the control board and the grouped pre-set modulators in different theater stage lighting circuits.[224]

A new stage and theater lighting system known as Colorama has been developed by the General Electric Company. It consists of a scheme of cones and flutes with lamps and color media so arranged as to give changing and overlapping color and shadow effects. Glass filters are used instead of gelatin.[225]

Theater Acoustics and Construction.—Considerable attention has been given the theater acoustics problem during the year of 1929. One firm has made an acoustical analysis of over 1500 theaters and made recommendations for treatment of the auditoriums. A lowering of the accepted optimum reverberation time as a function of volume was reported.[226] Theaters with square auditoriums were found in general to have better acoustic properties than long narrow theaters. Kellogg[227] stated that the trend will be toward very "dead" theaters in the future with the recording and reproduction arranged to adjust such variables as reverberation and loudness. According to Friend,[228] seats should be made of materials which absorb nearly as much sound as a person. Hair felt and other soft materials which reduce the reverberation have a high selective absorption for frequencies above 1000 and a masking of the audibility of high tones results.[229]

Eyring[230] has shown that the common method of calculating reverberation times is incorrect in some cases. Since theaters are effectively corrected to optimum amount of sound absorption, however, calculations with the old formula will result in correct adjustment in most instances. For sound stage treatment the new method is of importance, as it shows that a very dead set may be obtained by the use of less absorbing material than the older formula would indicate.

The effect of distortion on speech sounds during transmission was discussed by Steinberg.[231] The treatment considered only the effect on articulation and not at all the tonal quality of the sound. Knudsen[232] examined the factors affecting articulation in an auditorium after first discussing the characteristics of speech and hearing.

Lindahl[233] discussed several of the special acoustical problems of theaters from small 200 seat houses to large 5000 seat houses. Hatschek[234] analyzed data on building acoustics of motion picture theaters. Curved surfaces and domes should be avoided, according to Schiffe.[235] Carter[236] recommended lining the ceiling and walls with compressed cane fiber board, to reduce reverberation, and leaving air spaces in the walls. The proper adaptation of ceiling design with relation to the rest of the auditorium will provide all the audience beyond two-fifths the distance from front to back with equally clear reception.[237]

Scenery painted on brilliantly colored paper and impregnated against fire may be illuminated either from the front or back and costs less to manufacture.[238] A seating system for theaters consists of an automatic switch equipped to light a lamp at both the end of the row and on a chart in the foyer indicating row and seat number.[239] A box having an illuminated ground glass over which a continuous length of "score" film (photographically prepared) is passed eliminates the necessity for a director of a theater orchestra and insures easy synchronization with the projected picture.[240]

IV. APPLICATIONS OF MOTION PICTURES

A. Education, Business, and Legal Records

Sound motion pictures began to be used for non-theatrical purposes during 1929. The Hotchkiss School in Lakeville, Conn., was reported according to Lewin,[241] to be the first school to have sound reproduction facilities installed. He also reported that an experimental program of sound pictures was planned for a Newark, N. J., public school in April or May, 1930. A film entitled *Administration Departments of the Federal Government* was selected for projection. This film included voice and picture records of the President of the United States. Lewin gave a list of 18 industrial and educational sound pictures. A description was published of a sound film on vocational guidance made by Kitson of Columbia University.[242] Announcement of plans was made of the U. S. Department of Agriculture for recording such events as the National Dairy Show in sound.[243]

A sound newsreel was made of the wireless reception of the news of Admiral Byrd's flight over the South Pole.[244] More than 1000 feet of motion pictures were reported to have been made of the polar regions during this flight.

The first transcontinental use of a sound motion picture as a substitute for the presence of the actual person is stated to be the address made by Hon. R. L. Wilbur, U. S. Secretary of the Interior, in May, 1929, at the Muybridge Celebration at Stanford University. It was shown with portable equipment.[245] A more extensive application of this public address idea was made in January, 1930, when a corporation president spoke in eleven different cities on the same evening at the annual president's dinner, through the medium of the sound picture.[246]

Future students in universities may be able to see as well as hear some of the world's leading scientists which should serve to enhance their interest in the investigations of such men.* Sound films were made of lecture demonstrations by Sir Oliver Lodge, Sir Ernest Rutherford, Sir William Bragg, well-known English scientists, and of Dr. Irving Langmuir of the Research Staff of the General Electric Company.[247]

A series of sound motion pictures relating to business conditions has been planned by Harvard University on the subjects—*Regions of the United States*, and *Commerce and Industry*.[248]

Confessions of the defendants in burglary and murder trials** were recorded in Philadelphia as a part of an experimental investigation on the value of the sound motion picture in criminal court practice.[249] It was reported that a bureau is to be established for making sound pictures of prisoners so as to have records of their voices, gestures, and mannerisms. A similar bureau has been established in Paris by the Surete Generale.[250]

The cultural course, "Introduction to the Photoplay," established in 1928 at the University of Southern California, has been continued and has also been adopted by Stanford University and the University of Iowa.[251] Courses on technical and scientific cinematography were begun at the Vienna Technische Hochschule under Dr. P. Schrott and a three year course has been established in Berlin.[252] Santini[253] stated that there are over 5000 projectors being used for showing educational films in Italian schools. A résumé of the uses made of classroom films as an aid to teaching has been published by McClusky.[254] According to Walters,[255] increased interest, as well as a better understanding of processes, resulted from showing industrial films as a part of the work of chemistry classes in an Oklahoma high school. Thirty-two new films for classroom use have been released since October, 1929, by a corporation organized for the production of such films. A total of over ninety films have been prepared.

A motion picture conference held in New York between leaders of the industry and civic, educational, religious, and social service organizations, resulted in a better understanding of the relationship between the industry and the public.[256] Educators have

* A sound motion picture illustrating the educational application of sound pictures was shown during presentation of this report through the courtesy of General Electric Company, Schenectady, N. Y.

** A sound motion picture of a murderer's confession was shown during presentation of this report through the courtesy of the Fox Film Corporation, N. Y.

urged that the best photoplays should be preserved and revised for visual education after they have served their entertainment purposes.[257] A Dutch society for the preservation of motion picture records of the history of the Netherlands was organized in 1919 and has collected more than 1000 films during the decade.[258]

B. Medical Films, Radiography, and Photomicrography

Included in a group of motion pictures shown at the 1929 fall convention of the American College of Surgeons were four sound pictures, three of which were recorded addresses accompanying diagrammatic pictures, while the fourth represented an obstetrical operation accompanied by dialog.[259] The operation was performed by Dr. DeLee, well-known Chicago obstetrician, and the dialog was synchronized with the film by a crew of Fox cameramen.* Dr. DeLee has an elaborate laboratory for motion picture photography in the Lying-In Hospital in Chicago. It is also equipped with an animation department.[260]

Sound films have been made for the Los Angeles County Health Department by Hearst-Metrotone cameramen to encourage greater interest in public health.[261] Motion pictures of living cells of body tissues were made by Rosenberger, working with Carrel at the Rockefeller Institute, and shown at the Thirteenth International Physiologists Congress in 1929. Studies requiring days of observation were shown to an audience in half an hour.[262] Roon[263] predicts that voice recording of wills, testimony at trials, property sales, *etc.*, will make records of greater value and accuracy than written records. Fifteen medical films have been prepared in a program under the auspices of the American College of Surgeons, the Motion Picture Producers and Distributors of America, and the Eastman Kodak Company. Subjects made during 1929 deal with acute appendicitis, obstetrics, vestibular function, and development of the rabbit's ovum. The last named picture was made by Dr. W. H. Lewis of the Carnegie Institute of Embryolgy in Baltimore and represents a beautiful example of photomicrography.

Umbehr[264] has published an historical survey of attempts made to produce X-ray motion pictures. A method used by Ruggles is

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* A portion of this sound motion picture of Dr. DeLee's operation was shown during presentation of this report through the courtesy of Dr. J. B. DeLee, Chicago, Ill., and the Fox Film Corporation, N. Y.

considered by another writer to be very promising. The X-ray tube is turned on and off every twenty-fifth of a second in place of using a shutter.[265] Studies of movements of the heart may be made by roentgenographing the heart through a series of parallel slits in a lead screen upon a film moving slowly past the slits.[266] Rosenberger[267] published a brief description of a method for attaching the Eyemo camera to a microscope. An automatic microcinematographic apparatus mounted on a heavy rigid support has been described by Coissac.[268] Storch of Vienna made ultra-rapid

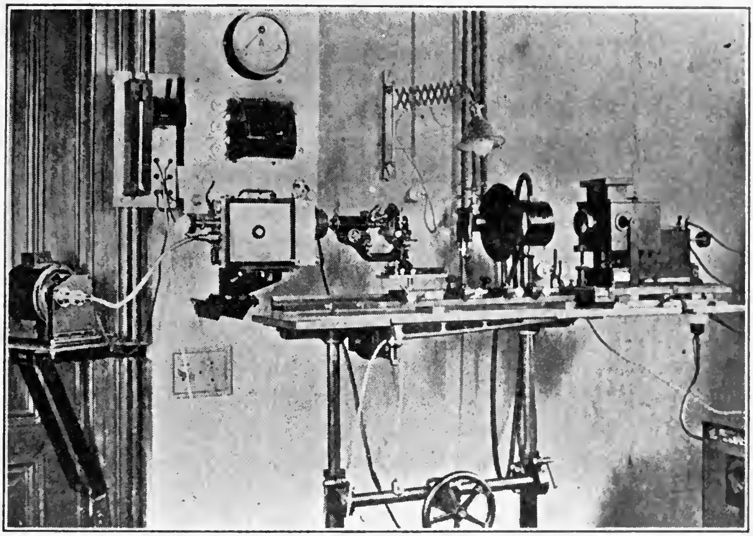

FIG. 4. Camera and photomicrograph used by Storch of Vienna for ultra-rapid motion analysis studies of microörganisms. Reproduced by courtesy of Dr. P. Schrott, Vienna, Austria.

motion analysis studies of microörganisms using an Askania high frequency camera. To reduce vibration effect, the camera was attached horizontally to the wall but the microscope may be used either in a horizontal or vertical position. (Fig. 4.) Exposures mostly over 100 per second were used, focussing was done with a green filter interposed, and the arc current reduced to 5 amperes so as to minimize heating effects on the delicate organisms.

Canti of London filmed the growth of normal, and of cancer cells.[269] Francois-Franck and collaborators made motion picture studies of white blood cells *in vitro* and of the embryonic development of the sea urchin.[270]

C. Telephotography and Television

The general public may deposit ordinary messages in postal boxes conveniently located in three leading French cities for transmission by telephotography as part of a service begun in France during 1929.[271]

The industry is alive to the possibilities of television and further progress has been made which, though rather slow, is encouraging. Three producers have included reservation of television rights in their contracts.[272] A demonstration of the RCA Kerr cell principle apparatus was given at Procter's 58th Street Theater in New York in January. Jenkins[273] gave a summary of progress by his method at the last meeting of the Society held in October, 1929. According to his estimates about 20,000 amateurs are receiving radio movies which are broadcast from station W3XK, Washington. Other new television stations are WENR, Chicago, operated by the Great Lakes Broadcasting Company,[274] and W2XCR, Jersey City, and W2XCD, Passaic. The last two named stations synchronize radio with the pictures and, though the images were said to be hazy, the lip movements are stated to be discernible with the sound.[275] A painted rectangle was transmitted by short waves in February from station W2XAF, Schnectady, to Sydney, Australia, and re-broadcast back again by station VK2ME in an elapsed time of one-eighth second.[276]

A new cathode ray type of receiver giving a picture 4 inches by 5 inches has been described by Zworykin.[277] The method eliminates the high frequency motor previously necessary for synchronization, together with its power amplifier. No moving parts are used. A fluorescent screen aids the eye's persistance of vision and makes possible a reduction of the number of images per second without noticeable flicker. The transmitter is a modified motion picture projector with means for horizontal scanning.

The selection of standards for radio television has been discussed, including picture proportions, number of scanning elements, number of pictures per second, scanning method and direction, and phase of current.[278]

In the Telefunken system of television being developed in Germany, a combination of a mirror wheel for illuminating the subject and a photo-electric cell are used for sending, and a Kerr cell, together with a rotating mirror wheel, for receiving.[279] A French patent covering one phase of this process has been issued.

D. General Recording

A camera capable of taking 40,000 pictures per second by means of a drum having 180 mirrors, revolving 225 times per second, was exhibited in 1929 at a Scientific Congress in Tokyo. The camera was designed by the Institute for Physical Research of the University of Tokyo.[280] Cranz and Schardin[281] described a method for photographing a series of pictures of rapid action on a stationary piece of film, the time between successive pictures being variable from 0.1 to 0.000003 second. Lawrence and Dunning of the University of California have been studying the characteristics of the high voltage spark by means of a camera which has a shutter speed equivalent to the taking of 250,000 pictures per second. A 20,000 volt spark lasting 0.00001 second was found to be nearly 50 per cent hotter than the sun.

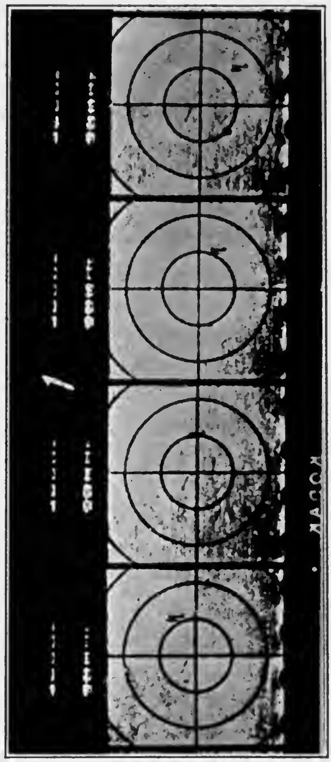

FIG. 5. Print from timing record of world's high speed airplane flight at Calshot, England, September, 1929. Note Veeder counter numbers reproduced along left side of film strip. Reproduced by courtesy of the Royal Air Force.

Cinematographic methods were used to time the high speed Schneider Cup airplane races held at Calshot, England, in the fall of 1929. A motion picture camera made pictures of the plane as it crossed the start and finish line and also recorded simultaneously the face of two calibrated Veeder counters which were actuated by a tuning fork vibrating 10 times per second.[282] (Fig. 5.) A machine gun motion picture camera makes 300 exposures per second, and, by means of a network of lines covering the image, it is possible to make a number of calculations of value to the designer of airplanes.[283]

A company has been formed in Paris to publish on cinematographic films, reproductions, page by page, of manuscripts, rare books, *etc.*, with the necessary illustrations. Application for a patent covering this principle has been made.[284] A device known as a photographic accelerometer was attached as a fifth wheel to the running board of an automobile and, by means of suitable disks and a motion picture camera, records were made of the distance travelled per second.[285]

A patent for an apparatus for making motion pictures of a moving object (such as an oil well rope, to detect wear) has been granted.[286]

V. COLOR CINEMATOGRAPHY

As noted earlier in this report the use of motion pictures in color has continued to expand and a number of new processes have appeared, although technical descriptions of them are rather meager. The new Technicolor laboratory in Hollywood has been completed and is stated to have a daily capacity of 47,000 feet of finished color film. Daily rushes are to be developed and printed in color on one side only, whereas double coated film has been used in the past.[287] An estimate has been made that 15 per cent of all pictures made in 1930 will be in color.

The first German all-color sound picture, *The Nun of Heiligenworth,* produced by Detofa of Berlin is scheduled for release in May, 1930.[288] Color sequences by the Horst three-color process are to be included in releases by the British Instructional Films Ltd. in the spring of 1930.[289] Newsreels made by a new color process were released by Pathé in March, 1930. The process is claimed to be equally as rapid in production as black and white prints and avoids the use of filters and prisms. Pictures of the New Orleans Mardi Gras floats were made and shown the following week in New York.[290] A recording photometer or color analyzer has been designed for the measurement of color values in sets, thus permitting more accurate control of illumination.[291]

A general summary of the principles and processes of color photography has been published by Matthews[292] which includes an extensive bibliography of all books and articles published on the subject between 1925 and 1930.

In the Herault Trichrome process, three-color component negatives are exposed in rapid succession by means of a rotating sector wheel; for the positive, a similar projecting device is used.[293] According to the scheme devised by a Boston inventor, prints from a color component negative exposed with the aid of a rotating sector wheel, are projected onto a special metal screen built up of four separate sections, each one being displaced slightly in front of the other and, except for the bottom one, perforated with holes. The outer screen is blue, the second yellow, the third red, and the base screen azure blue. Stereoscopic effects and undistorted side views are claimed.[294]

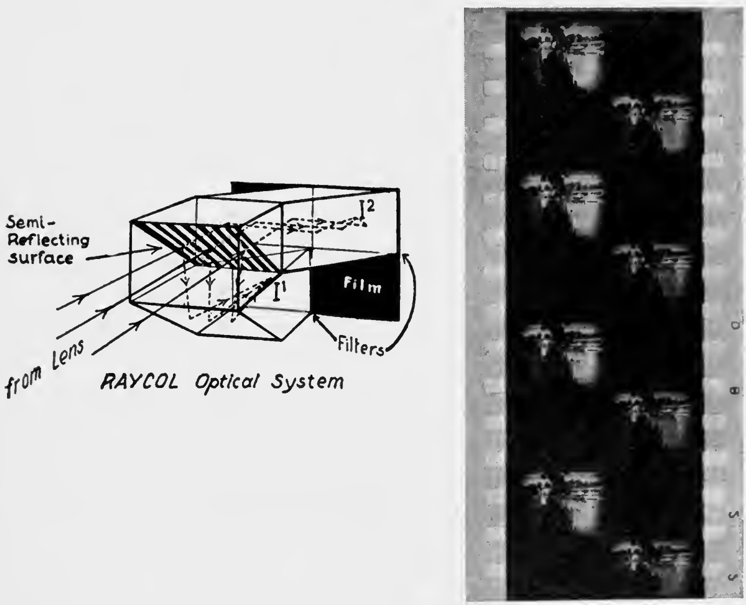

FIG. 6. Diagram of optical system used in the Raycol two-color additive process, and positive print showing disposition of component images. Reproduced by courtesy of *Kinematograph Weekly*, London, England, and Dr. W. Clark, Harrow, England.

Patents on three-color additive processes[295] described improvements in methods for utilizing color screens, objectives for superposing multiple images during projection, and a four-color method for exposing the four images on one frame with suitable projection facilities for registration on the screen.

A company is reported to have been organized in Switzerland for the exploitation of a color motion picture process using film coated on a lenticulated support. Patents related to lenticulated films[296] are concerned chiefly with methods of printing such films and with equipment for embossing the film support.

Naumann[297] has given a description of the illuminating equipment and other apparatus used by the Busch two-color additive process for medical cinematography. The film runs horizontally through the camera gate and the images, one-half standard size, are registered lengthwise along the film, one above the other, in such a way as to occupy one frame.

In the Raycol two-color additive process demonstrated in England, light enters the camera and is divided into two parts by means of a beam splitter. (Fig. 6.) It is then caused, by a system of rhomboids, to form two images one-quarter normal size in opposite quarters of the frame on standard size film, one through an orange filter, and the other through a blue-green filter. A twin lens projector with the appropriate filters over the lens superimposes the two positive images on the screen.[298]

Several patents[299] disclosing features of two-color additive processes have appeared, concerned with exposure and projector mechanism, the production of stereoscopic effects, and the positioning of the image pairs on the film, and other features.

Arc lights equipped with "silencers" are stated to be in use again for the production of Technicolor features, of which one hundred are scheduled for 1930. Cameras for this process are being manufactured at a cost of $14,000 and in April, 1930, about fifty cameras were stated to be available.[300]

A new film is reported to have been adopted for the Multicolor process which permits exposures on a black and white base.[301] In the Colorcraft process, although a beam splitter optical system was originally employed, early in 1930 the color separation negatives were being made by running two negative films, emulsion to emulsion, through the camera. Specially hardened double coated positive stock was utilized in making the positive records on which the color records were produced as dye images. Vague descriptions have been published of two other processes known as Photocolor and Harris color, respectively. The former purports to be a two-color process using dyed images on double coated film;[302] the latter is stated to be a three-color process using a single emulsion film for printing.[303]

The Sirius color process announced in Germany in 1929 produces the red and green exposures on alternate frames by means of a beam splitter and the prints are made on opposite sides of a double coated film, both sides being dyed simultaneously in the production of the color image.[304] The process was demonstrated in London early in 1930.

A considerable number of patents for subtractive color motion picture processes appeared during the past six months.[305]

VI. AMATEUR CINEMATOGRAPHY

A. *General Equipment and Uses*

Comstock[306] reviewed the progress in amateur cinematography from the period of the popularity of 28 mm. equipment to the present time. Thirteen makes of amateur standard cameras were available as well as several types of 9.5 mm. cameras. An automobile was equipped for demonstrating amateur motion picture equipment in the rural sections of England.[307]

A new apparatus for synchronizing 16 mm. film with disk records was described by Bristol.[308] A special printing device was designed to make prints either from 35 mm. or 16 mm. negatives, omitting every third frame. These shortened films may then be projected at 16 pictures per second, thus avoiding the noise made by amateur projectors when speeded up to 24 pictures per second. The turntable synchronizer drives the projector synchronizer at twice its own speed.

Amateur Cameras.—Several new models of amateur cameras appeared during the latter part of 1929 and the early months of 1930. The Filmo 70D incorporates seven speeds, three lenses on a turret, and a special view finder as features of its design.[309] A slow motion mechanism is incorporated in the Cine Ansco which is fitted with an $f/3.5$ lens.[310] Two new models of the Cine Nizo cameras were announced, both being fitted for four speeds and running off about 35 feet of film with one winding of the clock spring.[311] Three models of the Bolex Swiss camera are available, which have as a feature an exposure meter housed within the camera and an audible footage meter. Earlier models were fitted with $f/3.5$ lenses but a more recent model has an $f/2.5$ lens.[312]

The Kodel camera exposes four pictures on each frame of 16 mm. film by a mechanism which introduces an alternate horizontal and vertical movement of the film. The pictures are projected by a similar movement on a rear projector screen, the images being reflected from a shielded mirror onto the screen.[313] McKay[314] described methods of producing distortion effects by exposing motion pictures through ophthalmic prisms and an auxiliary lens.

Most of the patents issued on camera mechanisms are related to designs of claw pull-downs, spring drives, and types of film magazines.[316]

Projectors.—A combination projector turntable using a 16 inch disk recorder was announced for home talking pictures.[316] A Ger-

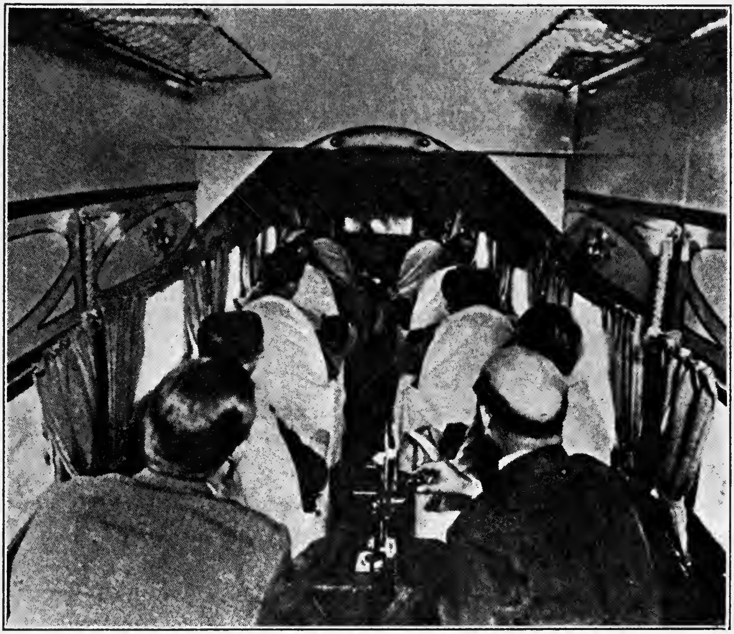

FIG. 7. Motion pictures being projected by an amateur projector on an airplane during a transcontinental flight. Reproduced by courtesy of the *Illustrated London News.*

man firm is also supplying a turntable and magnetic pickup suitable for attaching to any 16 mm. projector.[317] A non-intermittent amateur projector employs a 12 sided prism in a cylindrical mount which revolves between the aperture and the objective.[318]

A passenger airplane flying from Columbus, Ohio, to Los Angeles was equipped to show motion pictures on 16 mm. film *en route.* (Fig. 7.) The projector was operated with dry cells and a daylight screen was used.[319] Richman[320] briefly mentioned an amateur sound film process developed by Tager, a Moscow engineer, which incorporated sound and pictures on the film.

A new model Victor 16 mm. projector is equipped with a fan for cooling the rheostat, and a half-hour show is possible as an 800 foot reel may be utilized.[321] Two models of the Ampro projector are available, one of which is said to give a very bright screen since a 250 watt 20 volt lamp is used. The design of each is compact, all controls being mounted on one plate at the base.[322] The Bolex, Model C projector is air cooled and uses a 100 watt lamp capable of giving a picture 5 feet by 8 feet in size. It weighs six pounds. Stills may be projected.

Patents[323] related to projector mechanisms provide for projection of stills, reversal of the film, and details of claws, reels, *etc.*

Accessories.—A new Ross "Xpres" lens of aperture $f/1.9$ is made in 1, $1^1/_2$, and 3 inch focal lengths for amateur cine enthusiasts.[324] Tests made on the extreme aperture Dallmeyer lens listed as $f/0.99$ show good definition but rather small depth of focus.[325] An automatic panoraming device has been made available.[326] An improved rewind and splicing equipment represent a useful addition to the amateur's splicing table.[327] A combined exposure meter, distance gauge, and view finder has been described, which may be geared to the camera.[328] Only three patents deal with accessory devices.[329]

Scenarios.—Useful suggestions on set construction were published by Hugon[330] and on miniature building by Waller.[331]

Films and Film Processing.—The bulk of amateur motion pictures exposed on 16 mm. film are being developed to a positive by one of several reversal processes. A few firms began to supply negative film but most of this film was withdrawn from the market late in 1929. An unbreakable film was described which consists of strips of 16 mm. film, $4^3/_4$ inches long, sealed between thin pieces of steel which have holes cut through for the pictures and the film perforations. These strips are projected by stacking them in a projector magazine where an electro-magnet picks up the top strip which is then moved intermittently past a horizontal aperture. A mirror deflects the image along a horizontal axis onto a translucent screen. Test runs of 15,000 passages through the projector are claimed to show no wear on the film.[332]

Several articles have been published giving formulas and manipulative details for developing film by reversal.[333]

B. Amateur Color Processes

Only two patents[334] were noted dealing with color processes; one describes a color filter holder for projectors, and the other describes the use of a curved exposure gate in processes utilizing lenticulated film.

VII. STATISTICS, PUBLICATIONS, AND NEW BOOKS

A survey made early in 1930 by the secretaries of the thirty-two Film Boards of Trade of the Motion Picture Producers and Distributors of America revealed that there were 22,624 motion picture theaters operating in the United States.[335] New York had 1233 theaters, Illinois had 1286, and Ohio had 1247. About half the total number were wired for sound pictures. There were reported to be 57,743 theaters in the world as shown by a census taken by the Motion Picture Division of the U. S. Department of Commerce.[336] With the increased total for the United States shown in the Board of Trade's report, the world total would be 59,867.

A United States Department of Commerce report[337] stated that 2200 foreign theaters were wired for sound pictures by the end of 1929, distributed as follows: Europe 1500, Far East 400, Latin America 250, other places 50. There were 256 patents issued in Great Britain during 1929 relating to motion picture processes, 52 of which dealt with color processes and 57 with sound processes. Patents on motion pictures granted in Great Britain for the last thirty years outnumbered those in any other field.[338] About $28,000,-000 were paid into the Treasury for entertainment tax by the theaters of Great Britain.[339]

About 115,000,000 persons attended theaters weekly in the United States during 1929, an increase of 15 per cent over 1928. It was estimated that a half billion dollars were invested in sound motion picture development during 1928 and 1929.[340] Exports of film increased in 1929 over 1928, 282,000,000 feet being shipped out in 1929 as compared with 222,000,000 feet in 1928. Of the total for 1929, 8,400,000 feet represented negative film and 273,000,000 feet was positive film.[341] There were 145 feature pictures imported in 1929 as against 193 in 1928, the decrease being a result of the use of sound pictures only a few of which were being made abroad.[342]

There were approximately 1400 show houses in Australia which is a country having slightly larger area than the United States but having only 6,000,000 people. Two-thirds of the population are concentrated near the six capitol cities. About 600,000 feet of positive prints entered the country weekly. The vaudeville theaters were being wired during the winter of 1929–1930 for sound pictures.

Pictures made in studios of American companies represented 85 per cent of all film entertainment in 1929, although United States producers made less than half of the world's feature product.[343] The yearly payroll of Hollywood producers reached $100,000,000, averaging $2,000,000 weekly.[344]

A comprehensive series of reports was issued by the Motion Picture Division of the U. S. Department of Commerce on conditions in the motion picture industry in Italy, Roumania, France, Persia, and Germany.[345] North also reviewed the high-lights of the European situation for the year 1929 giving data on production, distribution, theaters, and legislation.[346]

Over 230 types of synchronous and non-synchronous sound equipment were installed in United States theaters in 1929.[347]

PUBLICATIONS AND NEW BOOKS

Valuable summaries of developments in the motion picture industry were published during 1929 in the Encyclopedia Britannica. The subjects treated and the authors are as follows: History—T. Ramsaye; Production—J. L. Lasky; Sets—C. Gibbons; Acting—M. Sills; Direction—C. B. DeMille; Make-Up—L. Chaney; Technology—C. E. K. Mees.

A section of the 1930 Supplement of the New International Encyclopedia deals with motion pictures and was prepared by R. Watts. In the article on Photography in this same publication, G. E. Matthews reviewed the growth of motion pictures from 1914 to 1929.

This Society passed a milestone in its progress when the *Transactions* issued quarterly for several years were replaced by a monthly JOURNAL, beginning January, 1930. Other new publications started during the past year are *Projection Engineering, Electronics, Journal of the Acoustical Society of America,* and *Cinematography.* New books which have appeared are as follows:

1. *Technical Digest, Academy Motion Picture Arts and Sciences, Hollywood, Calif., 1930.* A compilation of published lectures given as part of a school on sound fundamentals.
2. *Year Book of Motion Pictures,* Film Daily, N. Y., 1930, 12th Ed.
3. *Kinematograph Year Book,* Kinematograph Publications Ltd., London, 1930, 17th Ed.
4. *Encyclopedia on Sound Motion Pictures,* Cameron Publishing Co., Manhattan Beach, Brooklyn, N. Y., 1930.
5. *Photographic Emulsions,* by E. J. Wall, American Photographic Publishing Co., Boston, Mass., 1929, 256 pages.
6. *See and Hear,* by W. Hays, Mot. Pict. Producers and Distributors of America, Inc., New York, 1930, 63 pages.

7. *On Film Technique*, by V. I. Pudovkin, Trans. from Russian by I. Montagu, Gollancz, Ltd., London, 1930, 204 pages.

8. *Sound Projection*, by R. Miehling, Mancall Publishing Co., New York, 1929, 528 pages.

9. *Photo-electric Cells*, by N. R. Campbell and Dorothy Ritchie, I. Pitman & Sons, New York, 1929.

10. *Sound Pictures and Trouble Shooters Manual*, by J. R. Cameron and J. F. Rider, Cameron Publishing Co., Manhattan Beach, Brooklyn, N. Y., 1930.

11. *Sound*, edited by A. James, Exhibitor's Daily Review and Motion Pictures Today, New York, 1930.

12. *Sensitometry, Photographic Photometry, and Spectrography* (*Die Sensitometrie, Photographische Photometrie und Spektrographie*), by J. M. Eder, W. Knappe, Halle, 1929. This is Part 4 of Vol. III of the *Ausführliches Handbuch der Photographie.*

13. *Photo-chemistry and Photographic Chemicals* (*Photochemie und photographische Chemikalienkunde*), by A. Coehn, G. Jung, J. Daimer, W. Knappe, Halle, 1929. This is Vol. III of *Handbuch der Wissenschaftlichen und Angewandte Photographie*, edited by A. Hay.

14. *Photo-chemistry and Photographic Chemistry* (*Photochemie und Photographische Chemie*), by W. Noddack and E. Lehmann, Union Deutsche Verlags., Berlin, 1929. This is Vol. I, Part 1, of *Handbuch der Photographie*, edited by H. W. Vogel.

15. *Manufacture and Testing of Photographic Materials* (*Fabrikation und Prüfung der Photographischen Materialien*), by W. Nauck and E. Lehmann, Union Deutsche Verlags., Berlin, 1929. This is Vol. 1, Part 2, of *Handbuch der Photographie*, edited by H. W. Vogel.

16. *Production and Testing of Light Sensitive Films, Light Sources* (*Erzeugung und Prüfung Lichtempfindlicher Schichten, Lichtquellen*), by M. Andresen, F. Formstecher, W. Heyne, R. Jahr, H. Lux, A. Trumm. This is Vol. IV of *Handbuch der Wissenschaftlichen und Angewandte Photographie*, edited by A. Hay.

17. *Electric Transmission of Pictures and the Telehor* (*Das Elektrische Fernsehen und das Telehor*), by D. von Mihaly, M. Krayn, Berlin, 1926, 196 pages.

18. *Television*, by H. H. Sheldon and E. N. Griesewood, D. Van Nostrand Co., New York, 1929, 194 pages.

19. *Radio Movies, Radiovision, Television*, by C. F. Jenkins, National Capital Press, Inc., Washington, D. C., 1929, 143 pages.

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ABSTRACTS

The Editorial Office will welcome contributions of abstracts and book reviews from members and subscribers. Contributors to this section are urged to give correct and complete details regarding the reference. Items which should be included in abstracts are:

Title of article
Name of author as it appears on the article
Name of periodical and volume number
Date and number of issue
Page on which the reference is to be found

In book reviews, the following data should be given:

Title of book
Name of author as it appears on the title page
Name of publishing company
Date of publication
Edition
Number of pages and number of illustrations

The customary practice of initialing abstracts and reviews will be followed. Contributors to this issue are as follows: G. L. Chanier, E. E. Richardson, Clifton Tuttle, and the Monthly Abstract Bulletin of the Kodak Research Laboratories.

Camera Battery. K. Struss. *Intern. Phot.*, **1**, July, 1929, p. 17. This describes a method of arranging a battery of cameras for simultaneous photography of action in dialog pictures. Six cameras were used in one scene and the total time required for completing the photography was reduced considerably.—*Kodak Abstr. Bull.*

Mitchell Camera Adapted to Multicolor. *Intern. Phot.*, **1**, January, 1930, p. 15. The Mitchell camera has been adapted to multicolor photography. In three months of development, the principal difficulty overcome was caused by the back coating picking up on the aperture and pressure plates when the two negative films used in the process were put under pressure. C. M. T.

Optical Systems for Two-Colour Cinematography. *Brit. J. Phot., Colour Supp.*, **77**, Jan. 3, 1930, p. 2. Two recently accepted patent specifications (see Br. Pat. 319,194) describe optical systems for the production and projection of two-color motion picture films. A prism light dividing system is designed to produce two-color component images, which lie corner to corner across the diagonal of the standard area. The twin lens system is intended for use interchangeably with the ordinary lens on a projector. C. M. T.

New Super Simplex Projector. *Bioscope* (*Mot. Cinema Technique*), **82**, Jan. 8, 1920, p. vii; *Projection Eng.*, **2**, February, 1930, p. 29. An illustrated description of the Super Simplex 25 mm. projector. In this device the shutter, which is supplied with tilted blades, is mounted between the condenser and the aperture in such a manner as to direct a current of air on the film and surrounding

mechanism. Other features provide for automatic centering in changing over from silent film to sound-on-film and for the attachment of the magnascope lens.
C. M. T.

Photographic Aspects of Sound. A. PEREIRA. *Cinema*, **33**, Dec. 4, 1929, p. xvi. Among causes of lack of quality of sound films are the following: imperfect contact between negative and positive in the printer; slipping between negative and positive; scattering of light in the film; irregular motion of the film in camera or printer caused by sprocket teeth errors; sharp focus of the "sound beam" in recording. Unwanted sounds are caused by splices, reflections from edges of printer gates, hair-like spaces between sound and picture caused by a convex-sided camera mask, and fine serration of the black line between sound and picture.—*Kodak Abstr. Bull.*

Photographing Sound. *Photo-Era*, **64**, March, 1930, p. 160. Various methods of analyzing and photographing sound are discussed. Those considered are: Foley and Souder's method utilizing two spark gaps in which one produces the sound and the other furnishes the light (a record of the shadow of the wave being obtained); the method used by Koenig, Nichols, and Merrit, in which photographs are made of a gas flame, which vibrate in response to the sound waves; the phonodeik of D. C. Miller, which uses a vibrating mirror mounted on a tiny spindle; a similar system used by A. E. Bawtree; the sonometer of A. Hilger makes use of a platinized diaphragm as the refracting medium, and the system whereby the sound waves are converted into electromagnetic waves which in turn operate an oscillograph of the Blondel type.—*Kodak Abstr. Bull.*

Technical Problems of Talking Films. K. SCHINZEL. *Kinotechnik*, **11**, July 5, 1929, p. 346. The first of this series of articles deals with the general methods used for production of sound films and considers in a general way the requirements as to frequency range, width of sound track available, and similar factors. He considers the use of paper film both for photographic and magnetic records.—*Kodak Abstr. Bull.*

Technical Problems of Sound Film. II. K. SCHINZEL. *Kinotechnik*, **11**, Sept. 5, 1929, p. 464. This instalment is a discussion of photo-chemical problems.
C. M. T.

Making Sound Films. II. The Photographic Stock Factor. T. T. BAKER. *Kinemat. Weekly*, **155**, Jan. 2, 1930, p. 125. For variable width sound recording, the necessary characteristics of the emulsion are freedom from fog and from graininess, while for variable density sound recording a straight line form of the characteristic curve is the ideal. Methods of examination of the characteristics of negative or positive stock are simply explained.—*Kodak Abstr. Bull.*

New Sound Picture Laboratory. H. A. PRICE. *Bell. Lab. Record*, **8**, February, 1930, p. 257. This description of the new sound picture addition to the Bell Laboratories includes photographs and diagrams of the layout. Both film and disk recording and reproducing are planned, and a complete film finishing department has been installed in this model laboratory. C. M. T.

The Decibel. JOHN DUNSHEALTH. *Projection Eng.*, **2**, May, 1930, p. 15. The origin of the word *Decibel*. E. E. R.

Architectural Acoustics. P. R. HEYL. *Projection Eng.*, **2**, May, 1930, p. 15. A discussion in which the fundamental principles governing the construction of an acoustically successful auditorium are stated. An example is given which

illustrates the application of these principles in the planning of a new auditorium.
E. E. R.

Monitor and Recording Room. *Cinema*, **33**, Dec. 4, 1929, pp. xv and xvi. At the Wembley studios, a mobile monitoring box containing the amplifiers is used. Klangfilm recording apparatus will be used. British Talking Pictures recording system, using the "photeon" lamp is at present employed. The sound record is identified by photographing on the film at intervals of an inch or two a lantern slide carrying the scene and shot numbers. Each half minute, figures up to ten in Morse code are printed on the side of the film opposite the sound track. Corresponding figures are recorded on the picture negative in the space to be occupied by the sound track. Between shots, a punch hole is made on the edge of the film, indicating where cuts can be made in processing. The "photeon" lamp is in the anode circuit of a single L. S. 5 valve, having 900 volts anode potential, and an output of 15 milliamperes. The lamp resembles a minute arc lamp, with a fine iron cathode and tungsten anode.—*Kodak Abstr. Bull.*

Britain's Latest Sound Studio. *Cinema*, **33**, Dec. 4, 1929, p. xii. The article presents a description of the new sound studio of British Talking Pictures, Ltd., at Wembley. All lighting is controlled from overhead, and there are no cables on the floor. An outstanding feature is the use of intercommunicating telephones. The Plenum ventilation system is used. For sound insulation, the walls consist of one main shell of brick. The structure is of concrete blocks with triangular breeze blocks inside. Eight inches away from this is a lining of insulite, supported on a light wooden frame, and having no mechanical connection with the main structure. The wood floor rests on a three-inch layer of a kind of tarmac. The studio is 120 by 90 by 30 feet, to the top gallery, and about 20 feet to a second gallery running round the wall. A tank 33 feet square by 9 feet deep is provided.—*Kodak Abstr. Bull.*

Lighting a Modern Studio. *Cinema*, **33**, Dec. 4, 1929, p. xii. At the Wembley studios of British Talking Pictures, Ltd., incandescent lighting is used throughout. Lamps are massed in banks hung on cables which travel on overhead rails. The banks can be tilted to any desired angle. In the galleries, twelve switchboards feed eight mobile trucks each capable of handling 3000 amperes. The lamps are 500 watt, arranged in banks, and each lamp is provided with a reflector following the shape of the bulb. Lamps consuming several kilowatts are also available. Ventilation is so efficient that the heating is not noticeable on the floor.—*Kodak Abstr. Bull.*

New Fearless Silent Camera. A. REEVES. *Intern. Phot.*, **1**, January, 1930, p. 34. It is claimed that this sound and picture camera can be used at a distance of ten feet from the microphone. It is equipped with a high pressure oiling system, a unique focussing arrangement, and an automatic film tension control. Accessories are furnished which can be used for wide pictures and for Multicolor.
C. M. T.

Continuous Projectors and Colour. *Cinema*, **33**, Dec. 4, 1929, p. vii. The Photo-Vision continuous projector, invented by W. E. John, was demonstrated in London on Nov. 7, 1929. It uses a series of lenses, each independently mounted, moving in a D-shaped slot. The frames are centered to the lenses by lengthening or shortening the path of travel of the film from one reel to the other. A special mirror gives an elongated image of the arc, and the carbons are arranged so as to cast no shadow on the mirror. For wide film, it is proposed to use standard stock run through the projector sideways. The advantages of the continuous projector for additive color cinematograph projection are indicated.—*Kodak Abstr. Bull.*

Excellence in Auditoriums. W. A. MacNair. *Bell Lab. Record*, **8**, March, 1930, p. 325. MacNair gives a review of work done to decide on a criterion for good quality of reproduction of music and speech. It has been found that the product of the reverberation time and the loudness sensation produced by a standard source is constant for all good auditoriums. The absorption characteristics for each frequency can be deduced from known data and the results check the known fact that an extremely reverberant room is usually acoustically good with a large audience present.—*Kodak Abstr. Bull.*

A Year of Talkies. Survey of New Systems and Working Conditions. R. H. Cricks. *Kinemat. Weekly*, **155**, Jan. 2, 1930, p. 133. Eighteen sound reproduction sets are available to the British exhibitor, of which eleven are British products, six American, and one German. The use of selenium cells instead of photo-electric cells is being developed. C. M. T.

Moving Picture Industry Has Four Billion Capital. *Projection Eng.*, March, 1930, p. 32. A summary of the report of the International Labor Bureau on classified statistics regarding the motion picture industry. G. L. C.

Birth of the Cinema. W. Day. *Intern. Phot.*, **1**, July, 1929, p. 3. Neglecting certain primitive steps we can view the invention of the camera obscura about 1437 as the first step in the development of modern moving pictures. Early in the seventeenth century Athanasius Kircher described a primitive magic lantern. To Wedgewood, Niépce, Daguerre, and Fox-Talbot we are indebted for the beginnings of modern photographic processes. To bring about the invention of motion pictures, knowledge of persistence of vision was necessary. Roget apparently first recorded observations on this subject in a paper read before the Royal Society. The Thaumatrope, Phenakistoscope, Stroboscope, Daedaleum, and Zoetrope were early instruments using this effect to give the appearance of movement. John Rudge first portrayed movement using successive lantern slides, but his successors, Friese-Greene, Beale, Linnet, Ross, and Edison, made improvements which culminated in Marey's Stereo-Zoetrope. Muybridge first used pictures taken in rapid succession with a number of cameras whose shutters were electrically controlled. C. M. T.

Simulating Sunlight. M. Luckiesh. *Gen. Elec. Rev.*, **33**, February, 1930, p. 89. The new General Electric "Sunlamp" is described.—*Kodak Abtr. Bull.*

Glossary of Cinematic Terms. II. *Amat. Films*, **2**, January, 1930, p. 110. This is the second installment of a series of technical and general phrases used in cinematography. C. M. T.

BOOK REVIEWS

Technical Digest—Fundamentals of Sound Recording and Reproduction for Motion Pictures. *Academy of Motion Picture Arts and Sciences,* Hollywood, Calif., loose leaf, 1930, 216 pp. Authoritative articles on sound motion pictures will be issued from time to time in the form of loose leaf additions to the *Technical Digest.* Most of the material thus far included is based upon lecture-demonstrations given before the School in Fundamentals of Sound Recording and Reproduction conducted by the Academy in 1929. It is obviously impossible to present a comprehensive review of a series of papers covering so many phases of sound motion picture theory and technic. Some of the foremost authorities in the field have contributed well illustrated articles on the history of sound recording, physical and physiological aspects of sound, acoustics, psychological factors affecting the illusion of sound pictures, photographic theory, and the optical technic peculiar to the various recording processes. C. M. T.

Scenario Writing. Marion Norris Gleason. *Amer. Photographic Pub. Co.,* Boston, 1929, $3.50, 308 pp. The purpose of this book is to show simply and clearly to the amateur cinematographer the construction of motion pictures considered as drama. In working up a finished production the scenario's importance is very greatly stressed, and various hints are given on choosing its plot. The entire field of childhood stories can be drawn from if children are to be the audience. If an organized group is producing the picture, they may often have country clubs, private yachts, fire departments, and universities at their command and hence an elaborate plot may be developed. All have at their disposal an unlimited amount of written story material of the world—fiction, history, and classics. Since the experimental field has only been touched much can now be done with color and sound. The amateur enthusiast can learn a great deal from this interesting book. It will be of great value to the club planning its first production since it shows the background behind the successfully made professional pictures. Twenty scenarios are given to be used as models and there are also sixteen illustrations from some amateur productions.—*Kodak Abstr. Bull.*

SOCIETY OF MOTION PICTURE ENGINEERS

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E. JEWELL

Papers and Programs

E. HUSE, *Chairman*

CHICAGO SECTION

The organization meeting of the Chicago Section of the Society was held May 31, 1930, at the City Club. Mr. O. B. DePue and Mr. O. F. Spahr were elected governors. Mr. J. A. Dubary, Mr. Fred Kranz, and Mr. E. S. Pearsall, Jr., were elected to serve on the Papers and Program Committee. Mr. B. W. Depue was appointed as a Publicity Committee of one.

Boundaries of the Section were proposed as follows: The eastern boundary shall be a north and south line through a point 50 miles west of Cleveland; the western boundary shall be a north and south line running through a point 50 miles west of Denver; the north and south boundaries shall be those of the United States.

A motion was passed that a dinner meeting be held once a month in a place to be selected by the governors, and that the meeting of any month might be cancelled by the governors at their discretion.

LONDON SECTION

April, 1930

Sir Oliver Lodge, making his first appearance at a cinematograph trade function, was guest of honor at the first annual dinner of the London Section. A program of films, starting with the first Lumière film shown upon its original instrument by Matt Raymond, its original projectionist, and ending with a showing of present day talkies with equipment installed by Western Electric, followed the dinner.

The last general members' meeting of the session was held at the headquarters of the Royal Photographic Society on April 14th, when Mr. N. Fleming of the National Physical Laboratory read a paper on the "Acoustics of Buildings."

NEW YORK SECTION

A meeting of the section was held in the Engineering Societies Building, April 16, 1930.

Papers were presented by Mr. Hall of the *New York Times* on "The Critic's Viewpoint on Talking Pictures," by Mr. Mendoza on his experiences in orchestra direction before the microphone, and by Mr. Cook on "The Aperture Effect." A schedule of eight meetings per year has been adopted by the section.

A meeting is scheduled for June 12, 1930, at the Engineering Societies Building. At this meeting Mr. Townsend will present the report of the Projection Committee and Messrs. Lette and Wolf will present a paper on "Factors Governing Size of Sound Reproducing Equipment in Theaters."

PACIFIC COAST SECTION

The third meeting of the season was held on one of the sound stages of the Metropolitan Sound Studios, Inc. An open discussion of the type of programs desired by the Section and of regular *vs.* irregular meeting times was held. It was decided to continue the present policy of flexible meeting dates.

Mr. Richardson was elected as delegate to the spring convention in Washington. Mr. George Mitchell was selected to represent the Section in discussions of wide film problems at the convention.

Results obtained with the Douglass wide film panorama lens were demonstrated by projecting pictures from standard 35 mm. film.

Recent Multicolor films were shown by Mr. Harry Fisher.

SOCIETY NOTES

At the meeting of the Board of Governors held at the Engineering Societies Building, New York, N. Y., Tuesday, June 3rd, a large number of business matters were transacted including the following:

1. A committee was appointed to draw up a report for circulation to the sections of the Society, explaining in detail what expenditures are justifiable, and also to consider the desirable geographical boundaries of the various sections in the United States. The Board was in doubt as to whether the boundaries of the various sections should be limited to an area within a definite radius from the section's headquarters or whether the three sections, namely, New York, Chicago, and the Pacific Coast should include the entire United States.

2. The Board having satisfied itself that the financial situation of the Society justifies the appointment of an editor-manager, a motion was made and passed as follows: "A person of high caliber shall be secured to edit and publish the JOURNAL from a central office and also to transact the routine business of the Society, this individual to be supplied with qualified editorial and clerical assistants."

3. A motion was made and passed: That applications for membership originating in the territory of any section of the Society are to be first submitted for comment to the local section's Board of Managers.

4. A committee was appointed consisting of J. H. Kurlander and W. M. Palmer to recommend suitable headquarters for the Society in New York City. The Board recommended that the location should be within a reasonable distance of the Grand Central Terminal.

5. As a result of a proposal that all discussions of papers presented at meetings be eliminated from the JOURNAL, the Board recommended that the editor should continue to edit and publish discussions of papers in accordance with past practice.

6. The Board approved a recommendation of the Publicity Committee to permit trade papers to abstract the text of papers presented at conventions to an extent not exceeding 20 per cent of the text of any paper.

7. A revised application blank submitted by the Secretary was approved. The new blank provides for a more complete description of an applicant's qualifications.

8. The Treasurer reported on the Washington convention receipts and expenses as follows:

Gross Expenses	$2460.18
Gross Receipts	2305.50
Deficit	$ 154.68

9. A motion was made and passed that the President appoint a committee to consider the establishment of a post graduate course in motion picture engineering in a number of selected universities.

WANTED—AN EDITOR-MANAGER

In accordance with a resolution of the Board of Governors applications are hereby invited for a combined business manager of the Society and editor of the JOURNAL who will be located at the headquarters of the Society in New York City. The manager-editor will be supplied with capable editorial and clerical assistants and his duties will be (*a*) to edit the JOURNAL under the jurisdiction of the

Board of Editors, (*b*) to transact the routine business of the Secretary and Treasurer and the various committee chairmen, and (*c*) to assist the President in coördinating the various activities of the Society.

Desirable qualifications of the applicant include a pleasing personality, managerial and technical editorial ability, and a broad knowledge of the motion picture industry. The salary will be not less than $6000 per year.

Applications should be forwarded to Mr. J. H. Kurlander, Secretary, 2 Clearfield Avenue, Bloomfield, N. J., not later than July 15th.

CONSTITUTION AND BY-LAWS AS AMENDED OCTOBER, 1929 AND MAY, 1930

Article 1. Name.

The name of this association shall be Society of Motion Picture Engineers.

Article 2. Objects.

Its objects shall be: Advancement in the theory and practice of motion picture engineering and the allied arts and sciences, the standardization of the mechanisms and practices employed therein, the maintenance of a high professional standing among its members, and the dissemination of scientific knowledge by publication.

Article 3. Eligibility.

Any person of good character may be a member in any class for which he is eligible.

Article 4. Officers.

The officers of the Society shall be a President, the Past-President, a Senior Vice-President, a Junior Vice-President, a Secretary, a Treasurer, and a Board of Governors.

All officers shall hold office for one year, or until their successors are chosen, except the Board of Governors, as hereinafter provided, and the Vice-Presidents, one of which latter shall be elected each year to serve for two years.

Article 5. Board of Governors.

The Board of Governors shall consist of the President, the Past-President, the Senior Vice-President, the Junior Vice-President, the Secretary, the Treasurer, the Section Chairmen, and four other Active Members, two of which last named shall be elected each year to serve for two year terms.

Article 6. Meetings.

There shall be an annual meeting, and such other meetings as stated in the By-Laws.

Article 7. Amendments.

This Constitution may be amended as follows: Amendments shall be approved by the Board of Governors and shall be submitted for discussion at any regular members' meeting. The proposed amendment and complete discussion then shall be submitted by publication to the entire Active membership together with letter ballot as soon as possible after the meeting. Two-thirds of the vote cast within sixty days after mailing shall be required to carry amendment.

BY-LAWS:

BY-LAW I

MEMBERSHIP

SECTION 1. The membership of the Society shall consist of Honorary Members, Active Members, Associate Members, and Sustaining Members.

An *Honorary Member* is one who has gained high distinction in the science of motion picture engineering or the allied arts of sciences.

Honorary membership may be granted upon recommendation of the Board of Governors when confirmed by a four-fifths majority vote of the Active Members present at any regular meeting of the Society. An Honorary Member shall be exempt from all dues.

An *Active Member* is one who shall be not less than 25 years of age, and shall be:

(*a*) A motion picture engineer by profession. He shall have been in the practice of his profession for a period of at least three years and shall have taken responsibility for the design, installation, or operation of systems or apparatus pertaining to the motion picture industry.

(*b*) A person regularly employed in motion picture or closely allied work, who by his inventions or proficiency in motion picture science or as an executive of a motion picture enterprise of large scope, has attained a recognized standing in the motion picture profession. In case of such an executive, the applicant must be qualified to take full charge of the broader features of motion picture engineering involved in the work under his direction.

An *Associate Member* is one who shall be not less than 21 years of age, and shall be a person who is interested in or connected with the study of motion picture technical problems or the application of them. An Associate Member is not privileged to vote.

A *Sustaining Member* is an individual, a firm, or corporation contributing to the financial support of the Society.

SECTION 2. All applications for membership or transfers shall be made on blank forms provided for the purpose, shall give a complete record of the applicant's education and experience, and shall be accompanied by the required entrance or transfer fee.

SECTION 3. Applicants for Active membership shall give as references at least three Active members in good standing, and for Associate membership, at least one Active member in good standing. Applicants may be elected to membership by a three-fourths majority vote of the members and the Board of Governors.

SECTION 4. Active and Associate membership becomes effective upon payment in full of the entrance fee.

BY-LAW II

OFFICERS

SECTION 1. An officer shall be an Active Member of not less than one year's standing.

SECTION 2. Vacancies in the Board of Governors, except that of the President, shall be filled by the Board of Governors until the Annual meeting of the Society.

In case of a vacancy, the senior Vice-President shall fill the office of President, until the next Annual meeting.

BY-LAW III

BOARD OF GOVERNORS

SECTION 1. The Board of Governors shall transact the business of the Society between regular members' meetings, and shall meet at the call of the President.

BY-LAW IV

MEETINGS

SECTION 1. The location of each meeting of the Society shall be determined by the Board of Governors, after submitting not less than two places to be considered by the entire membership, the Board preferably selecting the place receiving the majority choice.

SECTION 2. Active Members only shall be entitled to vote.

SECTION 3. A quorum of the Society shall consist in number of one-tenth of the total number of Active Members as listed in the Society's records at the close of the last fiscal year; and of the Board, a majority.

SECTION 4. Special meetings may be called by the President and upon the request of any three members of the Board of Governors, not including the President.

BY-LAW V

DUTIES OF OFFICERS

SECTION 1. The President shall preside at all business meetings of the Society; he shall appoint all committees and be an ex-officio member of the same; he shall perform the duties pertaining to this office.

SECTION 2. A Vice-President, in the absence of the President, shall preside at meetings and perform the duties of the President.

SECTION 3. The Secretary shall keep a record of all meetings; he shall conduct the correspondence relating to his office, and shall have the care and custody of records, and the seal of the Society.

SECTION 4. The Treasurer shall have charge of the funds of the Society, and disburse the same, as and when authorized by the Board of Governors, subject to the approval of the President and Secretary. He shall make an annual report, duly audited, to the Society, and a report at such other times as may be requested. He shall be bonded in an amount to be determined by the Board of Governors, and his bond filed with the Secretary.

BY-LAW VI

ELECTIONS

SECTION 1. All officers and four Governors shall be elected to their respective offices by a majority of ballots cast by the Active Members in the following manner:

Not less than three months prior to the Annual Fall Convention, the Board of Governors, having invited nominations from the active membership by letter form not less than forty days before the Board of Governors' meeting, shall nominate for each vacancy several suitable candidates. The Secretary shall then notify these candidates of their nomination in order of nomination and request their consent to run for office. From the list of acceptances, not more than two names for each vacancy shall be selected by the Board of Governors and placed on a letter ballot. A blank space shall also be provided on this letter ballot under each office in which space the names of any Active Members other than those suggested by the Board of Governors may be voted for. The balloting shall then take place.

The ballot shall be enclosed in a blank envelope which is enclosed in an outer envelope bearing the Secretary's address and a space for the member's name and address. One of these shall be mailed to each Active Member of the Society, not less than forty days in advance of the Annual Fall Convention.

The voter shall then indicate on the ballot one choice for each office, seal the ballot in the blank envelope, place this in the envelope addressed to the Secretary, sign his name and address on the latter, and mail it in accordance with the instructions printed on the ballot.

The sealed envelope shall be delivered by the Secretary to a committee of tellers appointed by the President at the Annual Fall Convention. This committee shall then examine the return envelopes, open and count the ballots, and announce the results of the election.

BY-LAW VII

DUES AND INDEBTEDNESS

SECTION 1. The entrance fees for all applicants shall be $30.00 for admission to the grade of Active Member, and $20.00 for admission to the grade of Associate Member.

SECTION 2. The transfer fees from Associate to Active grade shall be the difference between the above mentioned fees, or $10.00.

SECTION 3. The annual dues shall be $20.00 for Active Members, and $10.00 for Associate Members, payable on or before October 1st of each year. Current or first year's dues for new members, dating from the notification of acceptance in the Society, shall be prorated on a quarterly basis, said quarters beginning October 1st, January 1st, April 1st, and July 1st. Ten dollars of these dues shall apply for annual subscription to the monthly publication.

SECTION 4. Annual dues shall be paid in advance. All Active Members in good standing, who shall have paid dues for the preceding year, may vote or otherwise participate in the meeting.

SECTION 5. Members shall be considered delinquent whose dues remain unpaid for four months. Members who are in arrears of dues for 30 days, after notice of such delinquency, mailed to their last address of record, shall have the names posted at the Society's headquarters which shall be the office of the Secretary, and notices of such action mailed them. Two months after becoming delinquent, members shall be dropped from the rolls if non-payment is continued.

SECTION 6. Any member may be suspended or expelled for cause by a majority vote of the entire Board of Governors; provided, he shall be given notice and a copy in writing of the charges preferred against him, and shall be afforded opportunity to be heard ten days prior to such action.

BY-LAW VIII

EMBLEM

SECTION 1. The emblem of the Society shall be a facsimile of a four-hole film-reel, with the letter S in the upper center opening, and the letters M, P, and E in the three lower openings, respectively. In the printed emblem, the four-hole openings shall be orange, and the letters black, the remainder of the insignia being black and white. The Society's emblem may be worn by members only.

BY-LAW IX

PUBLICATIONS

SECTION 1. All matters of general interest deemed worthy of permanent record shall be published in serial volumes as soon as possible after each regularly called members' meeting. A copy shall be mailed each member in good standing to his last address of record. Extra copies shall be printed for general distribution, and may be obtained from the Secretary on the payment of a fee fixed by the Board of Governors.

BY-LAW X

LOCAL SECTIONS

SECTION 1. Sections of the Society may be authorized in any state or locality where the Active membership exceeds 20. The geographic boundaries of each section shall be determined by the Board of Governors.

Upon written petition, signed by 20 or more Active Members, for the authorization of a Section of the Society, the Board of Governors may grant such authorization.

MEETINGS

SECTION 2. The regular meetings of a Section shall be held in such places and at such hours as the members may have designated at the preceding meeting.

The Secretary-Treasurer of each section shall forward to the Secretary of the General Society, not later than five days after a meeting of a Section, a statement of the attendance and of the business transacted.

OFFICERS

SECTION 3. Each Section shall nominate and elect a Chairman, two managers, and a Secretary-Treasurer. The Section Chairmen shall automatically become members of the Board of Governors of the General Society, and continue in that position for the duration of their terms as Chairmen of the Local Sections.

ELECTION OF OFFICERS

SECTION 4. The officers of a Section shall be elected to their respective offices at the Annual fall meeting of the Section, by a majority of autographed ballots of the membership of the Section, and counted by a Committee of Tellers appointed by the Section's Chairman.

All Section officers shall hold office for one year or until their successors are chosen, except the Board of Managers, as hereinafter provided.

MANAGERS

SECTION 5. The Board of Managers shall consist of the Section Chairman, the Section Past Chairman, the Section Secretary-Treasurer and two Active Members, one of which last named shall be elected for a two year term, and one for one year, and then one for two years each year thereafter. At the discretion of the Board of Governors and with their written approval this list of officers may be extended.

BUSINESS

SECTION 6. The business of a Section shall be conducted by the Board of Managers.

EXPENSES

SECTION 7. (*a*) As early as possible in the fiscal year, the Secretary of each Section shall submit to the Board of Governors of the Society, a budget of expenses for the year.

(*b*) The Treasurer of the General Society may deposit with each Section Secretary-Treasurer, a sum of money, the amount to be fixed by the Board of Governors, for current expenses.

(*c*) The Secretary-Treasurer of each Section shall send monthly to the Treasurer of the General Society, an itemized account of all expenditures during the preceding month.

(*d*) Other expenses than those enumerated in the budget, as approved by the Board of Governors of the General Society, to be payable from the funds of the General Society, must first be authorized by the Board of Governors.

(*e*) A Section Board of Managers may authorize, and shall provide for the payment of local assessments or any expenses of a Section beyond those authorized to be paid from the general fund of the Society.

(*f*) The Secretary of the Society shall, unless otherwise arranged, supply to each Section all stationery and printing necessary for the conduct of its business.

PAPERS

SECTION 8. Papers shall be approved by the Section's Papers Committee previous to their being presented before a Section. Manuscripts of papers presented before a Section, together with a report of the discussions, and the proceedings of the Section meetings, shall be forwarded promptly by the Section Secretary-Treasurer to the Secretary of the General Society. Such material may, at the discretion of the Journal Committee of the General Society, be printed in the Society's publications.

MEMBERSHIP

SECTION 9. Should the Active membership of a Section fall below 20, or the average attendance at meetings not warrant the expense of maintaining the organization, the Board of Governors may cancel its authorization.

SECTION 10. All members of the Society of Motion Picture Engineers in good standing residing in that portion of any country set apart by the Board of Governors tributary to any local Section, shall be considered members of that local

Section, and shall be so enrolled and they shall be entitled to all privileges that such local Section may, under the General Society's Constitution and By-Laws, provide.

CONSTITUTION AND BY-LAWS

SECTION 11. Sections shall abide by the Constitution and by By-Laws of the Society, and conform to the regulations of the Board of Governors. The conduct of Sections shall always be in conformity with the general policy of the Society as fixed by the Board of Governors.

BY-LAW XI

AMENDMENTS

These By-Laws may be amended at any regular meeting of the Society by a two-thirds vote by ballot of the members present at the meeting, a quorum being present, either on the recommendation of the Board of Governors or by a recommendation to the Board of Governors signed by ten Active Members.

JOURNAL
OF THE SOCIETY OF
MOTION PICTURE ENGINEERS

LOYD A. JONES, EDITOR *pro tem.*

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SOME ASPECTS OF THE NATIONAL ELECTRICAL CODE AS APPLIED TO THE MOTION PICTURE INDUSTRY

JAC. R. MANHEIMER*

Recent fires both in the East and in the West have more than ever attracted the attention of the various fire underwriters and fire prevention bureaus to the necessity of formulating rigid and definite requirements in connection with the vast amount of electrical work now being installed or contemplated in the studios, laboratories, film exchanges, and theaters.

The writer hopes, through this paper, to provoke sufficient discussion at this meeting to disclose any technical data regarding the explosiveness of gases given off by film, especially in view of the statements made by some writers that nitrocellulose film is not explosive.

It is not the purpose of this paper to discuss the chemistry of film nor the fire hazards attendant to the handling of it, but it cannot help but bring forth features which are relevant and important to some features of electric work, which have heretofore been uncertain.

The object of the Electric Code as recommended by the National Fire Protection Association is to provide definite requirements for the installation and subsequent safe operation of electric circuits, conduit systems, distribution centers, and electrical equipment in general in various types of buildings.

The development, however, of the motion picture art has been so rapid, especially the electrical phase, that the Code has been unable to keep pace with it. This is partly due to the fact that the Electrical Code Committee revises the Code only every second year.

The Code Committee works by subdividing and parcelling out to several subcommittees the various sections of the Code, and these committees turn in their reports to the committee chairman previous to the biannual meeting which usually takes place in February. The changes and additions are adopted or rejected by the full committee

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* E-J Electric Installation Co., New York City. (Read before the Society at Washington.)

at this meeting, and such changes and additions as are accepted are embodied in the next issue of the National Electric Code.

CONFLICTS WITH PRESENT CODE

The majority of our membership is generally familiar with many of the requirements of the National Electric Code applying to the motion picture industry; but few realize that if some requirements contained in the present Code were enforced, the development and expansion of the art would suffer considerably. Several items are ambiguously covered by the Code or are in conflict with it. For example, Section 503*n* reads, "Wires of different systems shall not occupy the same conduit." This is explained by a fine print note which states, "Different systems are those which derive their supply from (1) different sources of current, (2) transformers connected to separate primary circuits, or (3) transformers having different secondary voltages." While the ruling speaks of conduit only, it is interpreted to mean metal enclosures of all kinds, such as cutout boxes, raceways, troughs, and ducts.

In many systems of sound recording and reproduction, the a.c. street service is supplied to the motors which drive d.c. generators on motor generator sets. The generators usually furnish 12 volts for filament supply, 250 volts for grid bias, and as high as 1000 volts for plate potential. The circuits supplying these various voltages are grouped at the amplifying boards and in the amplifying tubes themselves.

There are also systems where different voltages are supplied from batteries which are in turn charged by either motor generators or rectifiers.

The question at once arises as to whether, under the Section 503*n*, these wires can be installed in the same conduits.

SOUND RECORDING INSTALLATIONS VS. ELECTRICAL CODE

The question of Code requirements is probably more complex in the studio at this time than in any other division of the industry.

Section 503*q* of the Code limits the number of wires in a conduit or a duct to those given in a schedule under this section. This causes mechanical conflict at amplifying boards, horns, motor patch panels, and at other pieces of apparatus where thousands of wires from all parts of the building may terminate at one location.

For example, in the Western Electric Company's electrical interlocking recording system; the energy which operates the various synchronous devices is obtained from a special motor generator assembly known as a "distributor." The generator of this device functions as a phase changer since it has impressed upon it the house supply of 220 volts, 3-phase, 60 cycle current, and in operation the phases are shifted so that the output voltage is approximately the same as the input at 3-phase but about 30 degrees phase difference. The distorted output supplies fractional horsepower motors on the various cameras and recording equipment in the studio at approximately 220 volts, 3-phase. The motor driving this phase changer is energized from a 110 volt d.c. supply which is the output of a $1^1/_2$ kw. motor generator set. The motor on the $1^1/_2$ kw. motor generator set is supplied by the 3-phase, 220 volt house current. The armature winding of the distributor motor is tapped at two opposite points through slip rings. By this means, 20 cycle a.c. at approximately 27 volts, is delivered for special speed control. This 20 cycle a.c. is passed through a small transformer and then through a rectifier tube for furnishing rectified plate current (d.c.) back into a special control field on the same motor for regulating its speed.

The same rectified a.c. is also transmitted to various "starting stations" on the studio stages to give visual indications on d.c. milliammeters of the amount of current in milliamperes flowing in the control field stated above.

A d.c. series field is also provided on the driving motor of the distributor to give extra torque for "starting duty" only, but is automatically taken out of circuit when the motor reaches full speed.

The rotor of the distributor motor is equipped with a small inductor generator which delivers a.c. at a frequency of approximately 720 cycles and 130 volts and supplies energy through a filter which in combination with a rectifier tube furnishes the energizing current to the control field stated above.*

The camera and recording motors each have a rotor and stator with independent windings. The stators are supplied from the 3-phase, 220 volt house current and the rotors from the distorted phase supply output of the distributor. The rotor current has the same

* In the theater projection booth, similar combinations having different voltages and different characteristics obtain with the Western Electric driving motor unit and speed control on projectors so that we have nearly the same problems, as far as the Code requirements are concerned, although of a lesser magnitude.

voltage and characteristics as the house current except for its angular phase displacement effected by the distributor.

From the distributor, a set of six wires is run to an interconnection panel, known in recording parlance as a patch panel. In addition to these six wires, there are two more wires for the rectified milliammeter current following the same route. Six wires are run between the patch panels and each fractional horsepower motor; eleven additional wires between the patch panel and each starting station.

Six wires running to the fractional horsepower motors are all a.c.

Two wires connect to the indicating d.c. milliammeters (rectified a.c.).

Three wires connect to a special 3-phase, 220 volt rheostat located at the motor station.

Six wires run to starting stations and are used for actuating solenoids, starting relays, and signals through momentary contact push buttons.

From the brief description of only the circuits involving the interlocking distributor system, it is readily seen how complex the conduit system would be if strict adherence to Section 503*n* of the Code were enforced.

In connection with the battery supply, "B" battery energy is usually furnished by the same set of batteries at 350 and 130 volts. These batteries are charged from the $1^1/_2$ kw., 120 volt d.c. motor generator mentioned above, the driving motor of which, as already stated, is connected to the 3-phase, 220 volt house supply.

The "A" battery supply of 6 volts is obtained from one high capacity set of storage batteries and the 12 volt "A" battery supply from another high capacity set. Both sets are charged by a combination $7^1/_2$—15 volt special d.c. motor generator set, the driving motor of which is also connected to the 3-phase, 220 volt house supply.

On the stages themselves, microphone junction boxes are installed which contain a 130 volt local dry "B" battery connected to the microphone amplifier. A 6 volt "A" battery supply is also brought to this same terminal point as well as six pairs of No. 19 twisted lead-covered conductors which run to the monitoring room for microphone output. At these junction boxes, the multiple point pin plug receptacles provided are arranged with a ground connection for the continuous electrostatic shielding and grounding.

These descriptions of interconnected electrical systems of various voltages and characteristics are not given as a treatise on the electrical circuits of sound recording, for this is neither the scope of this paper nor a task which the writer is prepared to undertake, but are given merely to indicate the complexity of the many problems which the Code Committee must work out.

NEW CODE REQUIREMENTS FOR SOUND RECORDING AND REPRODUCTION SYSTEMS

In order to provide all the safety possible and at the same time to permit reasonable methods to be used which will not hinder nor interfere with development and progress in this branch of the art, a subcommittee of the National Fire Protection Association has been delegated to work out this problem and will submit to the Electrical Committee which meets in February, 1931, the following recommendations dealing with sound recording and reproduction for inclusion as rules in the next issue of the National Electric Code:

3502 (*a*) Automatic overload protective devices shall be provided in accordance with the requirements of Article 8 of this Code. The smallest practical rating or adjustment with which the apparatus will operate should preferably be used. Circuits to supply "B" or "C" voltage shall be protected by automatic overload protective devices rated at not more than 1 ampere.

(*b*) Wires may be grouped in the same conduit, armored cable, metal raceway, pull box, junction box, or flexible cord, types K, S, or SJ between receptacles and loud speakers or camera booths, under conditions as noted in sub-paragraphs 1 to 5 below, provided all wires have insulation rated for the maximum voltage applied to any wire. In no case shall the insulation requirements be less than that for 600 volts.

1. Wires emanating from the same piece of apparatus and/or terminating in the same piece of apparatus.
2. Wires that carry current from a primary source which is used to drive a motor whose speed is electrically controlled, or to drive a group of motors operating in synchronism may be run in the same conduit, *etc.*, with wires that carry other currents of characteristics differing from the characteristics of the primary current, required for the operation and/or synchronization of a motor or group of motors.
3. Wires to loud speaker fields and armatures, also from receptacles to camera booths provided that when receptacles and plugs are used they shall be of polarized type.
4. Wires from the projector sound head and/or turntable to amplifier equipment.
5. Wires to supply "A," "B," and "C" voltage from motor generators and batteries provided they are protected by automatic overload protective devices installed at the nearest accessible point to the batteries or generators.

(*c*) Input leads to a motor generator or to a rotary converter shall be run separately from wires emanating therefrom.

(*d*) Storage batteries shall be installed in accordance with proposed requirements of revised Article 18.

(*e*) Insulation of wires exposed to oil or oil dripping shall be of a type approved for interior wiring that will not be injured by oil or shall be protected from such injury by a seamless metallic covering over the insulation.

(*f*) The number of wires in any one conduit shall be limited by Section 503*q*, Table 3.* That for metal trough raceway shall comply with Table 3, allowing 40 per cent of area for conductors.

(*g*) Wires terminating in groups at patch panels or similar connection boards shall be covered with a single wrapping of asbestos tape or equivalent material over convenient groups. This is not required where the metallic covering is carried to within 6 inches of the terminals.

(*h*) Wires to or from "A" batteries shall be run in conduit or duct compartments and separated from all other wires, unless all wires and cables in the same conduit or duct are sheathed with lead or other approved shielding.

(*i*) All metal trough raceways shall be of not less than No. 14 B. S. sheet metal gauge. They shall have ample strength and rigidity in order that they will keep their shape. Seams, corners, back edges, and splices in sheet metal shall be flanged or lapped over, unless made of continuous weld, or they may be butt jointed if reënforced by flat iron strips of same thickness of metal as that of raceway. Seams shall not show open cracks when finished and before the raceway or ducts are painted or enameled. Covers shall be of same gauge metal as raceway and secured to raceway by machine screws spaced not more than 1 foot apart. If raceway is placed in floor and has cover flush with the surface, covers of at least $^1/_4$ in. steel must be used.

Metal trough raceway may be installed in concealed space if run in a straight line between outlet or junction boxes. Covers of boxes must be accessible. Edges of metal must be rounded at outlet or junction boxes, and all rough projections smoothed to prevent abrasion of insulation or conductors. Raceways made up of sections shall contain a ground conductor to which each section shall be bonded and grounded as prescribed by Article 9.

PROPOSED REVISION OF ARTICLE 18—N. E. CODE (STORAGE BATTERIES)

1801—*General*

(*a*) The provisions of this article are intended to apply to all stationary installations of storage batteries consisting of a number of cells connected in series with a nominal potential in excess of 16 volts and connected for service where so installed.

(*b*) Wiring and appliances supplied with current from such storage battery installations shall be subject to the general requirements of this Code applying to wiring and appliances fed from generators developing the same difference of potential.

1802—*Battery Room*

(*a*) Provision shall be made for a sufficient diffusion of the gases from the

* Schedule giving maximum number of wires permitted in conduit for "stage pocket, border circuits and elsewhere by special permission" now also applies to recording installations.

battery to prevent the accumulation of an explosive mixture in the battery room. (NOTE: Normally, natural means of ventilation are sufficient. The closed closet type of battery installation shall not be permitted.)

(*b*) Wiring shall be enclosed in non-corrodible or suitably protected conduit system, or shall be exposed and installed in accordance with the requirements of Section 501 of this Code, except that in battery rooms varnished cloth or tape insulated conductors shall not be permitted, and except that bare conductors may be used in the battery room when properly supported. Where metallic conduit or covering is used in the battery room, at least 12 in. of the conductor at the end connected to cell terminal shall be free from such metallic conduit or covering, and the end of the conduit or covering shall be sealed tightly to resist the entrance of acid or acid fumes.

1803—*Batteries not over 250 volts (nominal) potential*

(*a*) Cells in series circuit not over 250 volts shall be subject to the following provisions for additional insulation.

(*b*) Cells in lead-lined wood tanks, not over 50 volts series circuit, shall be supported individually on glass or glazed porcelain insulators; over 50 volts, on oil insulators.

(*c*) Cells in jars made of conducting material shall be installed in trays of non-conducting material supported on glass or glazed porcelain insulators, with not over 16 volts in series circuit in any one such tray.

(*d*) Cells in unsealed jars made of non-conducting material shall be assembled in trays supported on glass or glazed porcelain insulators; or, when installed on a rack, shall be supported in groups on glass or other insulating members.

(*e*) Cells in sealed rubber or composition jars, assembled in wood trays, shall have such trays supported on glass or other approved insulators.

(*f*) Cells in sealed rubber or composition containers, without wood trays, shall require no additional insulation when not over 150 volts in series circuit; when over 150 volts, shall be installed in trays or on racks with not over 150 volts in series circuit, each such tray or rack to be supported on glass or glazed porcelain insulators.

(*g*) Cells in sealed glass jars, either with or without wood trays, shall require no additional insulation.

1804—*Batteries over 250 volts (nominal) potential*

(*a*) Cells, of any type, in series circuit of over 250 volts, shall be subject to the provisions of Section 1803, and in addition shall be installed in trays or on racks supported on oil insulators, in groups of not over 250 volts in series circuit in each such insulated tray or rack; except where oil insulators are specified in Section 1803 for cells in series circuit of less than 250 volts; and excepting that cells of not over 10 ampere-hour capacity in sealed glass jars may be grouped in trays with not more than 250 volts in series circuit, each such tray to be supported on glass or glazed porcelain insulators, the trays being mounted on racks supported on oil insulators with not over 500 volts in series circuit on each such insulated rack. (NOTE: Maximum protection is secured by sectionalizing high voltage batteries into cell groups insulated from each other.)

1805—*Racks and Trays*

(*a*) Racks, as specified in this article, refer to either (1) wood racks coated with an acid resisting material; or, (2) metallic racks coated with acid resisting material and provided with non-conducting members for the support of the battery.

(*b*) Trays, as specified, refer to crates or trays made of wood or other non-conducting material, and when not of glass, rubber, or composition shall be coated with acid resisting material.

There are still a great many more items in the studio, laboratory, and theater for which the present National Electric Code does not make adequate provision and with which the Code Committee is greatly concerned.

GROUNDING AND SPECIAL ATTACHMENT PLUGS

The Labor Department of the State of New Jersey now requires a third or additional grounding conductor on all portable cables, cords, and polarity plugs, and receptacles for grounding portable equipment. This feature is now required on all film printing apparatus used in the film laboratories in New York City.

There has been considerable discussion resulting in special local requirements in which the use of the ordinary attachment plug and receptacle is prohibited in locations where film is handled.

In New York territory, the local inspection departments are requiring the use of a plug and receptacle device where the arc established by the pulling out of a plug is confined to the inside of the receptacle before the pins of the plug are completely withdrawn, thereby eliminating the possibility of igniting a piece of film which might be in proximity with such a plug and receptacle. This has been accomplished in various ways. One is to enclose the complete receptacle and plug in a cabinet with a self-closing cover slotted to permit the cord to pass through. When the plug is pulled out of the receptacle, the cover is still closed. Another device is designed with a metallic skirt deep enough to permit the pins of the plug breaking contact while the pins are still completely enclosed. As far as the writer knows, the matter is still being discussed by the Code Committees and some standard construction for these devices will probably be incorporated in its February, 1931, report.

VAPOR PROOF FIXTURES

The question of vapor proof fixtures in buildings where film is handled is well known to most of us. Most of the local inspection departments are requesting the use of vapor proof fixtures not only in film vaults but also in rooms where film is worked, as well as in corridors leading to such rooms. This applies equally to rooms in which sound film recording machinery is located.

There seems to be considerable difference of opinion regarding the real necessity for vapor proof fixtures. One inspection department in New York requires vapor proof fixtures but will also accept the use of a metal dish under the lamp when located in film working rooms; in other words, a fixture similar to the totally indirect unit. This is merely a precaution to catch the hot filament of a broken lamp and prevent its dropping upon and igniting film.

If this practice is sound, the problem of properly lighting film work rooms is not a serious one as many commercial type fixtures can be obtained in this form. However, if the use of vapor proof fixtures is enforced in all locations, the problem of good lighting will assume a more complicated and expensive form.

New local rules in New York prohibit the use of chain fixtures with cords laced in and out of the rings, or drop cords in rooms where film is handled. All such units must have the fixture wires properly enclosed in a metal pipe stem. This applies as well to Wratten safelight units which heretofore were connected by means of a flexible cord into a lamp receptacle located at some convenient point near the safelight.

The question has been raised regarding the use of wall switches in rooms where film is handled. The Code now prohibits the use of switches in vaults but serious thought is also being given to the advisability of requiring the use of vapor proof type switches in all rooms where film is handled.

Attention is also being given to the use of wall fans in similar locations, especially of the types with commutators and with rheostats in the bases.

To definitely establish in the minds of the Code Committee whether there is a necessity for such devices will depend largely on a definite conclusion regarding the combustibility or explosiveness of the gases which are given off by motion picture film under ordinary conditions. These facts can best be obtained from the membership of our own Society, and any discussions or suggestions offered by you will be gladly received and considered by the Code Committee of the National Fire Protection Association.

EXIT AND EMERGENCY LIGHTS

Another section of the Code that is receiving the attention of the Code Committee deals with the matter of emergency lighting. Several sound recording studios and laboratories are being cut up into comparatively small areas for use as stages, recording rooms, battery and generator rooms, film-working rooms, inspection rooms, *etc.* Many of these are placed in the interior of large buildings and frequently below the street level. In case of failure of the electric current which might or might not take place at the same time as a fire, an unfailing supply of current for emergency and exit lighting is a most important consideration. Therefore, it has been recommended that an independent source of supply for these lights be provided, preferably of the "Surelite" type, in which a storage battery of sufficient capacity to maintain the emergency lights for at least a half hour is automatically kept charged at the proper voltage but is not left floating on the line.

In systems of this type, the emergency lighting is automatically thrown on to the emergency battery supply in case of failure of the normal current supply.

This system of emergency lighting is compulsory for theaters in many states.

As an adjunct to the emergency lighting for dark rooms in film laboratories, I wish to call to your attention a very simple pilot light device originated by Mr. J. C. Kroesen of the Fox Film Corporation and first used, I believe in their plant. This consists of a small red or green pilot light being placed on each group of key switches which operate the white lights. These pilot lights burn continuously and not only assist the laboratory operators in inserting the key to turn on the white lights, but also provide a permanent indicator to enable the white light switches to be quickly located in case of emergency. The local inspection departments have commended this type of construction and it very likely will be incorporated in the new Code.

SILENCING SIGNALS FOR SOUND STAGES

Another problem created in the studio is that of locking the doors leading to stages to prevent disturbance while recording is going on. The fire departments in most cities frown upon locking of exits in any type of building. In the eastern studios of the Paramount-Publix Corporation, Mr. M. W. Palmer, Chief Engineer, has had placed near the outside of each door leading into the various stages, an electrically illuminated translucent sign which indicates very forcibly when recording is going on. These signs have backs coated with a mercury compound so that when not illuminated they give the appearance of a mirror. However, when recording is to take place, a monitor at a central point operates switches which light the signs on the doors of stages on which recording is taking place, and at the same time announce in bold letters the word "SILENCE" operated by a flasher.

PORTABLE CABLES

The question of portable cables as used in the studio has been the subject of considerable discussion by the Code Committee. Certain local boards have objected to large amounts of energy being conveyed by portable cables to portable spider boxes for the reason that the cables are subject to mechanical injury from scenery, wheel trucks, *etc.*, and in the event of a short circuit taking place, the heavy capacity fuse used permits sufficient energy to pass to maintain a serious arc. Very frequently, these same fuses are reënforced, especially when they are of the renewable type, so that the hazard is even greater.

The consensus of opinion of members of the Code Committee working on this section has been that portable cables should not be fused for more than 150 amperes on each side of a two-, three-, or four-wire system and should terminate in portable pockets raised clear of the floor rather than in spider boxes; these portable pockets to be constructed in the form of a small enclosed "location" switchboard provided with magnetic contactors and control switches, if desired, so that the lights can be controlled remotely. However, the question of maximum allowable carrying capacities on portable cables is still an open one; and the Code Committee, being mindful of the expansion and development taking place in studio illumination, wants to consider this question with all regard to the requirements of the industry, but at the same time minimizing the electrical fire hazard in the handling and maintenance of heavy current equipment.

THEATER WIRING

The use of three-wire branch circuits in commercial building is permitted by the Code but since all present dimmer installations are being made so that the dimmers are connected into the neutral or grounded leg, the Code Committee is now considering prohibiting the use of three-wire circuits in any theaters or auditoriums where dimmers are to be installed.

Past experience has indicated that contractors and wiremen are misled by the fact that the neutral leg of a three-wire circuit carries no current when the circuit is evenly balanced; but in installations where dimmers are connected into the neutral, the so-called three-wire circuit does not and cannot exist. What has really occurred is that the installation man has used a common return for two two-wire circuits, usually of the same size wire as the outside circuit legs; obviously twice as much current is carried by this common return as the remaining leg of either circuit, producing an overload on this one wire which is not a neutral of a three-wire circuit. There would be no objection to running a wire of twice the capacity for a common return, but the surer method would be to enforce the use of two-wire circuits entirely for installations of this kind. Neutral wires should terminate in the magazine panel, and be connected to separate terminals opposite the live terminals of the corresponding circuits and not to common grounding busses as is customary in commercial installations. By arranging the connection terminals thus, the electrical inspector can, at a glance, check whether the circuits have been run as two-wire circuits, especially when one of them is a grounded conductor.

The conductor leading to the dimmer plate should have a capacity equal to the sum total of the capacities of the various two-wire circuits. A common ground bus is now frequently used to tie together all common terminals of the dimmer plates.

Switchboard manufacturers should pay more attention to the routing and grouping of bus bars and branch feeders so that opposite polarities on a.c. systems are always together. The contractor likewise should exercise caution in the running of wires in the gutter spaces and between the magazine panels and the switchboard or dimmers so that wires of opposite polarities are always grouped through bushings, conduits, or other metallic ducts. Where this practice is not carefully observed considerable "a.c. hum," inductive and eddy current heating of the conductors and iron is produced, with consequent damage to the installation.

CONCLUSION

Technical developments frequently involve changes in methods that may not be covered by the current Code or may be infractions of it.

It is the purpose of the National Electric Code to provide safety but not to hamper development. Therefore, when such conflicts arise, it is advisable to bring these promptly to the attention of the local

Inspection Bureau for a temporary ruling until suitable provision can be inserted in the National Electric Code. Any precautions adopted that will safeguard property and insure the safety of the employees and the public will redound to the credit of the industry.

DISCUSSION

MR. SAMUELS: In the case of motor generator sets operating with arcs, we have been frequently confronted with a situation where a motor generator operating on 200 amperes continuously and 400 amperes for the change-over interval of ten or fifteen minutes, had feeders installed for only 200 amperes. Motor generators for projection are distinguished for their flat voltage characteristics. This use of cables too small for the load causes a considerable voltage drop and defeats the purpose for which the equipment is designed. We have found several cases in the last six months where the inspector has passed a 200 ampere cable running to the booth from a 400 ampere machine. What I would like to know is, what provision is being made by the Code to enforce the installation of the proper size conductors for d.c. feeds to booths?

MR. MANHEIMER: In connection with motor generator d.c. feeds to booths, the inspectors usually are concerned only with the size of the feeder in so far as the fuses which protect it are concerned. If a feeder requires 400 amperes momentary carrying capacity, it is up to the customer to insist that the contractor install cables of such size as will safely carry this amount of current. In a new theater the wiring is installed long before the motor generator sets arrive, and it has been frequently found that when the sizes of projection feeders are specified, they are of insufficient size for the total output of the larger motor generator sets which so many theaters are now installing.

The inspector, in passing on a motor generator installation, usually checks the size of the a.c. feeder to see if it is large enough according to the a.c. motor name plate rating. On the d.c. end, he is principally concerned with the sizes of the fuses that protect the outgoing d.c. feeder, and if these fuses do not exceed the capacity of the feeder, the job is passed. After the inspector leaves the job, however, it is a simple matter, by the use of refillable fuses, to insert additional links having capacities two or three times greater. This is a most unfortunate condition which only frequent re-inspection can eliminate. It would, therefore, seem advisable that the inspectors on their periodic visits to the theaters check the fuses on d.c. motor generator feeds.

Many of the chain theater construction departments now specify wire no smaller than 500,000 circular mils for the d.c. booth feeders. These have a capacity of 400 amperes per leg, and are usually large enough to carry two projection machine arcs and one stereopticon or spotlight simultaneously.

MR. R. C. HUBBARD: In connection with the matter of switches and fixtures in film handling rooms, Mr. Manheimer solicits information regarding the explosive gases given off by film. I think we should go on record with the fact that no explosive gases are given off by film until it becomes heated to abnormal temperatures and that there is, therefore, no necessity for vapor proof fixtures in film handling rooms.

MR. MANHEIMER: I should like that particular point settled at this meeting, if possible, so that the Code Committee can be guided to some extent as to whether the requirements for vapor proof fixtures in film working rooms should be adopted or not.

MR. ROBIN: In line with Mr. Manheimer's paper, I found throughout the country many violations, and also found variations in frequencies and low voltages on the d.c. service on motor generator installations. In the majority of cases, voltage drop in lines has not been considered, and there is a general lack of proper protective devices. I have studied and interpreted the Code for theatrical motion picture installations for our different offices, and I have found many conflicts between the different inspection departments and the utilities companies as to the correct interpretation of the Code. I believe it would be well for this Society to appoint a committee to confer with the various underwriters with the object of assisting them in the promulgation of rules which will not put too great a burden on our industry.

MR. MANHEIMER: I believe it would be advisable to formulate some special rules for the installation of d.c. booth feeders in theaters, on a basis of the probable sizes of the motor generator sets contemplated. This requirement could be worked out probably on a basis comparable with the number of seats in a theater, which would indirectly determine the amount of current required by the projection arcs. This question should receive some very serious consideration. Both the discussions of Mr. Samuels and Mr. Robin are appropriate at this time and the conditions pointed out by them are a great deal worse than our membership realizes, due to a large extent to the highly competitive basis on which work of this kind is usually done and the free-for-all method of letting each bidder write his own specifications.

The Society could render a great service to the industry if it would adopt and recommend specifications for installations of this kind so that architects or theater owners would merely have to specify, "All in accordance with S. M. P. E. Standards," in a manner similar to the standards and specifications adopted by other engineering societies and frequently referred to by manufacturers. To formulate such standards, a committee should be appointed.

PRESIDENT CRABTREE: Who is drawing up these underwriters' regulations?

MR. MANHEIMER: The various Code Committees.

PRESIDENT CRABTREE: Are they collaborating with men having motion picture experience?

MR. MANHEIMER: Yes, they are, but only to a limited extent.

PRESIDENT CRABTREE: Do you think a committee from our Society necessary?

MR. MANHEIMER: In order for a committee from our Society to be represented on the Electric Code Committee, it will first be necessary for the Society to apply for membership in the National Fire Protection Association, the cost of which is very nominal, and representatives will then be appointed from our own membership by the National Fire Protection Association, to be represented on the various Code Committees in which our Society may be interested. This is the procedure followed by the various engineering and technical societies requiring representation in the National Fire Protection Association. I am quite sure that the Association will not only appoint representatives on the Electrical Committee but will probably appoint representatives on committees considering film and other branches of fire hazards incident to the industry.

PRESIDENT CRABTREE: If you will leave that to me and the Board of Governors, we will coöperate to the best of our ability.

DR. SEASE (*Communicated*): In connection with that part of Mr. Manheimer's paper that seems to solicit some definite information regarding the explosiveness of gases given off by film, I consider that the vapors in a film vault of average size filled with film under average conditions will not be explosive or combustible. The vapor to be found is largely acetone. The acetone in the film may be as high as 2 per cent. It is usually much less. This acetone is very hard to remove and would require quite high temperatures to get it out of the film. According to our information, vapors of acetone are not explosive until the acetone content of the air is 3.7 lbs. per 1000 cubic feet. We have no information on the accumulation of vapors in a vault which has remained closed a long time, but it is possible that the vapors may increase if the vault is practically hermetically sealed.

We know of no spontaneous combustion of vapors from film, nor have we had in our experience any fire caused by the ignition of vapors emanating from film. There are records of fires having been caused by static discharges over mixers into which solvents were being run.

While the vapor from film is largely acetone there is some alcohol, camphor, and fusel oil. These vapors have higher specific gravity than air, and, therefore, tend to settle.

It is possible that the vapor proof globe requirements have been established to reduce the hazard of igniting film by its contact with an incandescent lamp. Celluloid film ignites in a very short time at 300°F. At 212°F. it will not ignite for a considerable time. At 140°F. we have observed its decomposition without ignition in five or six months.

REPORT OF STANDARDS AND NOMENCLATURE COMMITTEE*

The present Committee on Standards and Nomenclature was organized during January of this year, and the first meeting was held in New York City on January 27th. All members of the Committee were present at that time except the representatives from France and the West Coast. A second meeting was held in New York on April 14th and was likewise well attended. Undoubtedly one reason for the excellent attendance at these meetings is the greater opportunity of service to the Society which the new method of adopting standards provides. Whereas as much as two years might elapse under the old method before the recommendations of this Committee could be adopted by the Society, the new method permits the adoption by letter ballots, which are sent all regular members of the Society immediately following the appearance of the report in the JOURNAL.

The work that this Committee is undertaking at present may be summarized under the following headings: Preparation of Booklet, Nomenclature, Safety Code for Projection, Standard Practice, and Wide Film Dimensions.

PREPARATION OF BOOKLET

The booklet giving the standards adopted by the S. M. P. E. to January, 1928, is now out of print. The board of governors has recently authorized the preparation and publication of a new booklet which will include also the standards adopted by the Society since January, 1928. The editor *pro tem* of the JOURNAL, Mr. L. A. Jones, has kindly assumed the responsibility for publication of this booklet and a few copies have been struck off. The Chairman of this Committee is taking the necessary steps to obtain the approval of the American Engineering Standards Committee, and it is hoped that the booklets will be available for distribution within a short time.

NOMENCLATURE

A subcommittee, consisting of Messrs. Carson, Dubray, Powers,

* Presented at the Washington meeting of the S. M. P. E., May 6, 1930.

and Rayton, *Chairman*, has been appointed to make such revisions in the glossary of technical terms as may be necessary from time to time. It is planned to print the revised glossary in the JOURNAL every year, preferably after the Fall meeting of the Society. Wherever possible, the foreign equivalents of the terms in the glossary will be included also. This should be a welcome addition, as these terms are seldom found in the dictionaries of foreign languages.

SAFETY CODE FOR PROJECTION

Most states and important municipalities have enacted regulations governing the projection of motion pictures, but these differ widely from place to place. It is felt that this lack of uniformity creates an unnecessary hazard. As matters stand at present, the projectionist must often learn an entirely new code whenever he moves from one city or state to another. Undoubtedly, the approval of a standard safety code for projection by an impartial body like this Society would provide a basis for new legislation which would tend to become standardized as time went on. To this end, a subcommittee is being organized to deal with this important problem and to report at a later meeting.

STANDARD PRACTICE

Although motion picture practice is constantly changing, certain details of the art tend to become standardized; and it is felt by this Committee that the publication of the details of recommended practice should be of benefit to the industry. A subcommittee has been organized, consisting of Messrs. Farnham, Hubbard, Mitchell, and Rackett, *Chairman*, which will present and publish recommendations on the length of titles, notching of negative film, sound film practice, and such other features of the art as it may seem wise to attempt to standardize. It is hoped that a report of this subcommittee will be available in time to be presented at the Fall meeting of the Society.

WIDE FILM DIMENSIONS

The Committee felt that the standardization of wide film dimensions was the problem of prime importance before it, and this subject was discussed at considerable length at the meeting of January 27th. The points under discussion were treated in the following manner, which seemed to afford a logical approach to the subject:

1. Is a larger screen desirable and can it be used in existing theaters?

2. Should the angle of view be increased—in other words, should the screen include more action than at present?

3. Can a larger screen be used with the present 35 mm. film?

4. What is the best ratio of width to height of the screen?

5. Is a wider sound track desirable?

6. What detailed film dimensions should the Committee recommend to the Society?

The Committee agreed unanimously, and experience has undoubtedly proved that a large screen is desirable and that it can be used in practically all existing theaters. The Committee also agreed that the enlargement of the screen should be accompanied by an increase in the camera angle so that more action will be included. In other words, the focal lengths of both the camera lens and the projection lens should remain about the same as at present. The wider film then automatically includes a larger camera angle and covers a larger screen without destroying the perspective relations, which are approximately correct with the present 35 mm. film. Although an increase in film size requires both the camera lens and the projection lens to cover a wider field angle, the Committee believes that there is evidence to show that the optical manufacturers can deal with this problem satisfactorily.

The Committee feels that it is impracticable to cover a larger screen with existing 35 mm. film since the magnification of the film on the screen is now about as great as can be tolerated without exceeding the limit at which the graininess becomes decidedly objectionable. At the present time, no method of reducing the graininess of photographic materials is known that does not entail a sacrifice of speed or sensitivity. The use of materials of lower sensitivity would introduce greater difficulties in the lighting of studios and does not appear to be a thoroughly practical solution of the problem. It has often been demonstrated (notably by J. H. Powrie, *Trans. Soc. Mot. Pict. Eng.*, No. 19 (1924), p. 49) that the graininess of the positive can be markedly decreased by printing by reduction from a larger negative. Thus, if graininess were the only factor, it might be possible to cover a much larger screen with 35 mm. positive film by increasing the size of the negative film only. However, the increased magnification required by the larger screen accentuates any unsteadiness of the film in the gate, and introduces some severe mechanical problems. With the increasing use of color films, it seems undesirable to contemplate any greater magnification between the film and the screen than at present and a slightly lower magnification is to be preferred. Also, the amount of light flux passing through the film is already so great that only with difficulty could it be increased to meet the requirements of the larger screen.

The ratio of width to height of the screen was discussed by the Committee at considerable length. It was felt that the best ratio depends upon the type of subject and that the old 4:3 ratio was not far from the best compromise. With the advent of sound films, the picture has become more nearly square, and it is quite generally agreed that this change was in the wrong direction. As the height of the screen can be increased only slightly in most theaters, any great increase in the size of the screen must be in the width. The Committee feels that the proper ratio can be determined only after comparative tests, and is arranging for a demonstration to which the producers will be invited.

At the time of the January meeting of this Committee, it was apparent that the entire Standards Committee was too large to undertake the problem of wide film standardization. Consequently, a subcommittee was appointed consisting of Messrs. Batsel, *Chairman*, Davee, DeForest, Evans, Griffin, LaPorte, Spence, and Sponable. This committee has worked faithfully on the problem and has held no less than seven meetings since February 13th. Every possible phase of the subject has been examined exhaustively, with the result that it now appears that there is little to choose from an engineering standpoint between the present 65 and 70 mm. layouts. It is thought that the 65 mm. film would be somewhat improved if the margins between the exposed areas were increased, and the 70 mm. film would doubtless be improved by the use of five perforations per frame instead of four.

As soon as it became apparent that the problem was no longer an engineering one, a second meeting of the entire committee was called on April 14th, which resulted in a resolution that the Chairman should interview the producers and acquaint them with the situation and propose that the producers agree to pool the cost of scrapping existing equipment where necessary in order that the industry may promptly arrive at a common standard for wide film.

Pursuant to these instructions, the Chairman called on Mr. H. L. Clarke, G.T.E.—Fox; Mr. A. Zukor, Paramount-Famous-Lasky Corporation; Mr. H. M. Warner, Warner Bros.; and Mr. H. Brown, R.K.O. Mr. L. P. Mayer is in California, and a letter has been directed to him there. The Chairman is pleased to report a general desire to do whatever is best for the industry and a feeling that the matter of standards can safely be left to this Committee.

We regret that we are unable to put a specific recommendation before you, due to insufficient time to arrive at an agreement on all points under consideration. However, work on this problem will be continued and an early report on this subject is anticipated.

Respectfully submitted,

M. C. BATSEL
W. H. CARSON
L. W. DAVEE
A. DEBRIE
L. DEFOREST
J. A. DUBRAY
E. W. ENGSTROM
P. H. EVANS
R. E. FARNHAM
H. GRIFFIN
R. C. HUBBARD
L. A. JONES
N. M. LAPORTE
G. A. MITCHELL
W. P. POWERS
G. F. RACKETT
W. B. RAYTON
V. B. SEASE
T. E. SHEA
J. L. SPENCE
E. I. SPONABLE
L. T. TROLAND
A. C. HARDY,
Chairman

SOME CONSIDERATIONS IN THE DESIGN OF SOUND-PROOF CAMERA HOUSINGS

L. E. CLARK*

The fundamental requirement of a silent cover—"bungalow," or "blimp," as it is colloquially called—is that the device shall effectually keep the camera noise from getting out on the set. In general, it can be said that any device which lets camera noise be heard by a person of normal hearing standing more than four feet from the camera in an absolutely silent room, is not sufficiently quiet to cover all conditions. This is the fundamental consideration; all others, while they may be of major importance, are secondary to this. Some of the other requirements are:

(1) *Accessibility of the Camera.*—Doors should be provided which are large enough and in such places that they readily permit the operator to get at all parts of his camera. For a Mitchell camera, for example, it is imperative that the operator be able to get at the back, the left side, and the front of his camera. There are certain adjustments which he has to make on the right side of his camera as well, but if a large door is provided in the back, it will be sufficient to cover this need. These doors should be readily opened and when fastened should make solid and airtight joints.

(2) *Freedom from Changes in the Camera.*—The successful photography of a feature production is in itself so much of a strain on a cameraman that he is in no condition to have imposed upon him added difficulties caused by changes in his camera necessitated by the blimp. For example, the relative location of finder and camera aperture should be maintained as at present. Furthermore, his elaborate mat box and filter holders should be kept as they are now so that he will be able to get any photographic effects he desires. Plenty of room around these should be provided for a man to work and make adjustments. The mounting of the camera in the blimp should be the same as at present, and the blimp

* Pathé Studios, Inc., Culver City, California. (Read before the Society at Washington.)

should place no restrictions upon the lenses which the cameraman can use.

(3) *Ease of Camera Operation.*—All the controls which it is possible to bring outside the blimp should be so arranged, the most indispensable, of course, being the follow focus control. Next in importance comes the control of the lateral adjustment of the camera finder to permit accurate centering on travel shots. It is also desirous to provide control for automatic fade-ins and fade-outs, although fewer of these are being used than was formerly the case in silent pictures. The motor control, of course, should be provided with necessary safety means whereby the motor is instantly shut off in the event that the camera becomes jammed. A very important set of controls is that governing the aiming of the camera—that is, the panning and tilting arrangement. These should not only be provided with gear movements, but provision should also be made for releasing the gear drive to permit the operation of the camera and blimp as if it were on a universal joint. Control is then obtained by means of a lever large enough to permit proper handling of the entire blimp and camera head.

FIG. 1. Side view of blimp and tripod—blimp closed.

With these requirements in view, the Academy of Motion Picture Arts and Sciences made a survey of the existing camera bungalows, which were in use, and found that none of them were quiet enough to fill the prime requisite as specified in the beginning of this article. On the other hand, practically none of them permitted all the other requirements being fulfilled either, so that the devices were in the nature of compromises, some of which were better than others. The best devices, from a sound standpoint, were all large and heavy, ranging in weight from 180 pounds to 225 pounds. For each of these blimps, also, a special tripod had been constructed to properly handle the extra weight, and it was more or less agreed that this sort of construction would have to be resorted to in order to provide a device adequate to fill all requirements.

With the results of this investigation, which were made public to anyone interested in the subject, it was a relatively simple matter to combine the good points and to design a set of equipment which seems to completely fill the requirements. In the first place, from a studio operation standpoint, such equipment should be designed to be interchangeable and more or less standard. Furthermore, provision must be made to cover all cases in which a blimp would be likely to be used.

FIG. 2. Front view of blimp and tripod—blimp closed.

The first point that was noted was that a blimp suitable from a sound standpoint would be so heavy that it would be impossible to properly operate it on any of the commercial existing tripods. The writer, accordingly, in connection with Mole-Richardson, Inc., of Hollywood, set out to design a complete line of tripod equipment to properly support a blimp of necessary weight. The details of this tripod are being presented to the organization in another paper, but the main feature from an operation standpoint is that a complete set of equipment is provided. Two heights of adjustable tripod and a set of castings known as "high hats" to permit the camera being placed even lower than the lowest tripod, have been designed and tested. A specially designed extra heavy tilt head, which is interchangeable on any of the tripods or on any of the blimps, has also been developed. With the design and construction of this line of equipment in the hands of Mole-Richardson Company, attention was next turned to the design of a sound-proof blimp.

After several experiments, the present design was decided upon, which produces ample quieting and at the same time is very convenient for operation. The body of the blimp is built around two sets of angle iron frames. The inner set is covered with $^1/_{16}$ in. sheet lead which is primarily responsible for any added sound proofing which the blimp may have. An aluminum shell is built around the second angle iron frame, the two frames being so designed that the lead slips inside the aluminum shell with a $^3/_4$ in, space all around. This space is filled with Johns-Manville "Akoustikos" felt. This provides a very rigid shell. The inside of the lead is lined with another $^3/_4$ in. of "Akoustikos" felt, and the felt surface is finished on the inside with black Kribble cloth, to provide a clean working surface inside the blimp. By use of the angle iron frame, the whole device is provided with enough rigidity so that the doors when once fitted, will always remain tight fitting and will not develop leaks at some later date. The side door and the back door are built of the same laminated construction as mentioned above, except that a flat frame instead of an angle iron frame is provided. The door jambs are of sponge rubber so that at the corners of the blimp a rubber to rubber seal about $2^1/_2$ in. through is provided at all joints. By means of special compression hooks which have been designed, the rubber surfaces are jammed together practically airtight. Incidentally, the problem of obtaining suitable compression hooks was quite difficult. Nothing even remotely resembling what was desired could be purchased, and the hooks had to be designed from the ground up. The resulting job provides a $^3/_4$ in. pull with a mechanical advantage of about 16 to 1, so that a 50 pound pull on the handle produces a compression equivalent to 800 pounds on the rubber surfaces.

The camera shoots through optical glass, this glass being fitted in a door which raises up to permit the cameraman to get at the front of his camera to adjust mats, filters, and other accessories. The front of the blimp is flared and extends out about six inches further than the body to permit the use of the mat box and very short focal length lenses. The blimp will clear a 25 millimeter lens with ease. This flare on the front of the blimp is also large enough to let the finder be used directly on the camera in its usual manner, and a window is provided in the back door so that the cameraman can look through his finder while the blimp is in operation.

Considerable trouble was experienced in getting a proper mounting for the camera. Most of them were either too rigid, allowing too much noise to be telegraphed to the outside, or if they were silent, so flexible that the camera wobbled back and forth whenever the blimp was panned. The present mounting eliminates these difficulties and is one of the major features of the blimp. A large aluminum casing, practically the entire base of the blimp in size, is laid on the felt floor of the blimp. This has a large enough area so that it has no tendency to wobble even under severe conditions. To this plate is screwed a shock-proof mounting consisting of alternate triangular shaped pieces of balsa wood with sponge rubber between, and a cast aluminum plate, top and bottom, the whole mounting being held together with strips of live rubber. A camera screw is provided in the top plate of this mounting which is identical with the camera screw existing in the standard Mitchell tripod so that the camera is mounted in its usual manner.

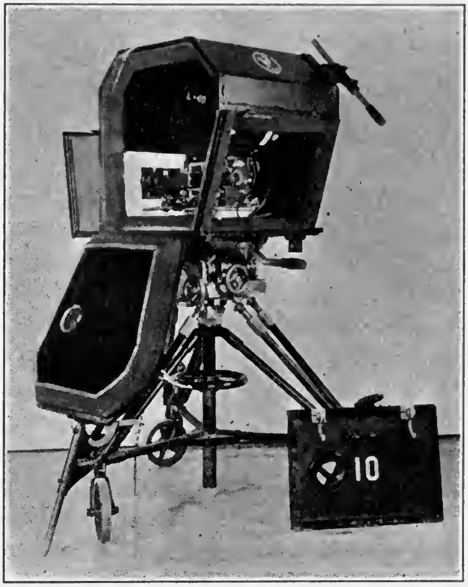

FIG. 3. Side view of blimp and tripod—blimp open showing camera in position.

This covers the general design of the blimp and its more important features. The cameras are provided with automatic trips which close an electric circuit connecting to a circuit breaker the instant that even a slight buckle forms in the camera. These have saved the camera from serious injury many times. The motor control and circuit breaker are mounted in a single unit on the outside of each blimp.

For following focus, which is one of the most important features of the camera, several devices are in use. The simplest and most fool-proof provides merely an adjusting ring which clamps around the lens in use and which has an extension arm to which a rod, passing up through the bottom of the blimp, is attached. A window in the side door and a suitable flash light inside the blimp permit watching the graduation on the lens barrel when the focus is being changed by means of the external rod. This device, although admittedly crude and simple, has the merit that the operator is constantly watching the calibration on the lens itself and not a secondary calibration somewhere outside the blimp.

Another control which has been provided is a similar rod operating out through the side door which connects with a pin on the finder permitting the finder to be moved laterally so as to keep the proper frame of the picture. Where pictures are being shot with the idea of making both full size prints and prints masked for sound track, the accurate alignment of the picture becomes a subject of prime importance, at least if an artistic result is desired.

The present blimp which is now in operation at Pathé Studios, Inc., Culver City, together with the tripod as designed and built by Mole-Richardson, Inc., seems to fulfill most of the requirements which can be laid down. While it is, of course, more difficult to use than when shooting with an open camera, yet it imposes less restrictions upon the cameraman than most of the blimps that have generally been in use. From a sound standpoint it is amply quiet, it being possible to record whispering within three feet of the blimp without picking up any noise from the camera whatsoever.

The writer wishes to express his acknowledgment of the wholehearted coöperation of everyone working on this problem. Especially the names of Peter Mole, Elmer Richardson, and Philip Coates, all of Mole-Richardson, Inc., and Joseph Wright, A. L. Domike, and Ferol Redd, of Pathé Studios, should be mentioned. Thanks are also due to the Academy of Motion Picture Arts and Sciences for the results of their investigation of this problem.

SOME EXPERIMENTS IN MOTION PHOTOGRAPHY OF THE VOCAL CORDS

G. OSCAR RUSSELL* AND CLIFTON TUTTLE**

It has been pointed out by one of us[1] that many of the commonly accepted theories regarding the mechanism of speech production are erroneous. Heretofore, visual observation of the laryngeal cavity by means of special instruments supported by the evidence of X-ray pictures during phonation has been utilized in these studies. In the

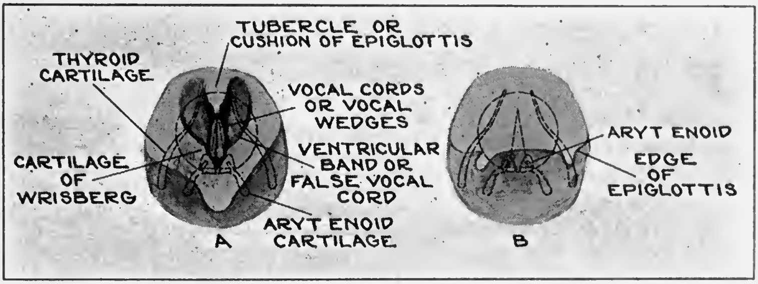

FIG. 1. Two views of the cavity of the larynx.

present paper we describe a new method of approach, a method which, when it is perfected, promises to be most valuable both in the continuance of the studies and in the presentation of findings to an audience. The motion pictures which have thus far been made, though their photographic quality is in no wise as good as we believe we can obtain, nevertheless indicate clearly the possibilities of the method.

Successful photography of the vocal cords previous to the attempt we describe has been accomplished by others[2,3] but these results have been achieved with long exposures of the order of one-half second.

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** Research Laboratories, Eastman Kodak Co. (Read before the Society at Washington.)

The Problem.—The vocal cords and the surrounding anatomical region which is of particular interest in the study of speech mechanism occupy a circular area about 5.5 cm. in diameter in the mid-portion of the larynx. *A* and *B* of Fig. 1 are drawings after laryngoperiscopic photographs of the cavity of the larynx.[3] The dotted circles inscribe the area to be photographed. *A* shows the full length of the cords (about 20 mm.). These are a pearly white in color while the surrounding areas vary from a cream pink to deeper shades

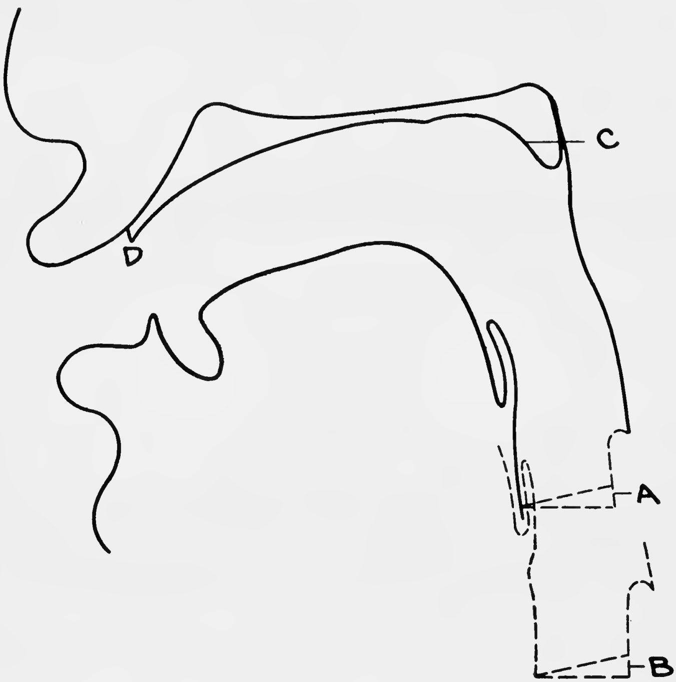

FIG. 2. Cross-section view showing extreme positions of the vocal cords.

of red. The false cords, which are a darker red than the true cords, lie approximately parallel to the latter. *B* shows the same area as it is covered with the epiglottis—a smooth, yellowish pink membranous material slightly concave forward and upward. Physiologically, the epiglottis was formerly thought to be a kind of trap door or lid which closed down tightly over the larynx during the act of swallowing. The present experiments show that in this subject the actual laryngeal closure is first created by an approximation between the pulvinar (or cushion) at its base, and the cartilages of Wrisberg in posterior-anterior direction; second, by the ventricular wedges (or false cords) laterally. These four points come together in such tight constriction as to prevent entrance of even liquids into the interior larynx below. The tip of the epiglottis then moves back apparently to facilitate posterior movement of the pulvinar, but evidently not downward in such a manner as to close the opening. A cough, clear-

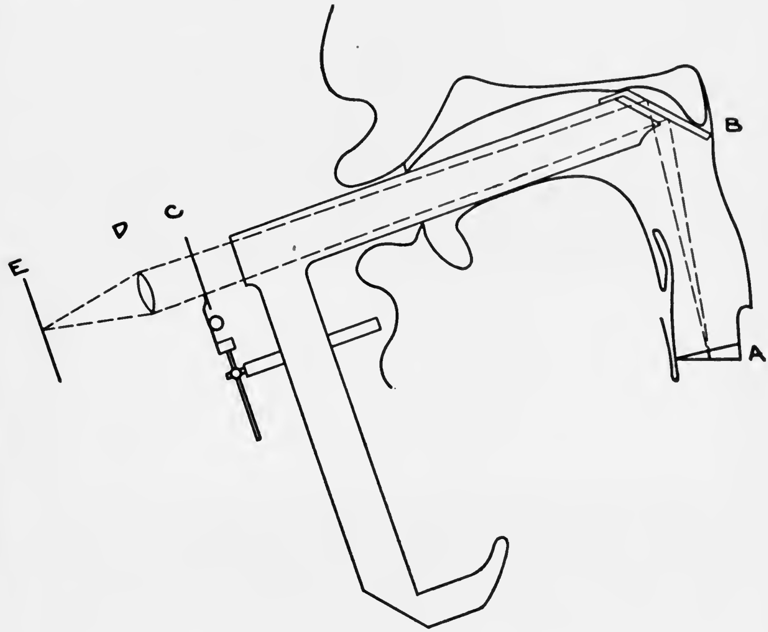

FIG. 3. Cross-section view showing instrument in place for photography.

ing the throat, or gagging, are all also accomplished by this four-point approximation.

The position of the vocal cord assembly varies from a distance of about 60 mm. to perhaps 100 mm. down the throat during the act of speaking or singing. The two extreme positions are indicated in Fig. 2, in which the vocal cavity is outlined from an X-ray photograph. *A* is the highest position of the cords and *B* the lowest. The distance of a point, *C*, at the back of the throat, from *D* at the front of the mouth is about 90 mm.

An optical system to image this inaccessible region upon the film in the motion picture camera presents some rather formidable difficulties. Nature has provided a nicely balanced set of reflexes to prevent the accidental introduction of hard material into the throat passages. The average subject will automatically protest an optical system thrust into the throat just as energetically as he will an inadvertently swallowed bone.

An unpracticed subject finds it very difficult to accommodate himself to any apparatus in his mouth and extending to the back of the throat, but even a subject who has a tendency to gag can, with some practice, tolerate a small tube if it is of the proper shape. We have designed a periscopic lens system (tube diameter 5 mm.) with high light gathering power (geometrical aperture $f/4$) which can be used without impeding the articulation of even the consonants, including both point and back lingual occlusives and fricatives.

Experimental Technic.—In these preliminary experiments, we have used the Russell "Fonofaryngoskop" made by the Electro-Surgical Instrument Co. of Rochester. This device consists essentially of a tube 135 mm. long and about 13 mm. inside diameter. At either end are mirrors which may be tilted with respect to the axis of the tube, thus enabling one to view his own layrnx. The use of this device in our experiments is illustrated in Fig. 3. The Fonofaryngoskop permits clear articulation of all vowels, though the *i* ("*ee*" as in *peep*) loses somewhat in brilliancy. Since the view is obtained through this small tube, there is no need of forcing the subject to open his mouth to the uttermost limit in order to pass in the light, forcibly depress the tongue, or pull it out so as to prevent the epiglottis from retracting and shutting off the view of the cords, as was formerly necessary in the usage of the old laryngoscopic mirror and illuminating device. Obviously no normal speech or voice could be produced under such circumstances. The Fonofaryngoskop permits a naturalness not heretofore possible for the tongue is left absolutely free to move without any depressing or other extraneous force or interference with its accustomed vowel and singing movements. It is impossible for the tongue ever to get in the way and shut off the view of the cords. Its tube is kept about the same diameter as that required of the front buccal cavity in order to pronounce a clear and unmistakable vowel *i* ("*ee*" as in *peep*). Sounding this vowel on unstrained high pitches automatically distends the back throat cavity and interior larynx over the vocal cords to the utmost, and brings the tip of the epiglottis well forward, whereas the vowel *a* (*ah*) closes the throat in the neighborhood of the epiglottis tip, and automatically demands what doctors call a "retracted epiglottis." In these experiments our use of the Fonofaryngoskop permitted us to induce nature to yield the best view through psychological persuasion instead of force.

Optical Limitations Imposed by the Fonofaryngoskop.—Since the inside diameter of the tube is only 13 mm. and since the amount of illumination which can be supplied to the area to be photographed is limited, the use of a lens of high relative aperture is required. If the diameter of the exit pupil of the lens is greater than 13 mm. it will be vignetted by the tube. For these reasons we have used a lens of 25 mm. focal length and $f/1.9$ aperture. With this lens as close as possible to the end of the tube, the object distance becomes 150 mm. and the image distance about 30 mm. The effective aperture is thus reduced to $f/2.3$. The magnification (0.2X) is somewhat less than could be desired.

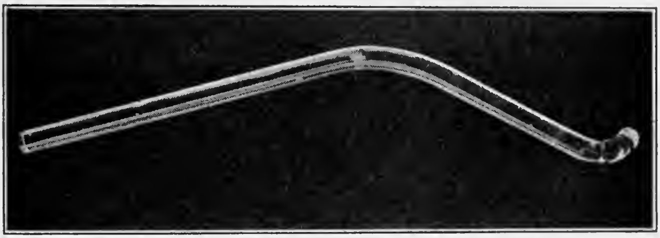

FIG. 4. Bent quartz rod.

Illumination.—It is necessary to supply to the rather inaccessible laryngeal cavity an intensity great enough to photograph red tissue with a lens working at $f/2.3$ at a taking rate of at least 16 pictures per second. Previous experience[4] had indicated that under these conditions and using panchromatic film, a minimum of about 200 visual foot candles of illumination from tungsten at 2900°K. would be required.

For visual observation, a small battery operated lamp (about $^1/_2$ watt) is provided with the Fonofaryngoskop. This lamp will furnish about 12 foot candles on the plane to be photographed—an intensity which is entirely inadequate for the photography. A quartz rod in contact with an external source appeared to be the best method of conducting sufficient light to the vocal cords. (Fig. 4.)

With a straight quartz rod 8 mm. in diameter in contact with the bulb of a 6 volt, 18 ampere ribbon filament lamp operated at 2900°K., we were able to obtain about 250 visual foot candles on a plane about 90 mm. from the rod end. It was necessary to bend the rod in two places in order to conduct the light from the source to the laryngeal cavity. The first bend was necessary in order to make the rod run parallel to the tube where the two entered the mouth. The position of the camera relative to the end of the instrument makes it impossible to place the lamp house in a more advantageous position. The first bend (*A* in Fig. 4) amounted to a total deflection of 55 degrees. Fortunately it was possible to make this bend with a circular arc such that the critical angle for quartz was always exceeded and there was no light loss at the bend. The other angle (*B* in Fig. 4) which

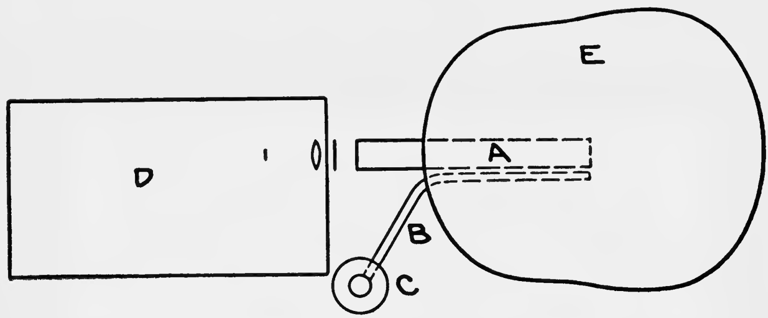

FIG. 5. Diagrammatic view of camera, instrument, and head of the subject.

turns the light downward at the back of the throat was necessarily so sharp a bend that some of the reflected rays were incident at an angle less than the critical angle. A light loss of about 70 per cent was the result. Silvering of this elbow did not improve the efficiency of the rod.

In order to obtain sufficient intensity for motion photography of the cords it was necessary to overload* the lamp for the short period of taking.

Fig. 5 is a diagrammatic top view of the camera, *D;* Fonofaryngoskop, *A;* quartz rod, *B;* light source, *C;* and subject's head, *E.*

Discussion of Results.—Undoubtedly much more can be learned from these preliminary pictures through frame to frame inspection

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* NOTE: An increase of one ampere in the current consumption of this lamp is approximately equivalent to a doubling of the photographic intensity. The filament can be overloaded to 22 amperes for short times without burning out.

than is possible by projection at 16 frames per second. Figure 6, a short section of the film, illustrates the possibilities of this method. In a relatively short time of actual picture taking we thus far gathered results which will furnish material for months of painstaking research before the information to be gleaned will be exhausted.

A few of the conclusions which seem well substantiated by inspection of these films may be of interest to this Society.

(1) In normal speech or song there is a regular gathering of mucus on the cords which loads them unequally, introducing inharmonic components and other like effects analogous to those produced by unequal loading on vibrating reeds, membranes, piano strings, and other vibrating media. As is well known the latter may give quality effects, which are piercing, screeching, nasal, guttural, *etc.* Many differing voice qualities may possibly be traced to this manifestation rather than any function of the so-called resonators above, represented in the throat, mouth, and nose.

(2) The false cords, contrary to accepted medical opinion,[5] play an important part in the speech, voice, and physiological functions of the human anatomy. It has been stated[5] that the false cords are unimportant and that their removal in the case of pathologic conditions has no effect upon the voice. These pictures show definitely that the false cords and whole interior larynx are in constant and wondrous play. It is evident that cauterization as treatment of the false cords, in such a manner that scar tissue is produced, should therefore be avoided.

(3) The cushioning effects of the pulvinar and the cartilages of Wrisberg, functioning along with the relaxed but approximated false cords, are proved by these experiments. They seem to act:

(*a*) As a means of mechanically lowering the pitch of the vocal tone, once a certain low limit of relaxation in the glottal actuators has

FIG. 6. Section of vocal cord film.

been reached. This is accomplished by a frictional slowing down of the surge through an opening between the pulvinar and cartilages of Wrisberg, often narrowed in extreme low pitches to a diameter no larger than that of a pinhead.

(*b*) As a guttural and other similar quality tone creator where mucus in this narrow opening is set into vibration.

(*c*) As a by-pass filter permitting the escape of only the low-pitched partials. This effect results from the extremely soft surfaces surrounding the opening thus created, its excessively small size, and the power of selfelongation in this narrowed soft tube.

(*d*) As an attenuator or tone deadening medium.

(*e*) As a creator of stage whisper and other similar effects.

(4) Contraction, with consequent hardening through extreme tension of the whole interior larynx from the tip of the epiglottis right down, is definitely proved herein. The effect must inevitably be:

(*a*) To create accentuation of the high partials with consequent variation of the tonal quality, running from the *bright*, to the *brilliant*, *white*, *tight*, *strident*, *piercing*, *screeching*, and *tight-choked*. Through the series, varying modifications of this tension are seen to take place. First a complete distension of the entire inner larynx, in both lateral, and posterior-anterior direction, for a pleasing *bright* or *brilliant* quality, with some apparent tendency toward peripheral loading of the glottal actuators (or vocal cords) along the laryngeal attached sides, and a thinning out of the edges. Through the progressive series one then notes a progressive tightening of the ary-epiglottal muscles which narrow and tighten the upper part of the laryngeal tube, and the same manifestation in the interior *membranaceous muscles*, and ventricular bands. Constriction of the latter leaves but a narrow slit between them through which the vocal cord vibration can escape. This narrow strip of glottal membrane is thus forced to push up between them producing a resulting cymbal-like slapping together of the free edges, or the equivalent to a clarinet or organ reed striking against the hard edge of the mouth piece. The effect of these latter is well known.

(*b*) To load the cords in such a way as possibly to create the effect of by-pass filters and net-works of varying types.

(*c*) To change the amount of cord permitted to vibrate, thus raising the pitch as this amount is decreased, without any necessity for increased tension in the vocal actuator itself.

All of this makes it clearly evident that too little attention has heretofore been paid to the manner in which the interior larynx is capable of altering voice and speech quality, without any intervention whatever of the cavities or so-called resonators above.

Teachers of speech or voice and of the deaf, surgeons and physicians, phoneticians, and other speech and voice investigators may be benefited by the results obtained from motion pictures of the laryngeal cavity. To mention a thing of perhaps small importance: The doctor who instructs his patient with the time honored phrase, "Now open your mouth and say "*Ah*" may be interested to know that this procedure results in the complete closure of the laryngeal cavity, whereas *i* ("*ee*" in *peep*) opens it wide.

We must offer our apologies in presenting before this audience of sound motion picture engineers a silent film which cries out for sound accompaniment. The addition of synchronized sound, the use of higher magnification, and color, and possibly an attempt at superspeed pictures are the developments which we should anticipate.

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DISCUSSION

MR. ROSS: It seems as if the instrument raises the palate and closes what is known as the "head structure." That is, what we call the "head" voice is absent. Does that interfere with the true voice? It is possible that this unequal loading of the vocal cords is due to physical deficiency of one side. Were these photographs taken of just one person? If so, this might have some bearing on the fact that the vocal cords seemed unequally loaded.

MR. TUTTLE: To answer Mr. Ross's questions about the functioning of the cords involves more of a knowledge of phonetics than I lay claim to. I believe

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AUTHOR'S NOTE: Since the presentation of this paper at Washington these experiments have been continued. Sound records on 35 mm. film have been made simultaneously with the pictures and fairly successful Kodacolor pictures have been obtained.

I am quoting Professor Russell correctly when I tell you that he has shown rather conclusively that the head tones are really of small importance in determining voice quality. He has been working with Metropolitan stars in New York and making a series of X-ray pictures of their throats. Before starting to sing these artists are careful to get their voices in the "right place" in their heads, and each one has his own device for doing this. Some of them choose some upper corner of the room and sing to this corner. When they have elevated the voice to a sufficient extent, they are ready to go on with the performance. Professor Russell has demonstrated by instruments showing where the vibration comes from that the effect of "voice elevation" which singers obtain is psychological rather than physical.

So far, all the pictures were made of Professor Russell's own vocal cords. To use this piece of apparatus requires a person of extraordinary experience. Professor Russell hopes to get other subjects who are able to use the instrument, and we hope to complete a periscopic lens system so that even those having a tendency to gag can tolerate the apparatus in their throats.

Mr. Ross: I don't agree with Professor Russell with regard to the statement that the head structure, that is, the portion of the head from which the head tones are drawn, is not essential. It is essential to have the palate forward in singing head tones. I think you will get all vocalists to agree on this.

A PROPOSED NEW METHOD OF "TIMING" NEGATIVES

M. W. PALMER AND A. J. RICHARDS*

In presenting this paper to you, we are fully conscious of the fact that some of the apparatus which will have to be used in connection with our idea has not yet reached the final stage of development. Thus far, we have produced operative apparatus only, but rapid improvements are being made, and we are assured by those immediately concerned that this improved apparatus will be available very shortly.

I will first explain briefly what is meant by "timing." Everyone who has experimented with photography has encountered the problem of "timing" his negatives. An exposure is made in the camera and then developed into a negative. This negative must then be printed, or in other words, light must be allowed to pass through it onto a sensitized emulsion to produce a positive. The proper amount of light to be used for this is determined by trial and error; several exposures are made with various light values, and the proper exposure is determined in this way, the results of the incorrect exposures being thrown away. Exactly the same procedure is followed in printing motion picture negatives, with the exception that the negatives are inspected by a "timer," before printing, and he records his best judgment as to the proper value of light which should be used. In some cases the judgment of this "timer" proves to be correct, but many times it is not, and millions of feet of film have to be reprinted. Sometimes a negative has to be printed five or six times, before a satisfactory result is obtained.

Mr. Richards, who is a laboratory man, myself, a studio man, with the aid and assistance of Mr. McCoy of the Westinghouse Lamp Company have tackled this problem and this paper contains our suggestions for improvements along this line.

In studying this problem of "timing," we began at the end and worked back to the beginning. We began by studying the screen

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* Paramount-Publix Corporation, Long Island City, New York. (Read before the Society at Washington.)

images in the theater. Since it is the object of the picture to give the audience the illusion that they are looking at real people on the screen, and since the attention of the audience is necessarily concentrated by the nature of the story, on one principal actor, to preserve the illusion, it is necessary that that actor should look the same in every scene no matter what may be the changes in his surroundings. In order to preserve this continuity of appearance throughout the picture, what we have called the "face value" of that actor must be maintained the same in all scenes. This "face value" is the actual value of light reflected from the screen by the image of the face. Starting with this "face value," we then worked back through the various stages of positive developing, printing, and negative developing to the actual exposure of the negative when the actor appears before the camera in the studio and we find that this is the controlling factor in the whole situation. It is merely necessary to measure the light value on the face of the actor as he appears before the camera, and we will have an index to guide us in "timing" the negative. If a lot of light is used in taking, the printing light must be strong and *vice versa.*

We measure this light value by means of a photo-electric cell photometer placed alongside of, or in the motion picture camera. We then produce, by means of a small lamp within the motion picture camera, an exposure strip along the edge of the film which will be an indication of the light value on the face of the principal actor in that particular scene. This exposure strip can be produced by having a small lamp inside the camera focused on the edge of the film, the intensity of this light being varied according to the reading of the photometer, but remaining constant for the duration of the scene. This lamp may be so arranged as to produce several density strips of known relative value, and thus give an indication of the gamma to which the film was developed. After development of the negative, we will have a strip of uniform density along the edge of the film which will be an index of the light used on the face of the actor in that particular scene.

In the printing machine, a fixed light source and a photo-electric cell are arranged on opposite sides of the film, in the same manner as the exciter lamp and photo-cell are arranged in the sound reproducing system. The amplified output of the photo-cell will control the value of the printing light. Thus the scene will be printed with a light which will bear a direct relation to the light used in making the picture, and the "face value" will be the same in all prints, thus producing a uniform density for the face of the actor as he appears in various surroundings on the screen.

In the case of scenics, light effects, or other special cases, it will only be necessary to decide what particular area we desire to print for and then to measure the light value at that particular area, and regulate the exposure of the density strip accordingly.

Ever since the industry began, there has been a conflict between the camera man and the laboratory man. In cases where an unsatisfactory result has been obtained, each claims that the other is to blame. By this method it will be possible for the camera man to place on the film an exact indication of the light which he used on every scene, and yet it will not hamper the camera man in any way in exercising all the artistry at his command.

And now a few words as to the application of this system to the making of sound records on film. The exciter lamp on the sound recorder can be assumed to remain constant during the recording of any particular scene, although it does vary from day to day, or hour to hour, as is evident from the fact that sound tracks have also to be "timed." To produce an automatic means for "timing" the printing of sound tracks, we provide in the sound recorder a means for diverting a small beam of light from the exciter lamp into the camera to produce on the sound track film a density strip regulated by the intensity of the exciter lamp in that particular recording. This density strip will control the value of the printing light when the sound track is printed just as the light was controlled in printing the picture. By the use of this system the operator of the sound recorder can if he so desires vary the amount of light used in making the density strip during the recording of a scene, and thus introduce trick photography into the making of the sound track record.

After a careful study of the whole situation involved in the application of the above principles, we believe it is practical and that it constitutes an extension of the better technic which has come about with the introduction of sound pictures into the realm of laboratory practice. It gives to the camera man, the laboratory man, and the projectionist, a new help in bringing to the man in the theater seat a better and more satisfying result.

Patents have been applied for on this method, and a more detailed description of the apparatus involved is shown in the patent application.

A method has been devised for making up a density strip for films, which have been "timed" by other methods so that they can be printed on machines to which this new device has been adapted.

DISCUSSION

PRESIDENT CRABTREE: The method described by Mr. Palmer is very ingenious, but why not adjust the lighting so that the brightness of the actor's face is constant in the first place?

MR. PALMER: Scenes are taken in the studio under so many different conditions and in the exterior in sunlight that it is not always possble to match the light exactly although something might be done in that directiion.

A COMPARATIVE STUDY OF SOUND ON DISK AND FILM

PORTER H. EVANS*

In considering the relative merits of sound-on-disk versus sound-on-film, there are a number of factors which must be weighed. The advantages and disadvantages of the two methods must be considered from a standpoint of sound quality, operation, and cost; and each factor must be considered practically as well as theoretically because we all know that the indications of theory are not always realized in practice.

In discussing this problem it must be borne in mind that the principal difference between the present phenomenal success of audible pictures and previous failures has been the superior quality of the present sound reproduction. The present success of audible pictures is undoubtedly due to comparatively pleasing reproduction in the theater which involves a good frequency characteristic and exceptionally uniform speed of the recording and reproducing mechanisms. It follows at once, therefore, that the advantages from a quality standpoint are of greater importance than the advantages from an operating or cost standpoint, up to the time that both sound-on-disk and sound-on-film yield uniformly equal results under commercial conditions.

In the beginning, disk reproduction unquestionably could be relied upon to produce better and more consistent results in the theater. When Warner Brothers started making audible pictures it was the only commercial system available. Prior to this time, several interests were endeavoring to develop the photographic process of recording sound but public demonstrations established the fact that this process was not commercial at that time.

Since that time on frequent occasions, it has been asserted that better results can be obtained with sound-on-film than with sound-on-disk. This statement is either based on tests made in the labora-

* Eastern Studios, Warner Brothers Vitaphone Corporation, Brooklyn, N. Y.
(Read before the Society at Washington.)

tory where every step of the recording, developing, printing, and reproducing is done by expert engineers or where the disk has been made by re-recording from film to disk and, therefore, has in addition to its own limitations the limitations of the original film record. As will be noted later, we are recording simultaneously on disk and film (but releasing only on disk) and at the studio we find little choice between the best film reproduction and the average disk reproduction. The disk method, however, has the extremely valuable characteristic of being more uniform and reliable than the film in the theater.

Records have been produced commercially for some twenty-five years and as a result the galvano and pressing processes have reached a high degree of perfection. Experience has been accumulating for several years on the use of electric recording equipment and as a result the technic of cutting waxes by the electric process is well understood and no difficulties are encountered with this part of the work.

From a theoretical standpoint, it would appear that a better frequency response characteristic should be obtainable by the use of sound-on-film than by the use of sound-on-disk because the former need not employ to any great extent the use of mechanical vibrating systems with their resulting resonant distortions. It would appear that an inertialess light beam and an aperiodic photo-electric cell should be capable of response to frequencies of higher order of magnitude than the recording stylus and electrical reproducer used in the sound-on-disk method. Laboratory tests seem to substantiate this view but this advantage has been lost in the theater up to the present time because the other elements in the system are not able to handle the frequency range which the sound-on-disk method is capable of producing, to say nothing of the increased frequency range claimed for the sound-on-film. On the other hand, sound-on-disk has the theoretical advantage of more inertia in the moving record and is, therefore, less susceptible to irregularities in record speed.

From the practical operating standpoint there are many advantages to sound-on-film which were apparent from the very beginning. On the other hand, there are many disadvantages which are apparent when pointed out, but which were not appreciated until an attempt was made to use this method commercially. While the practical difficulties which are arising may not be insurmountable, they do give the older disk method the advantage until they are solved. The obvious advantages of sound-on-film referred to above are so impressive that the development and perfection of this method of recording has and still is receiving a great deal of attention with the result that noteworthy improvements are being made in this process of recording. In order that Warner Brothers might have first-hand information on the sound-on-film method, we began recording on film about a year ago and today the majority of our sound is simultaneously recorded on both film and disk.

In spite of the fact that theory and laboratory tests indicate that a better frequency response characteristic should be obtainable on film than on disk—the reverse has been found to be the case in practice. The causes of this condition are gradually being discovered and eliminated with the result that there is less difference between the two methods of recording at the present time than at any time heretofore.

Obviously, there is a marked advantage to the distribution and exhibition organizations in having the sound and picture permanently associated with each other. The use of disk records requires the maintenance of two separate exchange organizations—one for the film and one for the record, and requires two independent shipments to the exhibitor with a small increase in shipping expense and twice the danger of some one making an error in the shipment.

Another practical advantage of the film method arises when the film is damaged in projection. In the case of the disk print, it is essential that the damaged section of film be replaced by a blank leader of exactly the same length as the portion removed, otherwise synchronism is destroyed. In the case of the film print, the continuity of the sound may be lost and some bad splicing noises introduced but it does not involve any question of synchronism in subsequent sequences.

To offset the unrealized theoretical advantage of a wider frequency response characteristic a great deal of difficulty has been experienced in obtaining uniformity in the film product. This unforeseen difficulty is very important from a practical standpoint. It has been necessary to establish tolerances in exposure, development, printing, and reproduction which have been difficult and expensive to meet. In addition to this, the equipment required to record, print, and reproduce the sound record has been found complicated by comparison with its disk equivalent and, therefore, difficult to maintain in proper adjustment. On the recording end, the more exacting technic for film recording has not been difficult to meet because the film recording equipment is in the hands and under the control of experts. In addition, the recording equipment is satisfactory from a speed variation standpoint. A driven rotating sound gate is used in the recording machine which supplies the inertia inherently lacking in the moving film.

Since virtually everything is re-recorded before release, retakes on account of cut-overs are very rare, as it is possible to use records in re-recording which are cut too heavy to pass commercially. While this is a disadvantage for disk it is more than offset by the advantage that a wax may be played back immediately.

From an editing standpoint there seems to be little choice between the two methods of recording. The vast majority of the release sound must be re-recorded in either case. Re-recording can be done by either method without any appreciable change in sound quality. From the director's standpoint the sound film is very useful. The cutter can join up the sound track at the same time he cuts the picture. The director can, therefore, judge the length of the waits between sequences and the effect of changes of sequences on continuity without having to wait for the sound department to re-record the reel, and changes in the cutting can be made and reviewed immediately. From the sound department's standpoint, however, there is little or no advantage to editing with film. Before sound film can be re-recorded a matched print should be made. This requires time and, in general, delays the re-recording operation. As a result we have found that the most practical procedure is to supply the cutters with sound track for their use, and when the production has the director's approval we make the release records by re-recording from disk.

In our sound-on-film work we have been extremely fortunate from the film laboratory standpoint. Our laboratory has quickly learned the use and value of sensitometric control and is capable of producing the density and contrast specified within practical operating limits. Their greatest difficulty has been in the suppression of ground noises, but in this respect the product is thoroughly commercial.

On the exhibition end, most of the sound heads in use at present slide the film past a stationary sound gate with the result that irregularities in the friction of the film against the gate produce a flutter. As a result of film shrinkage, only one pair of teeth in the pulling sprocket made contact with the film at one time. At the moment the pulling pair of teeth are disengaged from the film a slight slippage of the film is required to bring the next pair of teeth in contact with it. This results in a speed variation known as sprocket-hole modulation. Where a hold-back sprocket is not provided, variations in the tension of the takeup mechanism are transmitted directly to the pulling sprocket with resulting variations in speed.

In addition to the difficulties with speed variation in film reproduction, the adjustments in the sound head are complicated and exacting. There is an exciter lamp which must be placed in exactly the right location and supplied with the right current; an optical system which must be accurately adjusted so as to properly focus the light coming from the lamp; mechanical guides for the film which must accurately align the sound track with the sound gate; and a photoelectric cell and a two-stage amplifier in which the energy level is extremely low which makes the problem of excluding extraneous noises such as those caused by electrical induction and mechanical vibration very difficult, and consequently makes the ratio of tube and cell noise to sound relatively high.

From the standpoint of the equipment, a disk reproducer is simplicity itself. The only attention the reproducer requires in the projection booth is the insertion of a new needle with each disk. If anything goes wrong with the reproducer, a new one may be installed quickly, easily, and cheaply. The only skill required on the part of of the projectionist is that required to select the correct record and place the needle on the start mark, and occasionally replace a section of damaged film by the same length of blank leader. A little difficulty has been experienced in getting projectionists capable of doing this. It is much more difficult to find men who can properly maintain the more complicated sound head.

Another recognized disadvantage of the use of sound-on-film is the effect on the shape of the picture rectangle. Many people did not like the proportions in the silent pictures, after stealing space for the sound track the proportions are worse.

In comparing sound-on-film with sound-on-disk from a cost standpoint, again it must be considered from both the producers' and exhibitors' viewpoint. From the producers' viewpoint, as pointed out above, the disk method involves the cost of the records and the cost of the record exchanges—this represents quite an item. On the other hand, if the addition of sound to the release prints materially shortens the life of the release prints, an enormous increase in film cost follows.

Very little information is available on the life of the combined sound and picture print, and what is available is not reliable because there are no established standards for determining when the useful life of sound track has been passed. In the beginning, first-run houses did not attempt to project a print more than fifty or sixty times. If this standard of reproduction were maintained film costs would be increased four or five times and would more than offset the cost of records. At the present time, the life of combined picture and sound film appears to vary from 50 to 100 per cent of the life of the picture print without the sound—the difference depending upon the care exercised in handling the film. If the addition of the sound track does not reduce the life of the release prints, obviously the sound-on-film method is less expensive from the producers' viewpoint.

On the other hand, when the sound track is placed on the film alongside of the picture it is necessary to replace the entire print whenever a new sound record is needed. Inasmuch as a thousand foot release print costs many times that of a disk it is only natural that there is a marked reluctance to retiring a print before it is absolutely necessary. As a result, sound-on-film is frequently retained in service long after it would be desirable from the sound standpoint to retire it. With disk recording, additional records are furnished to replace the records in service whenever there is a noticeable depreciation in the quality of the reproduction. This results in a marked advantage to the second- and third-run houses.

It has been our contention that the superior quality resulting from the use of sound-on-disk will increase the theater patronage enough to more than offset the increased transportation costs of this method. However, it may be desirable at some future date, due to improved results obtainable with film, to make sound available by both methods and permit the exhibitor to choose the type of sound record he prefers. Those who have been fortunate in obtaining good film equipment and those who are unable to detect any difference in box office returns between the two methods will undoubtedly elect sound-on-film.

CONCLUSION

From a theoretical standpoint it would appear that a better frequency response characteristic can be obtained using photographic recording. This theoretical advantage, however, has not as yet been realized from a practical standpoint.

We would expect to have less speed variation troubles with sound-on-disk, and this advantage has been observed in practice.

From the handling standpoint, sound-on-film is preferred by the exhibitor and distributor. On the other hand the disk method has the advantage that the problems of equipment and maintenance in the theater are greatly simplified.

From the standpoint of quality, sound-on-disk has in the past given consistently better results because of the greater simplicity of the reproducing equipment and the absence of speed variation. As theater reproduction of sound-on-film improves this advantage of the disk method will gradually disappear.

From a cost standpoint the sound-on-film is preferred by the exhibitor who does not take into account the effect of quality on the box office returns.

From the producers' standpoint, the relative cost of the two methods depends on the sound film life. At the present time there is little choice between the two. As the sound film life is improved by more careful handling the cost of this method will decrease.

In other words sound-on-film appears to have many potential advantages which, if realized, should make it superior to sound-on-disk but until they are realized in practice we prefer disk.

DISCUSSION

MR. CARLTON: May I ask from what standpoint the sound record on film goes to pieces? Is it ground noise, or what does limit its life?

MR. EVANS: Film that is handled in the average way in the theater gets dirt and grease on it. This raises the ground noise. If it is handled carelessly in the projector or run through projectors that are out of repair, the film tears at the sprocket holes. If these tears extend into the sound track the tear produces noise. Film life is apparently determined by the amount of ground noise tolerated.

PRESIDENT CRABTREE: Perhaps the Projection Committee has information on that point. I know that Mr. Faulkner of the Paramount organization has information on it. Mr. Coffman says he will mention this in a paper later.

MR. BRAUN: Has Mr. Evans figures on the preferences of the exhibitors of motion pictures? I think such a statement might be most illuminating.

MR. EVANS: I have no figures. If one talks to the exhibitors some prefer one and some the other. If the exhibitor prefers disk, it is because he is particular about the quality of his reproduction. If he prefers film it is because he worries about the handling and shipping problems. This man generally is not critical of sound quality. In our theaters, they run both, and when they have a disk job they take an evening off and enjoy themselves.

MR. MAXFIELD: I think first that this paper is one of the most comprehensive and, to my mind, unbiased attempts to analyze the differences between film and disk records that I have heard. My experience in Hollywood was limited to producers releasing most of their material on film. Two producers record important musical selections on disks, and if they dub it on film they dub from the disks because they get a cleaner production in the loud passages in the disk method than on the film. When they have to dub from film they compound the film defects. They are therefore recording their heavy numbers on disks and re-recording to disks for disk releases and to film for film releases.

MR. COFFMAN: During these discussions it might be wise to keep in mind what one of the speakers termed the "subjective factors" affecting the judgment of sound quality. Several papers on semi-controversial subjects have been presented here today, and the discussions seem to indicate that most individuals tend to develop a strong bias in favor of the method or equipment with which they are most familiar. In my own case, I find that nowhere does reproduction sound so generally satisfactory as in my own projection room. It is no better than many places elsewhere, of course, and it is undoubtedly poorer than may be found in some of the best projection rooms. Our own bias may sometimes lead us into false interpretations of the most accurate data, even when our intentions are most sincere. The ear seems to develop habits very much more easily than our other sense organs, so let us be on guard when we invoke its assistance in arriving at important decisions.

PRESIDENT CRABTREE: In case the sound is recorded on a separate film, would there be any greater handling difficulties than when handling disk records?

MR. EVANS: I should think the problems would be greater. The sound film would have more bulk and weight and would be much more expensive than the record. It is subject to the same handling problems that disk records are. From a sound quality standpoint, it is open to the objection that nobody has been able to develop and construct a sound head as simple as the magnetic pickup for a record. The only advantages I see for it are that it could be shipped in the same package with the picture film and it would eliminate retracking troubles but from every other point of view it would be less desirable than the disk record.

In connection with Mr. Coffman's remarks, I know what he means. It is very difficult to keep an open mind on these things. Our sound film generally comes from the laboratory before the disks come in. When I listen to it without disk for comparison I sometimes think it is entirely satisfactory, but later on when we run it against the disk on a blindfold test, invariably the observers pick the disk because it is firmer and clearer and contains more detail than the film.

SOME EXPERIMENTS IN MEDICAL MOTION PICTURES IN COLOR

HARRIS B. TUTTLE*

From the beginning of the motion picture the possibilities of its application to the field of medicine as an educational medium and a means of satisfactory record has been well recognized by the motion picture profession. Because of this current feeling there has been a constant effort to produce satisfactory pictures. Medical motion pictures invariably deal with a specific type of subject in which the emphasis lies in detailed structures, which as a rule depend on differentiation of fine color gradations for their successful interpretation. Unfortunately these predominant hues are found in the red end of the spectrum, that portion which the earlier photographic materials were unable to record correctly. This situation, together with the fact that photography on 35 mm. film is expensive considering the small distribution and limited use to which medical films are subject, tended to discourage the progress of these pictures.

With the introduction of panchromatic film, the problem of color rendition in monochrome was solved. The advent of the 16 mm. camera and film in 1923 and later the production of panchromatic reversal film in 16 mm. size gave a combination which is relatively inexpensive and capable of producing pictures of very satisfactory quality.

As a result of the comprehensive program of medical motion pictures begun in 1927 under the joint auspices of the American College of Surgeons, the Motion Picture Producers & Distributors of America, Inc., and the Eastman Kodak Company, an organized study[1] was undertaken of the technic for making medical and surgical pictures. This technic is applicable to the use of 16 mm. pictures as well as 35 mm. pictures on the same basis of illumination. In either case the production of good pictures is the combined effect of proper staging,

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correct placing of the camera, and the use of properly directed light of sufficient intensity.

During the past decade interest has been increasing in processes of color motion pictures, but until very recently none of the processes has been used for medical photography. Within the past year Naumann[2] has described a rather elaborate equipment for medical color motion pictures by the Busch two-color additive process. Although very pleasing flesh tones can be recorded by a two-color process, a much superior color rendering of medical subjects is possible by three-color methods.

There are several processes of color photography which yield a transparency as the final color picture. Several of these processes have been utilized by surgeons and clinics for recording interesting pathological cases. The Kodachrome process,[3] a two-color subtractive method devised by J. G. Capstaff, is adaptable to medical photography. Many excellent pictures have been made with this process by Dr. Nathan T. Beers of Brooklyn, N. Y.

The Kodacolor process[4] of amateur cinematography on 16 mm. film, announced in 1928, offers a simple, economical, and accurate medium for medical color cinematography. It is the purpose of this paper to describe several experiments by this process which have been conducted during the past few months. Some of these experiments were performed with the assistance of Dr. H. H. Baker of the Highland Hospital and of Dr. R. Plato Schwartz of the Strong Memorial Hospital, both of Rochester, N. Y. Dr. Baker recently published a short description of his work.[5]

The daylight available for photographic purposes indoors is usually of insufficient intensity for medical motion pictures. In any event, it is exceedingly variable, changing with the season of the year, the time of the day, and the prevailing weather conditions.

Experiments have shown[1] that incandescent lights are admirably adapted to medical cinematography. Carbon arcs obviously cannot be used in the operating room because of the danger of ignition of the vapors from liquids used for anaesthesia.

It is possible with incandescent lights to duplicate an exposure, and by means of portable units to direct the light almost exactly onto any part of the operative field.

There are, however, certain types of operations which cannot be properly lighted with any of the present types of lamp. These are mostly of the deep incision type where even the surgeon has difficulty in seeing. The success of medical motion pictures in color lies in recognition of the impractability of photographing such cases and avoidance of them in the beginning.

The incandescent tungsten light has a continuous color spectrum, suitable for color photography when the filament is burned at the rated voltage. Tungsten lights are portable and compact and occupy very little space in the usually crowded operating room. They are entirely safe to use where ethylene or other inflammable gases are used as anaesthetics.

The quality of light coming from any tungsten filament lamp is dependent upon the amount of electric current passing through the filament. With the filaments burning at their rated voltage, the spectrum of such lamps is not the same as sunlight. If a lamp is

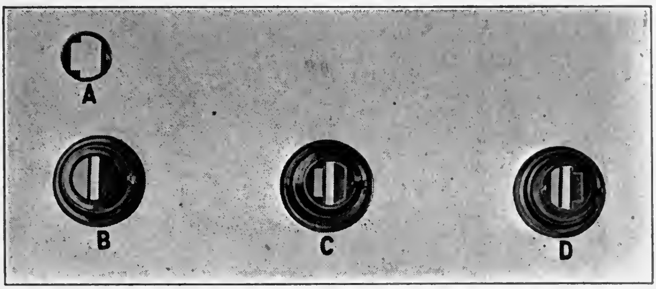

FIG. 1. Kodacolor filter and diaphragm.

over-volted, it will burn at a much higher temperature, and the radiation will contain a greater amount of blue and violet.

The ratio diaphragm (see *A* in Fig. 1) which is supplied with each roll of Kodacolor film is matched to the film for the sunlight spectrum. If this diaphragm were to be placed on the filter in the usual way (see *C*, Fig. 1) and used with tungsten light at its rated voltage, the resulting color picture would be too reddish throughout most of its tones. If the ratio diaphragm usually supplied is turned around so that the section meant to cut down the blue area of the filter is placed on the opposite side so that it cuts down on the red area of the filter (see *D*, Fig. 1), that is, if the ratio diaphragm is rotated 180°, we have found that the color balance is established between Kodacolor film and tungsten light so that the resulting pictures will show good color rendering.

Two types of tungsten filament lamps are recommended for medical photography in color: the Eastman Medical Spot Light and the Kodalite.

The Medical Spot Light[1] (see Fig. 2) was designed by the Eastman Kodak Research Laboratories for the specific purpose of surgical

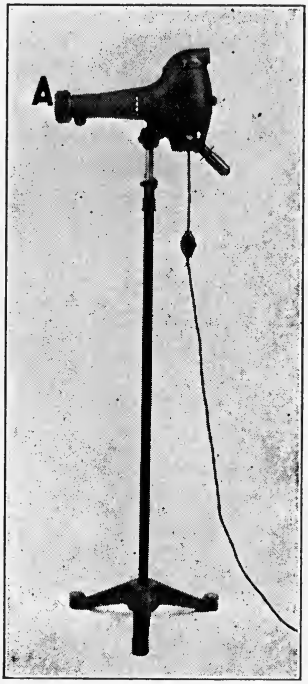

FIG. 2. Eastman Medical Spot Light.

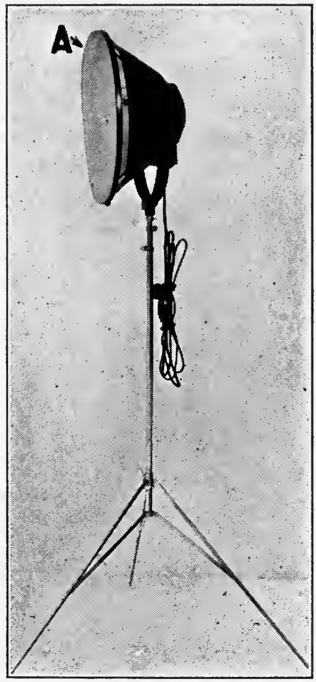

FIG. 3. Kodalite with diffuser.

motion picture work. A 500 watt tungsten lamp is the illumination source. The spot light is so constructed that the beam of light passes through a water cell (see *A*, Fig. 2) which absorbs most of the heat radiation without diminishing the intensity of the actinic radiation useful in photography. Therefore, from a practical standpoint, this light can be called a cold light, and in consequence it is particularly adapted to the photography of operations.

The Kodalite (see Fig. 3) uses a 500 watt tungsten filament lamp but is designed for flood lighting. It is important with this lamp that a diffusing medium be used, such as cheesecloth or draftsman's tracing linen (see *A*, Fig. 3). The heat radiation from an undiffused Kodalite or any other similar type lamp might cause burn if the patient were subjected to it for a long time.

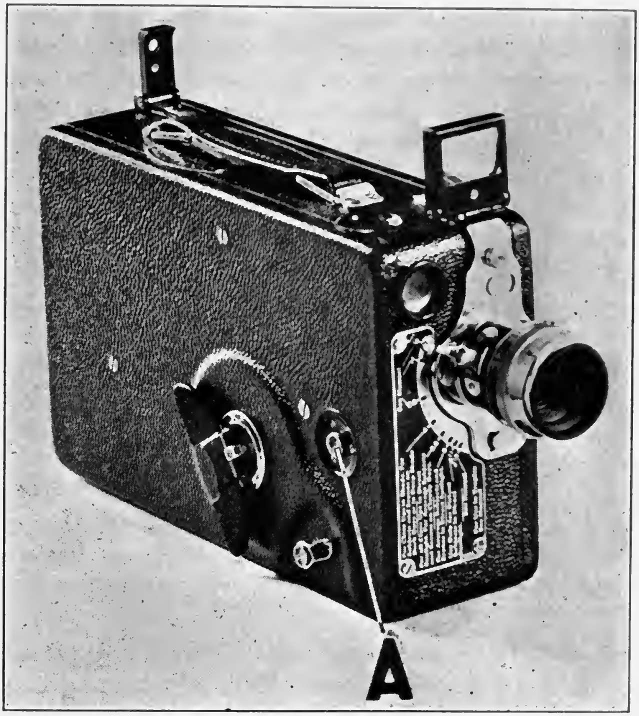

FIG. 4. Model B Cine Kodak fitted for Kodacolor.

To make black and white pictures of an operation, it is necessary to have approximately 400 foot-candles of light to get good exposure at a diaphragm of *f*/4. This, of course, depends somewhat upon the color of the subject and the depth of the cavity. If this amount of light were used from one source, the lighting would obviously be somewhat contrasty. To obtain a softer lighting effect with more roundness and less of the deep shadows, it is necessary to use at least two lights. The brighter areas of light from the lamps should be so directed that they join one another, with the less intense areas over-lapping. With two Kodalites diffused with two thicknesses of cheesecloth, each four feet from the subject and the light directed as recommended, the correct exposure at a speed of sixteen frames a second would be obtained with an aperture of $f/4$.

To make Kodacolor at normal speed (sixteen frames a second) requires 3200 foot-candles which makes it necessary to use eight Kodalites diffused with two thicknesses of cheesecloth at a distance of four feet. It can easily be seen from this that the amount of heat from so many lamps and the space they would occupy in the operating room would make color cinematography somewhat difficult. The number of lamps, as well as the amount of heat, can be reduced one-half by using the half-normal speed attachment on the Cine Kodak (see Fig. 4). By moving the lights up to three and a half feet, one more can be eliminated, reducing the number to three. So, with three Kodalites, approximately three and a half feet from the subject, and the camera operating at half normal speed, satisfactory Kodacolor pictures can be made.

The Medical Spot Light because of its design gives a concentrated, uniform spot of light. Therefore, in case of its use, only two lamps are necessary at a distance of four feet from the field for taking Kodacolor pictures at half normal speed.

The foregoing illumination conditions assume that the average operating area will constitute the photographic field. If the field is greater than the operating area, then an additional 500 watt flood light should be used with the Medical Spot Light for general illumination.

Regardless of the type of lamps used, they should be placed so that there are no deep, heavy shadows. Flat, even lighting is better in color work than contrasty lighting.

It has been found in most cases that the most convenient place for lights and camera is at the foot of the operating table. The table can sometimes be slightly tilted toward the camera to improve the perspective.

At present, lenses of 1.0 in. equivalent focal length are the only ones available for making Kodacolor motion pictures. To meet this condition, it is necessary to place the camera about three feet from the subject.

Precautions to assure asepsis of the cinematographer and his equipmen in operation pictures are extremely important because of the proximity of the apparatus to the field.

It is the practice of a great many hospitals to use either iodine or mercurochrome in sterilizing the area of operation. Both of these absorb a considerable amount of the heat radiation from the lamps. It is therefore recommended that alcohol and Kalmerid solution be used for sterilization. Both of these solutions are practically colorless and are being used entirely by a large number of hospitals at the present time.

In the following two tables, the approximate illumination intensities in foot-candles are given for the Eastman Medical Spot Light and the Eastman Kodalite.

TABLE I

Illuminating Intensities for Eastman Medical Spot Light

Distance from Front of Lamp to Subject	Diameter of Spot of Light	Approximate Intensity (Foot-Candles)
3 feet	6 inches	1800
4 feet	9 inches	800
5 feet	12 inches	450
6 feet	15 inches	300
7 feet	18 inches	200
8 feet	21 inches	150

TABLE II

Illuminating Intensity for Eastman Kodalite

Distance from Front of Lamp to Subject	Diffusing Material Two Thicknesses of Cheesecloth	One Thickness Tracing Cloth
	Approximate Intensity (Foot-Candles)	
3 feet	700	350
4 feet	400	200
5 feet	250	125
6 feet	180	90
7 feet	120	60
8 feet	100	50

The efficiency of a light unit may decrease with use, because of a blackish deposit which collects on the inside of the glass bulb. Lamps are available, however, that contain tungsten powder, with which the blackening can be removed thus prolonging the useful life of the lamp. For color motion picture photography, this type of lamp should prove useful. Allowance for decreased light with a blackened bulb must be made in the exposure when the old type of lamp is used.

SUMMARY

Members of the medical profession interested in making clinical and surgical motion pictures have felt strongly that the addition of color would increase the usefulness of such films. Satisfactory medical motion pictures in color on 16 mm. film have been made with the use of a camera equipped to operate at eight frames per second. Three Kodalites placed three and a half feet from the subject or two Eastman Medical Spot Lights placed four feet from the subject give ample illumination. To prevent over-exposure in the red the ratio diaphragm supplied with each roll of Kodacolor film should be fitted on the filter holder in reverse from the manner recommended for daylight pictures, where blue and violet radiations predominate.

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DISCUSSION

MR. ROSENBERGER: I appreciated these pictures very much, but the only objection I would have is that for medical studies these motions are about twice too fast. I think it would be better to increase the light if possible and take the pictures at normal speed instead of eight per second.

APPARATUS FOR THE ANALYSIS OF PHOTOGRAPHIC SOUND RECORDS*

OTTO SANDVIK

The origin of the distortions which occur in the photographic sound recording process may be classified in four general groups, namely, electrical, optical, mechanical, and photographic.

The group of instruments to be described here were designed for the purpose of studying the various phases of the photographic process alone. Broadly speaking the only condition to be satisfied by the photographic process is that the positive transmission be proportional to the negative exposure.

The literature dealing with the photographic problems connected with the variable width sound recording process is limited, and that devoted to the problems relating to the variable density method is more extensive but represents primarily deductions from the general theory of tone reproduction. The theory is valuable as a working basis for certain phases of the problem which, however, has many other aspects, and a great many data are required before a practical application of this theory alone can be made. Such data should deal with the characteristics of photographic materials under conditions which obtain in the practice of sound recording and sound reproduction. For example, owing to the failure of reciprocity, the sensitivity or the speed of an emulsion determined by means of a step tablet or any type of sensitometer where the exposure time is relatively long, may yield results differing considerably from those that will be obtained when the intensity factor of exposure is very great and the exposure time is of the order of 5×10^{-5} second which is true in practice. Moreover, densities measured on a reliable densitometer of the type with a diffusing medium against the film sample, give values which are quite different from the values that would be obtained with a photo-electric cell as used in a standard sound reproducer. In the former cases the values obtained are so-called diffuse densities, while

* Communication No. 438 from the Kodak Research Laboratories. (Read before the Society at Washington.)

in the latter the values are more nearly specular densities. The difference between these two values depends upon the type of photographic material used, the type of optical system, and on the absolute value of density.

At this point it may be well to mention that where it is required to develop a routine method of sensitometric control in a processing laboratory, it will ordinarily be found quite satisfactory to use a low intensity sensitometer, and a densitometer that reads diffuse densities, so long as the control is restricted to the material and the conditions for which it has been determined. Discordant results would generally be obtained, however, if one were to measure relative speeds of two different types of emulsions at low values of illumination, and apply the speed ratios, so found, at very high exposure intensities, the reason being that the deviation from the reciprocity relation may, and very probably would be different for the two materials. Likewise, the gamma product relation of negative and positive based on values of either specular or diffuse densities, may lead to discordant results were one of the emulsions changed. To illustrate: A series of experiments on two photographic materials has shown that the best results are obtained when the gamma product has a certain value, a, as based on diffuse densities. The positive is not changed materially and it is found that the best quality is obtained with a gamma product larger than a, or it may be less than a. Since the densities of the positive were measured as diffused densities, whereas the photo-cell in the reproducer measures more nearly specular densities, this apparent discrepancy may be accounted for by a difference in the ratio of the values of density obtained by the two methods of measurement in the two cases. These factors will be treated in greater detail in a subsequent paper which will present experimental data dealing with the various phases of the problem.

From the above brief statement of the problem it appears that the sensitometric study should be carried out according to precisely defined conditions, and that it is desirable to duplicate exactly conditions which obtain in practice. Moreover, having formulated a satisfactory method of sensitometry, it remains to subject the results obtained to critical quantitative analysis. This can be accomplished by analysis of the wave-form of the sound records.

Before proceeding with a description of the instruments for the analysis of wave-form it may be well to consider briefly the problem itself. As already stated the condition to be satisfied by the photographic process is that the positive transmission shall be proportional to the negative exposure. In order, however, to study the relation between negative exposure and positive transmission it is necessary to know the exact distribution of exposure along the film, where the distribution of exposure is defined so as to hold for either variable density or variable width type of recording. For the purpose of simplicity let it be assumed that the exposure modulating device is actuated by the current from a source which delivers a pure sine wave. The distribution of exposure on the film, however, will not be sinusoidal on account of certain distortions occurring during the transformation of a variable electric current to a variable exposure

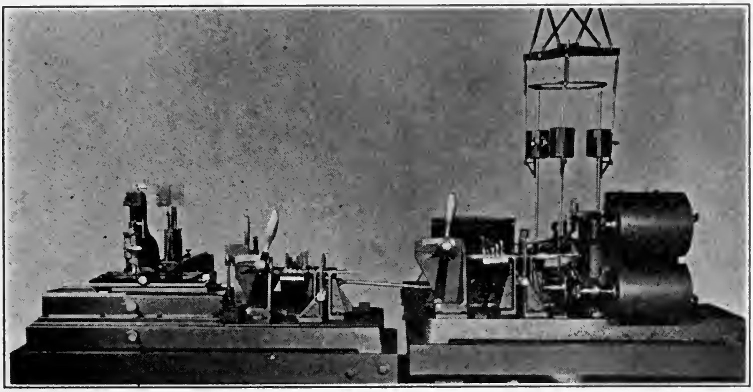


FIG. 1. Photograph showing front view of microdensitometer.

(width, intensity, or time). The cause of these distortions may be optical, due to finite slit width, imperfect image formation, diffraction, or similar cause, electrical, or purely dynamic. The form and amplitude of these can be ascertained with a fair degree of accuracy by measurements and by calculations which are based on fundamental principles.

In general, non-linearity between the variation in the sinusoidal current which actuates the modulating device and the corresponding variations in the intensity of the radiation transmitted through the positive sound track moved uniformly past a scanning slit, may be due to three causes: first, distortions introduced during the "electro-optical" transformation, that is, by the modulating device; second, distortions introduced by the photographic process; third, distortions in the "opticoelectrical" transformation due primarily to a finite slit width and non-uniformity of the image formed by the optical system of the reproducer. In the investigation which is to follow, these three factors will, so far as possible, be studied separately so as to determine step by step what is occurring.

There are three instruments to be described. The first is a microdensitometer shown in Figs. 1 and 2. This instrument traces out the wave form of the sound record on a scale eighty times as large in amplitude with a proportionally magnified base line. It consists of a microscope with a moveable microscope stage driven by a precision

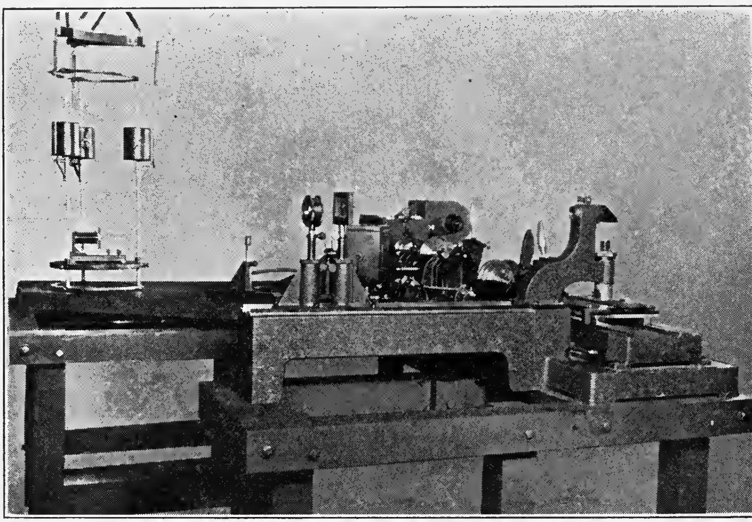


FIG. 2. Photograph showing a side view of microdensitometer.

screw, and a carefully made train of gears from a synchronous motor. (The motor need not necessarily be of synchronous type.) The microscope stage is so constructed that it can be shifted laterally for the purpose of analyzing different sections across the sound track or the entire sound track, as is, of course, necessary in the case of variable width records. It can also be rotated about the optic axis in its own plane, so as to place the longitudinal axis of the sound track parallel to the axis of the screw. The train of gears provides speed reduction ratios such that the screw will advance the microscope stage at the rate of 5, 2.5, 1, 0.5, or 0.25 mm. per minute, respectively. The speed at which the stage should be advanced depends on the time constant of the recording system and on the structure of the image to be analyzed. A reversing gear is provided, and records may be traced with the screw running in either direction. The film with the sound record runs over a guide, or gate, which is elevated slightly above the plane of the microscope stage; this provides accurate side guiding and prevents the film from buckling and moving out of the focal plane.

The optical system (Fig. 3) consists of a tungsten ribbon lamp, O, imaged on the film by a pair of condensers, C_1 and C_2. When the substage condenser, C_2, is removed, the ribbon can be imaged on the film full size or larger so as to more than cover the entire width of the sound track. By careful choice of ribbon, very uniform illumination

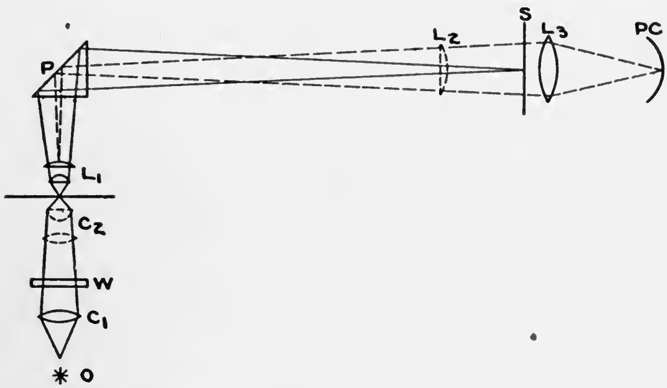


FIG. 3. Schematic diagram of the optical system of the microdensitometer.

across the entire track can be obtained, which, of course, is essential for the analysis of variable width sound records. A copper sulfate cell, W, is inserted between the two condensers as shown, its purpose being to filter out the infra-red radiation (to prevent excessive heating of the film) where this part of the radiation does not contribute materially to the response of the photo-sensitive surface. This is the case for most types of photo-electric cells. An image of the sound record is formed by a microscope objective, L_1, on an adjustable slit placed in front of the photo-sensitive surface. The focal length of the objective and the slit width depend on the magnification and resolution desired. A cylindrical lens, L_2, may be inserted in the beam at the point shown to reduce the magnification along the longitudinal axis of the slit. It has been learned by experience that a certain amount of reduction is possible without materially affecting the definition in the image plane.

It is desirable in the present investigation to use a photo-electric cell for the photo-sensitive element. It is well known that photo-electric cells are not uniformly sensitive over the surface, but that the sensitivity varies from point to point. When the image of a variable area sound record is caused to move across the slit in front of the photo-cell by the motion of the microscope stage carrying the record, the area and the location on the cell which is illuminated

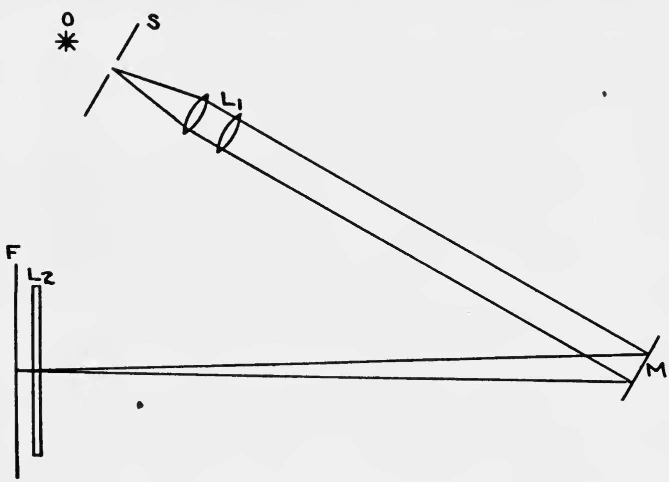


FIG. 4. Schematic diagram of the camera optical system of the microdensitometer.

do not remain constant, but will shift up or down as the phase of the wave advances. Therefore, if the sensitivity of the cell changes from point to point, the variation in photo-electric current will not be proportional to the variation in the total radiation falling on it. To overcome this difficulty a lens is placed behind the slit in a position such that it images the gauss point of the microscope objective on the cell surface. This forms on the cell an image of which the size is constant and of which the intensity is essentially uniform. The intensity of this image depends on the amount of radiation transmitted by the slit.

The camera (at the right in Figs. 1 and 2) is driven through another system of carefully made gears from the same shaft which drives the microscope stage. Therefore, the film and the microscope stage are driven at a constant ratio of speeds for any given gear combination. The gear reductions on the camera are such as to advance the film at rates of 1000, 500, 200, 100, and 50 mm. per minute. This wide range of speed is not necessary for the purpose of analyzing sound records, but the instrument was designed so as to be useful also for other purposes. The film on which the trace is made is about 165 mm. (6.5 inches) wide and can be inserted in the camera in 400

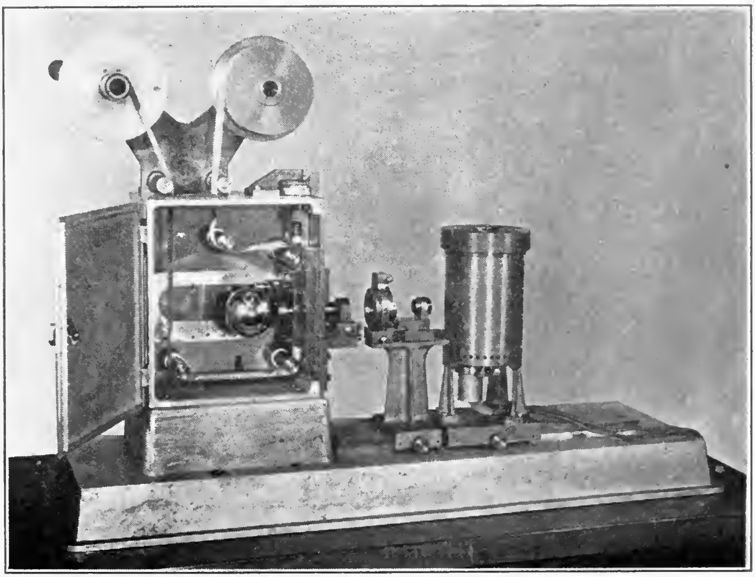


FIG. 5. Photograph showing side view of sound track densitometer.

foot lengths. Any length may be detached as required for development.

A top view of the camera optical system is shown in Fig. 4. A vertical slit, *S*, is illuminated by a lamp, *O*. The radiation from the slit passes through a lens, L_1, to the galvanometer mirror, *M*, from whence it is reflected on the film, *F*. The lens images the slit on the film through a cylindrical lens, L_2, which brings the slit image down to a point image on the film. Stops may be introduced in the lens for the purpose of obtaining the correct exposure at different film speeds.

The galvanometer is shown placed on a suspension for the purpose of eliminating vibrations.

The wave form of the microdensographs will be analyzed and resolved into the component parts by means of a harmonic analyzer of the Henrici type built by the Mathematical-Mechanical Institute of G. Coradi, Zürich, Switzerland. This instrument is designed to give ten terms of the Fourier series, and by a slight modification it will give thirty terms if so desired.

The second instrument which may be called a sound track densitometer is shown in Fig. 5. This instrument is so designed as to ap-

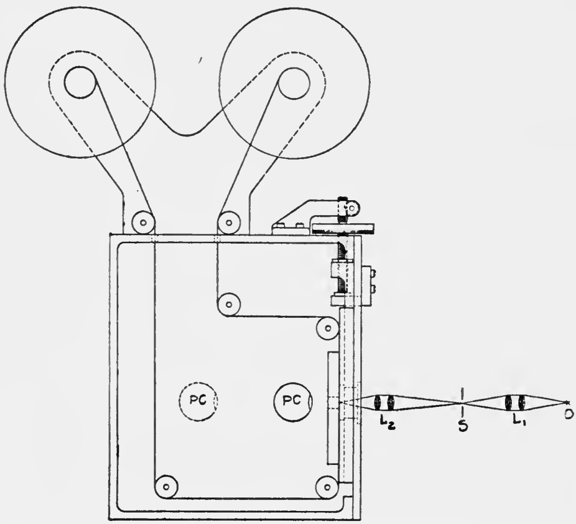


FIG. 6. Schematic diagram of one optical system and film moving mechanism of sound track densitomer.

proximate closely the conditions of a standard sound reproducer, except that the film, instead of being moved at a speed of 90 feet per minute by a rotating sprocket, is moved step by step past the scanning slit by the rotation of a very accurate screw mechanism.

The purposes of this instrument are fourfold: first, to measure photoelectric densities in connection with sound recording emulsion sensitometry; second, for practical wave form analysis; third, for practical or experimental investigations of the effect of slit widths, orientation of the slit, and lack of focus; and fourth, to make a study of the relative merits of various types of optical systems.

The film is held taut between two planes which may be moved up or down by means of the screw as shown in Fig. 6. This screw is guaranteed by the maker to have an error less than 0.001 mm. With the divided head on the screw one can set it accurately to 0.005 mm. and with close approximation one-half of that. In other words, the sound track can be advanced in steps of 0.0025 mm. The transmis-

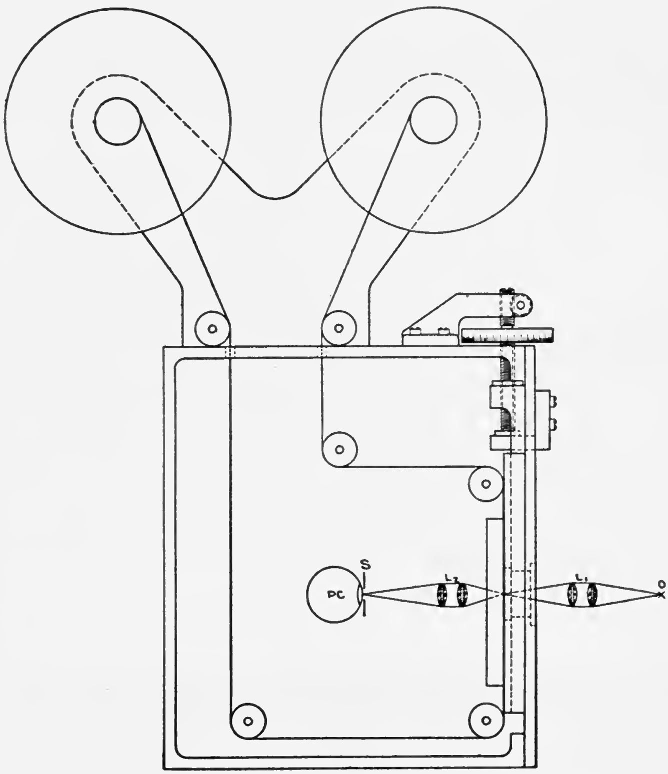


FIG. 7. Schematic diagram of another optical system of sound track densitometer.

sion, step by step, is determined by readings of photo-electric cell currents. Since the wave-length on the film moving with a linear speed of about 457 mm. per second (90 feet per minute) is about 0.91 mm. for a 5000 cycle frequency, one can obtain 36 readings from 0 to 2π with a proportionally greater number for lower frequencies. This gives a sufficient number of points on which to plot a good curve of the wave, which can if desired be analyzed on the harmonic analyzer. The film slides between two stationary planes in which there are small rectangular apertures providing passage for the radiation through the film to the photo-cell. The purpose of the stationary planes is to firmly fix the film in the image plane of the slit.

The lamp filament, O, is imaged on the slit by L_1 as shown in Fig. 6, and the slit is imaged on the film by L_2. The photo-cell is mounted on a slide so that its front surface may be placed within about 15 mm. of the film plane or as far as 100 mm. away from that point.

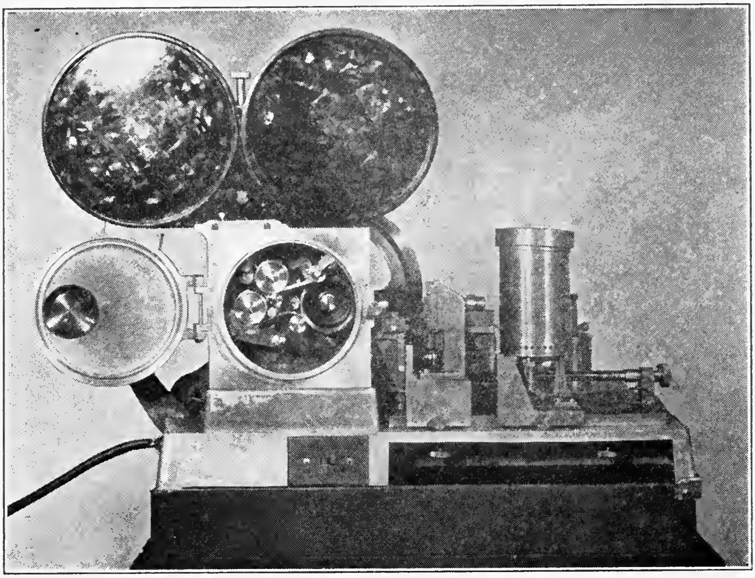


FIG. 8. Photograph showing side view of variable slit sensitometer.

A different type of arrangement is shown in Fig. 7. The radiation from the lamp, O, is condensed on the film by a lens, L_1. Another lens, L_2, is placed on the opposite side of the film so as to project an enlarged image of the sound track on the slit, S, in front of the photoelectric cell. This scheme is not new, in fact, it is nothing more than a projection microscope, but it will be interesting to compare the relative merits of the two systems. One obvious advantage of it is that focusing and alignment of the slit is less difficult, because one can actually see the grains in the film when they are brought to a focus on the slit jaws, and the slit can then be rotated until it is perpendicular to the sound track. Experimental data obtained with the two systems will be presented in a subsequent paper.

The third instrument is a variable slit sensitometer, designed for the purpose of investigating the sensitometric characteristics of sound recording emulsions, as for example, sensitivity or speed and failure of reciprocity under sound recording conditions. The instrument is shown in Fig. 8. It consists of a camera moving the film at a uniform speed of 90 feet per minute past an exposing slit of variable width. The light source is a tungsten ribbon filament lamp. The lamp filament is imaged on the variable width slit which in turn is imaged on the moving film at two to one reduction, as shown in Fig. 9.

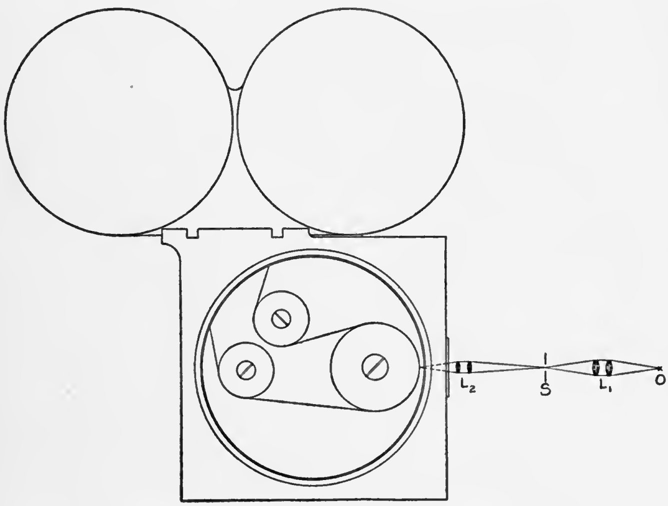


FIG. 9. Schematic diagram of optical system and film path in variable slit sensitometer.

The width of the slit is varied automatically by the rotation of a precision screw. This screw is guaranteed by the maker to have an error of less than 0.001 mm., and since it turns through only a very small angle, the error is probably more nearly of the order of 0.0001 mm. The screw is actuated by a cam mechanism. This mechanism can be understood more easily by referring to Fig. 10. One member of the cam mechanism consists of a cylindrical drum around the periphery of which are placed a series of stops. An arm pinned to the screw shank extends out from the screw so as to rest on one of these stops while the exposure is made. Another member of the cam mechanism, in fact another cam, rotates continuously and when it advances in a given angular position it engages the arm which controls the rotation of the screw and lifts it to a point which clears the highest stop on the cylindrical cam. The latter is now advanced one step by a ratchet mechanism and stops; the arm which rotates the screw is now brought back into this new position and the slit opening is varied by a correspondingly different amount, where it remains while a second exposure is being made. This process continues through the complete cycle of the cylindrical cam when the process is repeated.

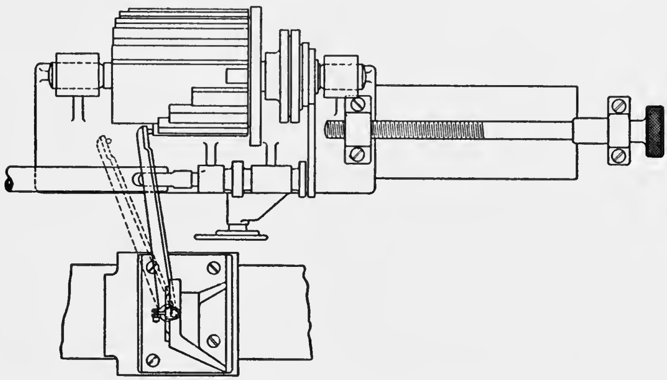


FIG. 10. Drawing showing top view of slit and cam mechanism of variable slit sensitometer.

Figure 11 gives a better idea of the slit and cam arrangement with respect to the film which is shown wrapped around the drum. There are sixteen stops on the cylindrical cam so arranged that the width of the variable slit is changed by square root of two steps from a slit width of 4 mils to about 0.016 mil. This range of variations is more than sufficient to cover the normal exposure range occurring in practice.

DISCUSSION

MR. COFFMAN: I feel that the Papers Committee owes Dr. Sandvik an apology in forcing him to abridge his talk so materially. I strongly urge every one interested in recording sound on film to study the description of the instruments when the paper is published in the JOURNAL, because these instruments make it possible to secure real precision data on what happens in photographic sound recording. The instruments are ingeniously designed and the results should throw light upon a number of our most mooted questions.

MR. TAYLOR: I hope in addition to the illustrations of the machines we shall have the results of what is obtained with them.

MR. COFFMAN: I should like to reply to Mr. Taylor for Dr. Sandvik. Dr.

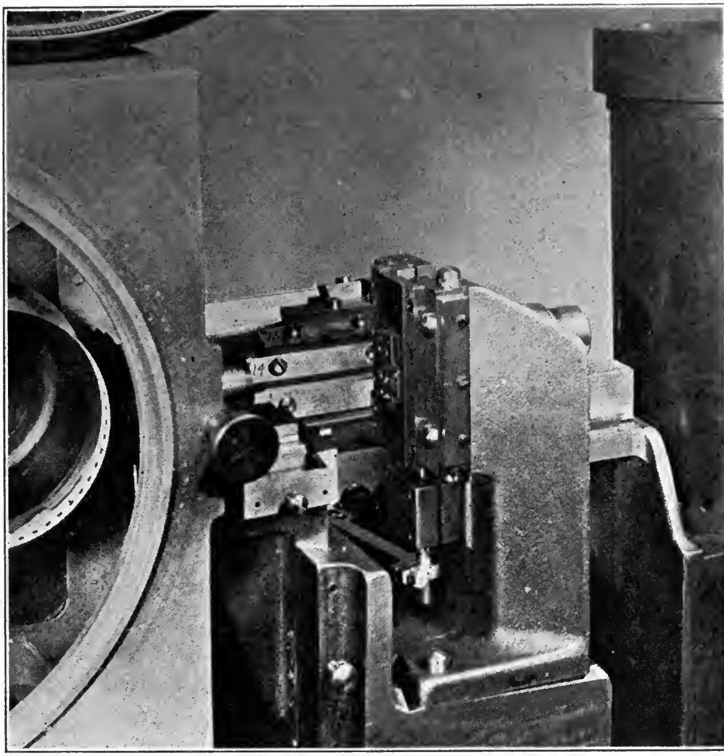


FIG. 11. Photograph showing slit and cam mechanism of variable slit sensitometer.

Sandvik insisted that the description of these instruments should not be presented to the Society until the data secured with them was ready for publication; but I thought they were sufficiently interesting to excite thought on how they could be used. The Papers Committee will insist on publication by Dr. Sandvik of his results as soon as they are ready for release.

PROGRESS IN INDUSTRIAL AND SCIENTIFIC CINEMATOGRAPHY IN FRANCE*

MARCEL ABRIBAT

The notes and information which follow treat very briefly the activities in the sound film industry in France for the late months of 1929 and the early part of 1930. This information is followed by descriptions concerning some innovations in motion picture apparatus, both planned and effected in France during these months. Only the most interesting of these will be described.

THE SOUND FILM SITUATION IN FRANCE

The introduction of sound film in France has been very slow. The causes of this slow beginning are many, but among them only the most important will be cited: (1) The lack of enthusiasm of the public and the producers for synchronized talking films. These, although very poor technically, had appeared even before the war and had cooled the spark of curiosity which would have been shown for the new sound films coming from across the Atlantic. (2) The disagreement between the American and French producers who during the year of 1929, had not been able to come to a suitable agreement. If sound films had become immediately popular in France, it could only have been by the use of American material and films, and the time for this was evidently poorly chosen.

Toward the end of the past year and in the beginning of 1930, the situation cleared up somewhat. An agreement concerning the freedom of entry of foreign films having been established for better or worse, it has now become possible for certain foreign firms to enter freely under an agreement with the French producers and French theaters.

More and more, the old French firms are changing and increasing their activities and those having means for both production and exhibition have already entered actively into the field.

Among these, Pathe Cinema, really Pathe-Natan, having at its

* A contribution to the Progress Committee Report of May, 1930, by M. Abribat, Kodak-Pathe Research Laboratory, Vincennes, France.

disposal both important exhibition circuits and enormous studios at Joinville (formerly studios of the Société des Cineromans) has commenced sound productions on a large scale.

The process used is the RCA and one after the other of the studios at Joinville have been equipped for sound taking work, or to use the technical word already current, they are "*Sonorisés*."

During the delay in changing the French studios, Pathe-Natan filmed in the studios of the British International at Elstree, England, *Les Trois Masques*, a film spoken in French, which has run for many weeks now on the Parisian "boulevards."

No special technic was employed in the large French speaking production (featuring Adolph Menjou) in the Pathe-Natan studios of Joinville but the RCA process was exactly as in the United States.

La Société des Établissements Gaumont even before the war produced short synchronized films with disks and for several years and even in these past few months used the Danish Petersen-Poulsen process. The sound is recorded on the entire width of a separate 35 mm. film. Recording is by variable width method. The reproduction necessitated the use of two films (one film for sound and one for picture) passed, respectively, through the reproducer gate and a separate projector in synchronism.

Gaumont, who already has equipped the Buttes Chaumont studios in Paris for sound work and has produced some experimental film, has a new projection apparatus called "l'Ideal Sonore." This reproducing arrangement uses a selenium cell as in the Gaumont-Petersen-Poulsen system. The apparatus is fitted with a turntable for phonograph records.

A public demonstration given recently at the theater of the Champs Élysées in Paris showed that the Gaumont l'Ideal Sonore is able to give an excellent rendition from any films, Gaumont, RCA, Movietone, Tobis, as well as disk processes: Vitaphone, L. N. A., *etc.*

Aloel Gance productions used the new Gaumont sound process for their film *La Fin du Monde*.

On the other hand, the Société Gaumont has recently joined the powerful Aubert-Franco-Film group and large productions are being planned. The same group has already taken under its direction the G. M. Films developing and printing studios and the firm of motion picture equipment makers, Continsouza. It is therefore likely that the new group will be able to extend its activity into all the branches of the motion picture industry, production, distribution, and exhibition.

The firm of Tobis, which was one of the first to introduce a non-American sound apparatus in France, has completed the equipment of their Menchen d'Epinay studios where they are actually producing films. The Tobis and Klangfilm processes are used, employing either a Kerr cell or lamp.

As in all the French sound studios, lighting for the scenes is done by incandescent lamps: Nitraphot, Pyralux, and Phillips, from 600 to 5000 watts. The Tobis studios employ arcs with filters successfully.

In its latest installation, Tobis has given up the system employing a camera booth for sound recording. A fixed central station in the center of the studio and in communication with the different rooms, receives the current by wire from the microphones placed on the different sets. The recording apparatus is simply encased in a rubber box. The operator and his camera can thus move as freely as they could when taking silent films.

The equipment for these studios is imported exclusively from Germany. Moreover, the Tobis company leases its studios and its materials to different companies.

A film which has had a great success is *La Nuit Est a Nous* filmed in Berlin in three languages simultaneously with artists of three different nationalities. The French version is very satisfactory.

La Société Haik exploited its "Cinevox" process which is a variation of the DeForest process where recording is accomplished with a glow lamp. Original work dealing with amplifiers and loud speakers has been carried out by the engineers of this society. Unfortunately the studio at Courbevoie which was operating successfully was almost completely destroyed by fire on Feb. 8, 1930. Productions under way are being continued in the studios on location, but a good part of the material was destroyed.

La Société L. N. A. headed by Louis Nalpas, formerly director of the Société des Cineromans, built a projector for disk and film records. This projector is simple and inexpensive. This, together with Gaumont's Ideal Sonore, should help in spreading sound films in parts of France where the talkies have scarcely penetrated or have not been introduced at all.

The L. N. A. company is producing in the Billancourt studios where they are now working on synchronization of silent film and the making of song films.

La Société Melovox formerly allied with Gerardot built a machine for film and disk sound records. There is nothing particularly novel about it technically. The Melovox company does not make film itself.

Les Productions Robert Kane, an American organization, started

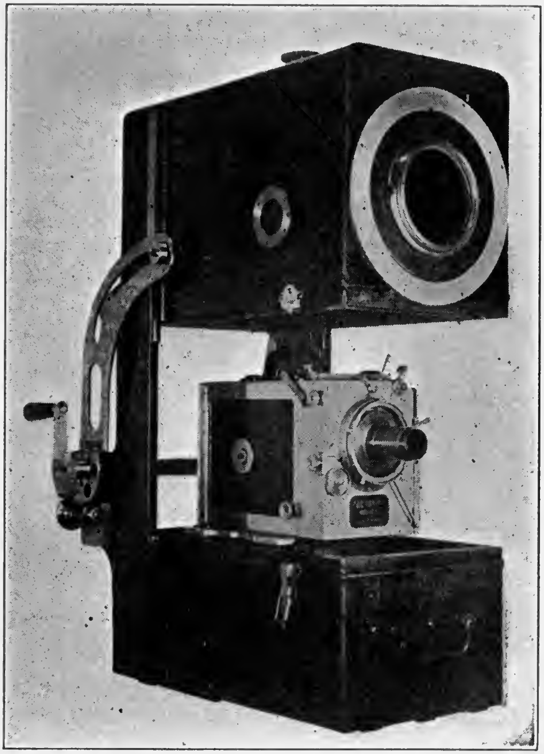


FIG. 1. Debrie sound proof camera case.

first with the RCA process. This firm erected a studio on the grounds of the former Joinville studios.

From this very brief exposition, it is seen that the purely French processes for sound films are not numerous. The process for recording on film used by the Gaumont company is the only one which is actually complete from the taking to the showing with the Ideal Sonore projector mentioned above.

NEW APPARATUS

New Anti-sound Case for Camera and Printing Device.—A sound proof case for acoustically insulating the taking apparatus has been built by A. Debrie. The camera is mounted on a platform and a cover is lowered over it, sealing it hermetically. (See Fig. 1.) The case is arranged so as to allow for the necessary freedom of movement for loading and for changing the lenses. All the controls for film punching, automatic dissolve, *etc.*, may be reached from the outside of the case. The focusing magnifier is placed very ingeniously. The

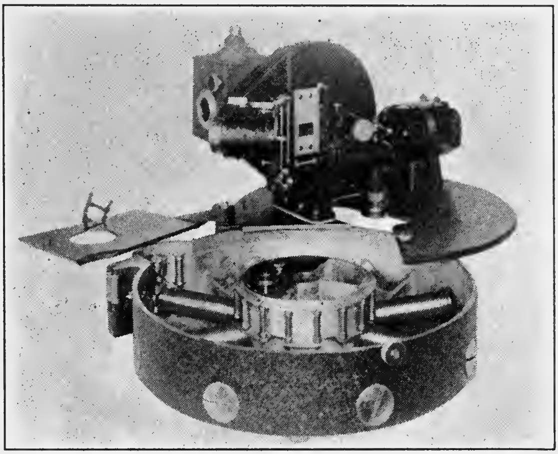


FIG. 2. Speico projector showing tractor rollers.

eye-piece remains fixed on the box and it is therefore possible to open and close the box without it being necessary to readjust the magnifier. The closed box assures perfect insulation from the sound produced by the camera mechanism.

For printing sound films the studios were obliged to use continuous printers. The firm of A. Debrie has adapted to its well known printer "Matipo" an arrangement for printing by an illuminated slit. The device is placed on the printer and the negative sound film runs continuously in contact with the positive which has just come from the gate where the picture is printed as usual. All the French printing studios have adopted this device including French Tobis in their Epinay studios.

*New Apparatus for Handling Endless Film—the "Speico" Box.**—The problem of unrolling and rolling up simultaneously of a film on the same roll is not new and numerous tentative suggestions have already been made for solving it.

The "Speico" device consists of a flat cylindrical case containing

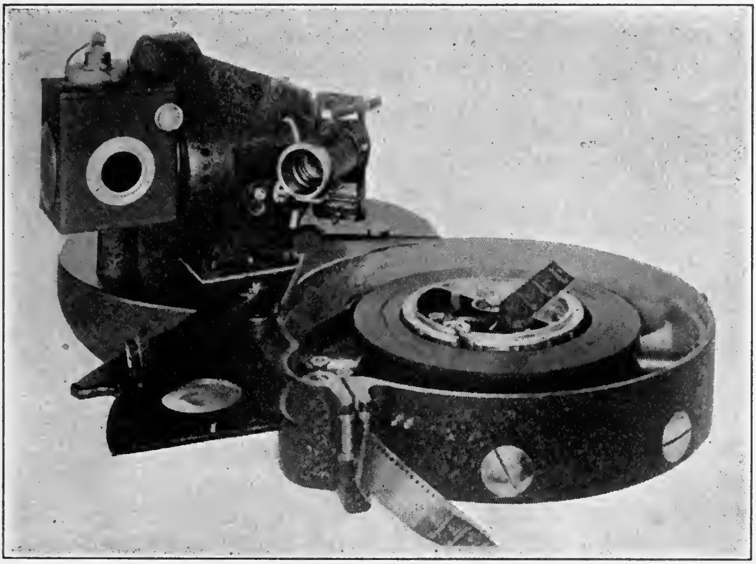


FIG. 3. Speico projector loaded with film.

several cylinders whose axes are arranged radially. (See Fig. 2.) These cylinders may be turned around on their axes and are carried at equal speeds by means of a bevel gear. One of these cylinders is connected to each of the extremities of a vertical drum to guide the film from its entrance to its exit from the case and to keep a constant length of film on the outside of it. The circumferential leading of a reel of film placed on the rolls in question is solved by the grooves of this reel being in contact with the generators of the rotating cylinder. All the grooves are turned at the same speed irrespective of their distance from the center.

The Speico company, which supplies boxes holding up to 3000

* BOITIER, SPEICO. *Recherches et Inventions,* **180** (1929), p. 233; *Ibid.,* **183** (1929), p. 326. M. R. HUC, French Patent No. 532,312, issued Jan. 11, 1928.

meters of standard film, has perfected a projector which may be very easily mounted on the film box. This projector (Fig. 3) has some interesting innovations, one of which is a result of the use of the box. Abolition of upper and lower sprockets, abolition of framing, and an arrangement for simultaneous ventilation of film and lantern and use of a device for humidifying are features which are incorporated.

Marcel R. Huc Projector with Continuous Film Movement.—This apparatus is based on the known principle shown schematically in Fig. 4. The film is inserted in the direction of the arrow, *2*, guided by a track, *3*, which has an opening window, *4*, which is the width of the image, *5*, of the film and about the height of two images. The

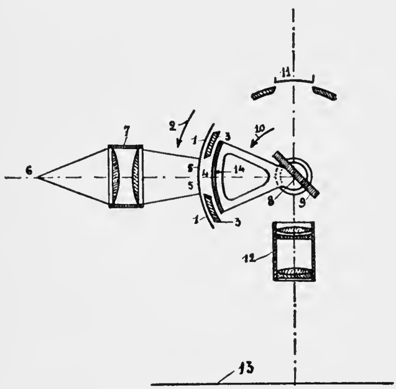


FIG. 4. Schematic drawing illustrating the principle of the Huc non-intermittent projector.

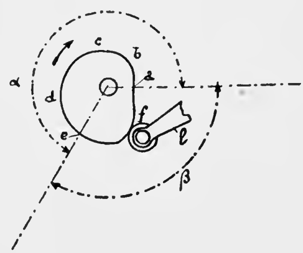


FIG. 5. Diagram of cam.

light rays pass from the light source, *6*, through the condenser, *7*, on to the portion of film in front of the window, *4*. The track, *3*, in the form of a part of a cylinder whose axis, *8*, passes through the reflecting face of a polished optical surface, *9*, capable of turning around this axis. If the film is passed in front of the window with an angular speed, ω, and at the instant the mirror turns in the direction of the arrow, *10*, with an angular speed, $\omega/2$, the virtual image, *11*, will be immobile on the lens, *12*, which will give a real image on the screen, *13*. On the contrary, the virtual image of the edge of the window, *4*, appears to move in front of the fixed virtual image, *11*, with a speed, ω, in the direction of the arrow, *2*. M. Huc's patent claimed from the first the use of ordinary interchangeable lenses of different focal lengths. On the other hand, the window, *4*, having a greater height than that of a single frame, the screen will receive the image of one picture accompanied, above and below, with portions of two adjacent frames. The patents claim a remedy for this objection consisting in the use of a movable window, *14*, integral with the mirror, framing exactly the frame in the projector and accompanying it exactly in its movement. The movable window is cut in one piece sufficiently large to mask the adjacent frames.

A machine made exactly according to the diagram in Fig. 4 will give images which are visible in their normal position only to a spectator placed behind the supposedly translucent screen, *13*. It is therefore necessary to correct this projection either by inserting a plane mirror or a totally reflecting prism in front of the lens and at 45 degrees to the axis, *11–13*, or by turning the projected film around and by making it run in the desired direction in its track. The first of these methods is objectionable in that it leads to the use of lenses of great focal length which, in certain cases, may call for supplementary optical systems for enlarging the image on the screen.

The analysis of the mechanism of the machine is as follows:

One frame, surrounded by the mobile window, *14*, begins to descend while the mirror, *9*, begins to turn. At this moment, the shutter of the lens unmasks it. The mirror, *9*, continues to turn until the upper edge of the picture has descended the length, A (less than the height of one frame), starting from the upper edge of the window, *4*. The shutter then closes over the lens while the window, *14*, and the mirror stops. While the shutter masks the lens, these two pieces return to their initial positions. This takes place progressively and without impact during the time that the frame has covered the distance, B to A, B being the height of one frame. It is evident that this time, which corresponds to the shutter period is a little less than the relation A/B, and approaches unity. The window and the mirror having come back to their initial positions, the movements described above are repeated, and so on for each frame of the strip.

Fig. 5 represents the diagram of a cam meant to engage through the intermediary of a lever with the roller, *1* (Fig. 4). The cam corresponds to the simple case where the pull down sprocket advances the film one frame for each revolution. Since this cam is supposed to turn in the direction of the arrow, the time the roller takes to cover the distance, *abcde*, corresponds to one picture cycle in projection. The lens is masked during the time which corresponds to the line, *efa*. The angle, α, determines, therefore, the time of projection and the angle, β, that of occultation. The time of occultation will bear a relation to the time of projection as β/α and according to the author a sufficient reduction of this ratio permits dispensing with the shutter.

In the case of engagement of the film by the usual sprockets (4 frames per turn) and by using a cam resembling that which has just been described, a multiplication of auxiliary gears becomes necessary but then the least play between the teeth of the gears interferes with the precision of the mirror drive, *9*. This objection is eliminated

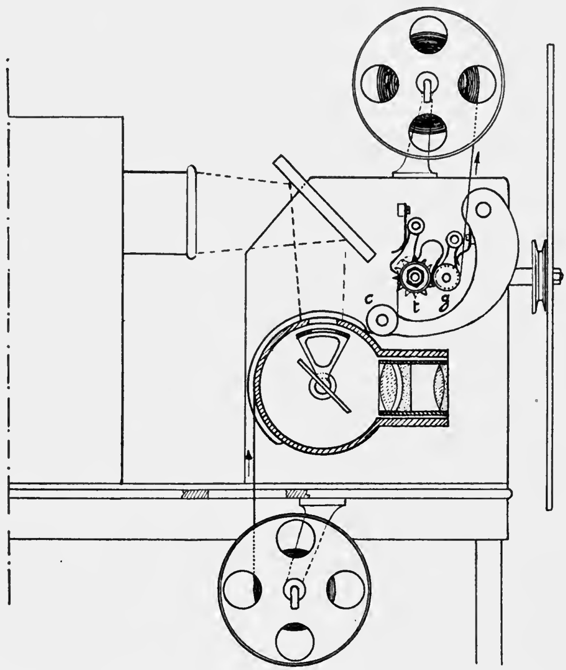


FIG. 6. Application of the Huc principle to a practical projector.

by engaging directly to a cam which has as many depressions as the sprocket engages pictures per revolution.

M. R. Huc's patent provides several arrangements for framing.

Figure 6 represents schematically a practical realization of the principles which have been pointed out.

In closing I thank my colleague, M. L. Didiee, for the valuable collaboration which he has given in the preparation of this report.

APPLIED AND SCIENTIFIC CINEMATOGRAPHY IN AUSTRIA*

PAUL SCHROTT

PRODUCTION

At the present time the production of motion pictures in Austria is limited by lack of financial support. In Vienna, the center of the Austrian film industry, there were several important studios before the war, while now there are but four. Three of these are in current use and are very well equipped. They are not used by one company alone, but are rented to different ones in turn. The fourth studio, which is better equipped than the others, is not in use at present. It has been purchased by an English company, has been rebuilt for sound work, and production is scheduled for an early start.

Austrian film production is impoverished. To avoid a crash in the industry, a "Film Kontingent" has been formed, which governs film importation and production.

There has been more progress in the scientific applications of cinematography. A special course has been formed at the Technical High School in Vienna, where classes are held in technical and scientific cinematography, and the students gain a thorough training in theory and practice. This institute is headed by the writer.

CINEMATOGRAPHY OF ATMOSPHERIC STRIAE AND SIMILAR REFRACTION PHENOMENA

During the past year there has been considerable work done on photography by spark illumination, and the photography of atmospheric striae and similar refraction effects. This work is still in progress. The writer in his investigations is using Töpler's method. The principles are as follows:

A slit, *ab* (Fig. 1), is illuminated by a light source, *L*, and by means of the illuminating lens, *BL*, a sharp image, *a'b'*, is produced at the diaphragm, *SB*. This diaphragm is so shaped that it just obscures the

* A contribution to the Progress Committee Report of May, 1930, by Dr. Schrott, Technical High School, Vienna, Austria.

entire image, $a'b'$. By this arrangement no specular light from lens, *BL*, enters the imaging lens, *SL*, which is in contact with the diaphragm, *SB*. If a transparent body, *S*, having a refractive power which differs from that of air, *e.g.*, heated air, carbonic acid, ether vapor, *etc.;* is placed in the beam of light near the lens, *BL*, then the beam will be deflected. Some of the beam will then pass the edge of the diaphragm and enter the lens, *SL*. The result is that lens, *BL*, and the object, *S*, are sharply imaged by the lens, *SL*. This image can be viewed by means of an eyepiece, projected on a screen, or photographed on a film or plate.

Töpler employed an Argand burner, the flame of which fills the entire slit. Now the brightness of the image at *SB* depends on the intensity of the refracted rays, hence on the brightness of the area at *ab*. For this reason the images Töpler obtained were not very bright, and could be observed only with an eyepiece.

An arc lamp was used as a light source for cinematography with this

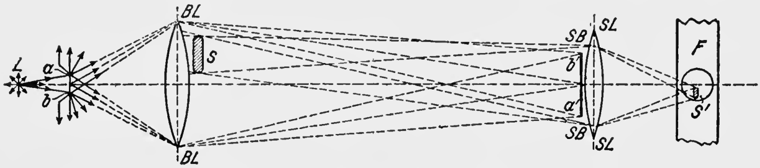


FIG. 1. Optical system for the photography of striae.

apparatus. On account of the relatively short time required for taking the pictures, it is quite easy to keep the arc constant enough after the carbons have burned some time. Goerz-Beck carbons are used. These carbons have a heavy copper coating, and give a very intense and steady light. A quartz mercury vapor lamp (Hanan) will give good results, but low pressure mercury lamps have not the intensity required. The radiation from incandescent lamps is low in actinic value. Even the Osram 15 volt projection lamp (100 hour life) gives poor results. Panchromatic film should be used with incandescent lamps.

The illumination of the slit can be accomplished in two ways:

1. The diaphragm is covered with opal glass. A 10 ampere arc light with a mirror reflector is used as a light source. With this light an intensity of 3 cp. per sq. mm. resulted. The highest intensity obtained with the Argand burner used by Töpler was 0.02 cp. per sq. mm.

2. A light source is projected on the diaphragm to fill it with illumination of high intensity.

For this method a suitable lens must be used with the slit. As illuminating and imaging lenses, objectives must be used which are well corrected for spherical and chromatic abberation. Astigmatism is of minor importance, as the slit is on the optic axis, and is small in size. The illuminating lens, *BL*, which serves to image the diaphragm, should be rather large, so that the phenomena being photographed cannot exceed its area.

The form and position of the slit are of great importance to the sensitivity of the instrument. Both slit and diaphragm are of variable width. The slit is built like that of a spectrograph and the width

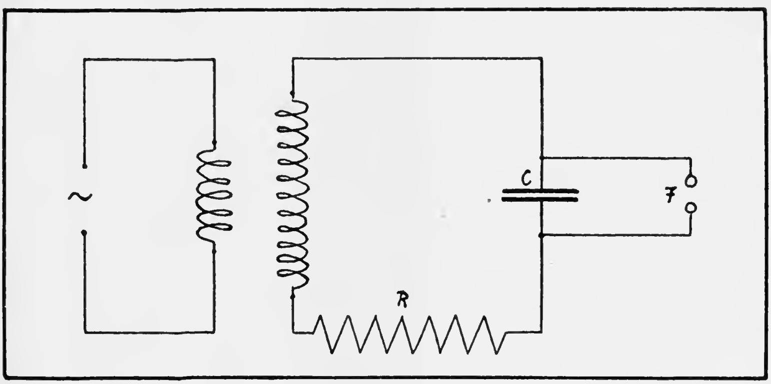


FIG. 2. Circuit for spark photography.

can be adjusted with a micrometer screw. The slit is mounted so it may be rotated by means of a worm and pinion. The reason for this type of slit is that there is usually a direction of maximum deviation in the striae being photographed, and it is necessary to orient the slit parallel with this direction in order to show the striae to best advantage. The diaphragm, *SB*, must be large enough to cover the slit image. It must also be capable of rotation.

The outside edges of the diaphragm, *SB*, must be exactly coincident with the edges of the slit image. The diaphragm is composed of two strips, the edges of which are sharp and accurately parallel. One strip is fixed, while the other can be moved, the two remaining parallel. The whole equipment must be mounted on a solid floor free from vibration. The factor of greatest importance is that the slit and condenser must be absolutely rigid as it is impossible to get good results otherwise. A single candle flame or bunsen burner serves as test object. These flames give typical striation phenomena. When the apparatus is used without any opal glass for diffusion, a taking speed of 500 pictures per second is not difficult.

CINEMATOGRAPHY BY SPARK ILLUMINATION

Dr. Franz Söchting has been working with photography by spark illumination. A method was developed for taking spark photographs by reflected light at such a frequency as would be of technical value for many purposes. It should be said that up till now all work with spark photography has been done by transmitted light, as only one per cent of the light required in the former case is needed for transmitted light photography.

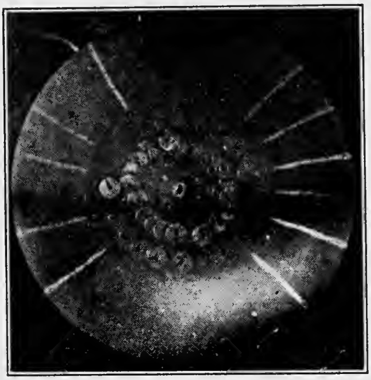
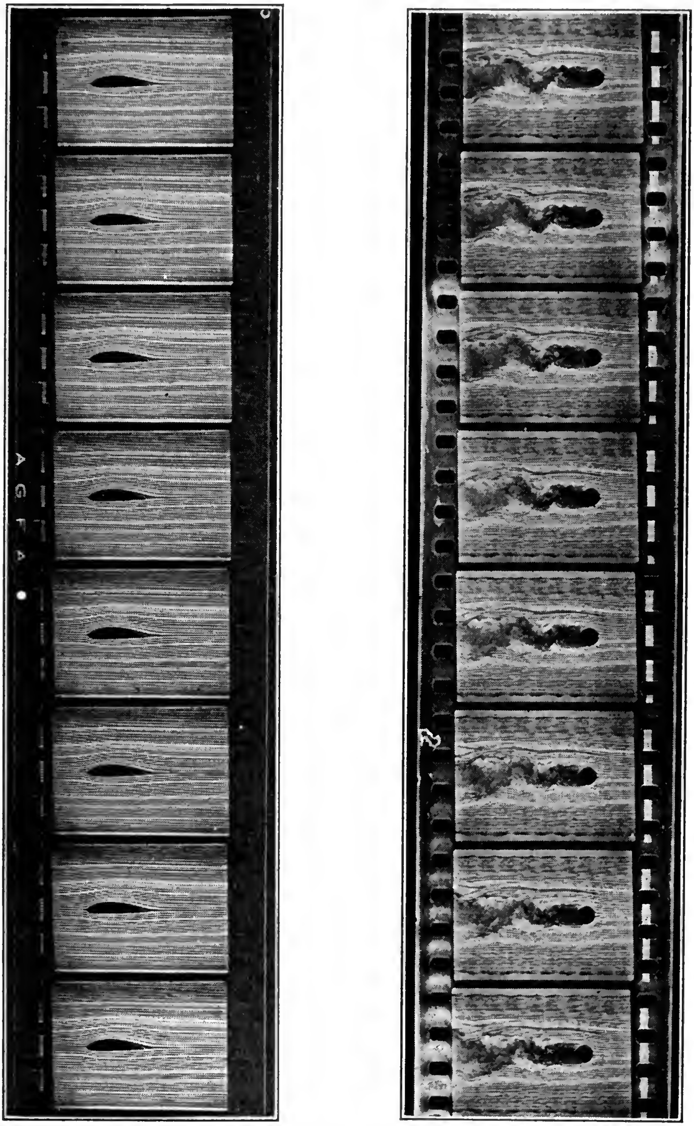


FIG. 3. Test of spark regularity.

The wiring diagram of the apparatus is given in Fig. 2. A 1000 volt, 5 KVA transformer acts through a water resistance, *R*, on a condenser, *C*, which is in shunt with the spark gap, *F*. Using the natural frequency of the circuit, 50 cycles, if the spark gap is so adjusted that a spark occurs at each half cycle, the resulting spark frequency, and hence the exposing rate, is 100 per second. By making the spark gap narrower, or decreasing the water resistance, more sparks occur per half period, but in an irregular way. Since, however, the time scale is determined by the velocity of the film, this factor may be disregarded.

Test exposures were made for spark regularity and for intensity of illumination. A matte black disk with white marks was mounted on the shaft of a 2-pole synchronous motor, running at 3000 rpm. The light from the spark was reflected to the disk by a parabolic mirror of 80 mm. focal length and 240 mm. diameter. The rotating disk was photographed with an *f*/4.5 Tessar on an ordinary plate having a speed of 16° to 17° Scheiner. Each spark gives a picture of the white mark, hence the intervals at which sparks occurred may be seen from the angles between the mark images. As the camera shutter was open

0.02 sec., and as one revolution of the disk takes 0.02 sec., the exposures for one cycle only were recorded. Figure 3 is an example of



A B

FIG. 4. Stream-line photography.

such a photograph. It will be seen that the mark images are separated into two groups of six each, in which each group represents 0.01 sec.

With the apparatus as described above, it was possible to record spark frequencies of 800 to 1000 per sec. The spark frequency has no effect on the exposure, which depends on the duration of each individual spark, about 0.00000005 sec., which is extremely short compared with attainable film velocities. No blurring due to movement of the film during exposure has ever been noticeable. Thus sparks can be used to photograph the flight of bullets or other rapid action.

FIG. 5. Section of an anatomical film.

CINEMATOGRAPHY OF STREAM-LINE PHENOMENA

Richard Katzmayr has described a new method for recording stream-line phenomena with the motion picture camera. A stream of water runs in a tray with a glass bottom. The tray is illuminated from below with diffused light. On the surface of the water are produced thin red colored streams of a solution having the same specific gravity as water. The camera is placed vertically above the tray. This red colored solution is supplied under pressure from a tube with a number of holes. The rate of flow is the same as that of the water. If a solid body is located on the surface of the water, the streams separate and show a change in stream lines. If the colored liquid is supplied continuously no motion is noticeable. (See Fig. 4*A*.) By supplying the liquid intermittently, dotted lines which show progressive change are formed. (See Fig. 4*B*.) This is accomplished by placing in the supply tube from the tank of colored liquid a rubber tube on which an electric vibrator strikes twice a second.

SURGICAL CINEMATOGRAPHY

Motion picture recording has been used extensively in anatomical work. A special technic has been evolved by Prof. Pernkopf and his assistant Dr. Schmeidel; and several films useful for anatomical teaching have been made.

In most cases, only the preparatory acts, and the dissecting of the individual anatomical structures need be recorded. By doing the work on cadavers which have been prepared before hand, much better results are obtained than with photography of surgical operations on living subjects. With cadavers, the opened and dissected structures are not covered with blood, which photographs black. The view can be taken from a short distance and any desired illumination can be used. The advantage of the anatomical film is that the pictures can be projected before a large audience, and as often as necessary. This results in a saving of time over repeated dissections, which can only be seen by the students nearest the demonstration.

The method of dissection which is photographically recorded was worked out and introduced by Hochstetter in the Zweiten Anatomischen Institute at the University of Vienna. Figure 5 is taken from a film so made.

SLOW MOTION PHOTOGRAPHY OF MICROÖRGANISMS

Dr. Otto Storch has done important work with slow motion photography on motion analysis of microörganisms. The "Askania" high speed camera was employed in this work. With this camera a speed of 100 to 120 pictures per second is attainable. The outstanding feature which makes this camera very useful for microscopic work is the finder, which focuses on the film and gives four to eight diameters magnification. The image is erect and can be observed before and during the exposure. All the light from the subject is focused on the film; there is no loss since a prism or a half-silvered mirror is not used.

The second part of the equipment, the microscopic apparatus, was built by the Wiener Optischen Werke (C. Reichert) in Vienna. Two matters of great importance required attention in the construction of this equipment: (1) All the necessary movements should be capable of adjustment from a position comfortable for the operator. (2) The microscopic subject must always be in view. In other words, the operator must observe the subject continuously. He must be able to adjust the table height, to focus, and to start and stop the camera at the required moment. The fulfillment of these conditions is important, as biological subjects demand great patience and skill on the part of the operator in preparing them suitably for photography.

When the preparation is in place, the adjustment of the microscope and camera must be accomplished quickly and easily. At this stage the operator must watch the subject in the finder, and must be able to start the camera at the proper time. The subject is naturally intractable and the high intensity of the light used makes it just so much worse. Adjustment for using the microscope either horizontally or vertically has been provided.

The apparatus is adaptable for macrophotography (×20 to ×30 diameters), using enlarging photographic objectives ("Mikropolars,"

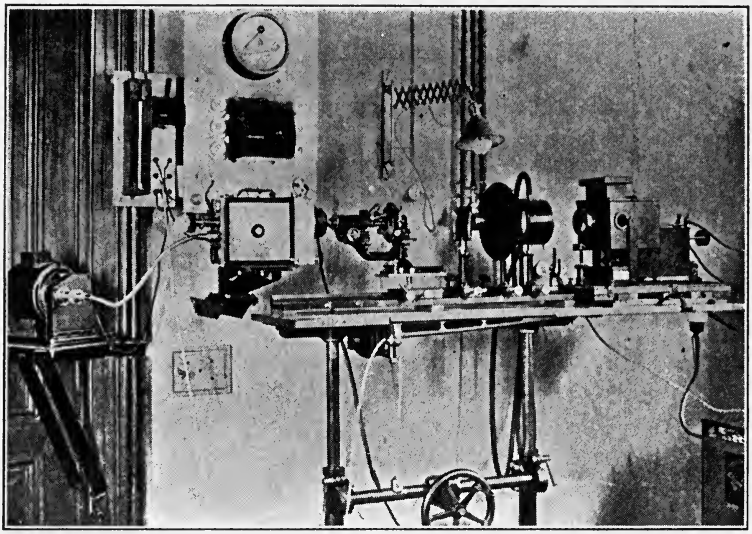


FIG. 6. Photomicrographic equipment.

made by C. Reichert). The specimens are placed in a cell and may move in a vertical plane when the axis of the objective is horizontal and are held in a glass tray, in a horizontal plane when the axis is vertical.

At the present time the equipment is used only with transmitted light, but arrangements are being made for work with reflected light.

The camera position is fixed, irrespective of the microscope arrangement, and the finder is always at eye level. The camera is mounted on a massive arm which can be swung horizontally. (See Fig 6.) By this arrangement the camera can be easily shifted away from the microscopic apparatus, and all operations such as loading and unloading can be accomplished easily without disturbing the rest of the set-up. Changes in the microscopic equipment—lenses, *etc.*, can be accomplished quickly.

The optical equipment is mounted on a massive adjustable bench supported on the floor. By supporting the camera from the wall and the optical bench from the floor, no vibration will be transmitted from the camera to the bench. The camera itself is very steady on its support, and no lack of definition has been noticed. The excellent definition may be partially due to the high speed at which the pictures are taken (usually over 100 frames per second) and to the relatively short exposures given (from 1/500 to 1/3000 sec.).

The camera remains in a horizontal position, whether the microscope is in a horizontal or vertical position. Experiments were made with the camera in a vertical position, but this arrangement did not prove feasible. Not only was the finder position too high, but no simple way could be found to mount the camera on a steady support.

When using the microscope vertically it is necessary to mount a prism between the ocular and the camera. This can be done without loss of light or other disadvantages. During exposure the camera and microscope are joined by light-tight tubes, which are not in contact, thus avoiding transmission of vibration. By having the optical bench adjustable for height, and having the camera remain in a position convenient for the operator, it is possible to mount on the bench various optical systems of different heights, and still bring the optic axis level with that of the camera. Having the camera movable is a great advantage, as it may be swung out of the way when changes must be made in the optical equipment.

For photography with the microscope horizontal, the microscope is placed on a table of such height that the beam from the arc lamp is axial with the microscope condenser, and goes directly through to the camera frame.

For the macrographic subject a separate table is provided which may be raised, lowered, or moved sideways. The subjects are placed in a cell in which is a movable glass wall which may be brought as close as $^1/_2$ mm. to the side of the cell, making it possible to keep the subject continually in focus without interfering with natural movement. This type of cell has the advantage that water can be run through it in quantity, hence it will not heat up during the short time required for the preparation and photography of the subject. This micro-aquarium also was constructed by the Optischen Werken (C. Reichert). In the set-up, for photomicrography a spectacle lens is used for a condenser to concentrate the light from the arc on the objective, while for photography with the microscope the Abbe condenser is mounted in the usual way on the substage.

A Goerz 25 ampere arc light built into a lamphouse with a condenser is used on d.c. The light is very intense and highly actinic, so that even with high magnification, short exposures are possible. When using the "Mikropolar" (relative aperture *f*/4) exposures of 1/2880 sec. (120 frames per second with a shutter opening of 15°) were given and fully exposed negatives were obtained.

With a high microscopic magnification (Reichert 4 mm. apochromat, compensating ocular, 4×) exposure times as short as $^1/_{500}$ sec. give full exposure. These short exposures make it possible to show clearly the fastest motion of the microörganism, and very little loss of sharpness results.

Slow motion pictures of the living organism offer the greatest difficulty. The heat from the arc light is great enough to kill the organism in a very short time. For illumination in this case the following system was worked out by the writer and more research work is in progress at present. In front of the arc light is placed a large cell with running water. (See Fig. 6.) This alone proved insufficient so that the following artifice is employed. The arc is connected with a rheostat and while focusing and preparing for exposure, the current is cut down to 5 amperes. A light absorbing green filter is also placed in front of the water cell, cutting down the heat considerably. It is now possible to focus the camera and adjust the optical equipment for any required time without damage to the subject to be photographed when the equipment is adjusted. After the subject has been focused on the film, and the shutter opening has been set, the assistant removes the filter and at the same time runs the arc current up to 25 amperes. The camera is started immediately and during the actual time consumed in taking the picture no harm is done to the subject. For slow motion work, 100 to 120 frames per second can be exposed, which amounts to 30 to 40 meters of negative material in 15 to 20 seconds.

A few remarks should be made regarding the scientific use of the photographs. The first step is to have a positive made, and run through a projector several times at slow speed. A small home projector, of which there are many makes available and which are safe when handled with care, is suitable for laboratory use. In scientific work it is necessary to view the motion of the organism repeatedly and this can be done best by the use of a loop. The projector should also be equipped with a single frame attachment.

It was found by experience that the best scientific information could be gained when the frames were printed by contact on glossy paper strips. Strips are cut into single pictures and arranged in

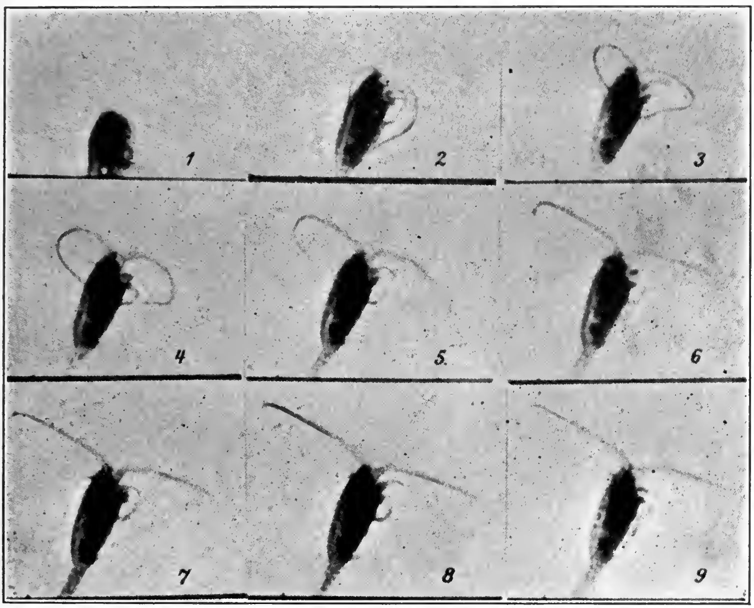


FIG. 7. *Diaptomus denticornis.* Enlargements from consecutive photographs from a film taken at 120 frames per second. Stretching of the antennae after a jump.

sequence on a sheet of paper. Such copies (Fig. 7) are very convenient in studying the subject.

PRODUCTION OF MOTION PICTURE EQUIPMENT IN AUSTRIA

No projectors are made in Austria, but a very satisfactory camera has been placed on the market by the firm of Castagna Co. G. m. b. H. (Fig. 8). A light metal is used for the camera housing. All fast moving parts run in roller bearings. The camera is built on an entirely new plan, except for the pull-down mechanism, which is of the Lumière type. Four lenses are mounted on a turret. Any lens from 35 mm. up to a telephoto lens can be used. The turret can be rotated slightly to raise or lower the lens, which eliminates moving the whole camera for the desired result. Focusing can be done directly on the film with a telescope, or by turning the lens turret through 180 degrees and focusing on a ground glass with a prism. The camera front can be swung open, and the lens turret and pressure gate are built into it, thus eliminating any error in focusing. The patented shutter is also built into the front. This shutter which is of a new type was designed by Dr. Julius Urbanek, of the staff of the Technical

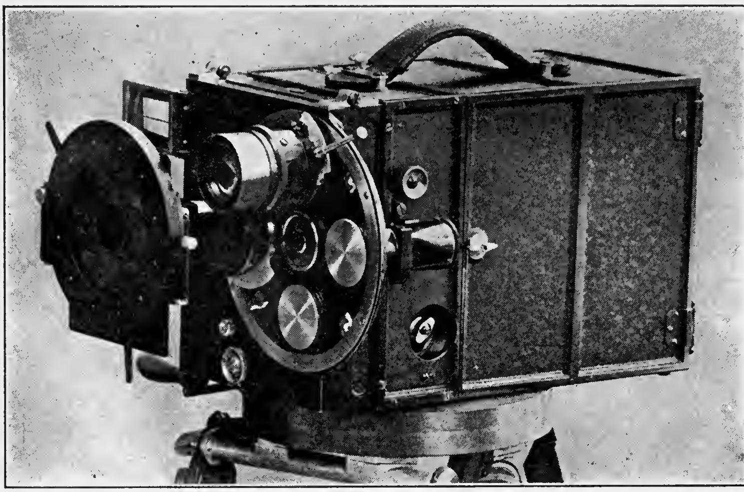


FIG. 8. Castagna camera.

High School at Vienna. It is actuated by a double differential gear. The special feature of this shutter is that it can be closed in 3, 5, or 8 turns, irrespective of the sector setting.

In changing the rate from eight to a single frame per turn, the camera crank remains in the same position. The film magazines are made from a light metal and have a fool-proof aperture, not lined with velvet. The tension of the take-up can be adjusted from the outside of the camera if required while operating. The following equipment is incorporated in the back of the camera: footage and single frame counter, finder, a lever to control the tension of the supply magazine, a lever to adjust the shutter opening, and a scale to show the shutter opening in degrees. The control of the automatic dissolve (3, 5, or 8 turns) is also handled from the rear. A lever to effect the automatic opening or closing of the shutter, and the film punch are placed on top of the camera.

An invention of considerable value in running arc lamps for motion picture projection is the Rosenberg cross-field generator, manufactured by "Elin" a. g. für Elektrische Industrie, Vienna-Weiz. This generator makes possible the running of arc lights without any rheostat. The arc is connected directly to the generator terminals, and the voltage and current are self regulating. The principles of the machine, which was originally built for arc welding, are as follows:

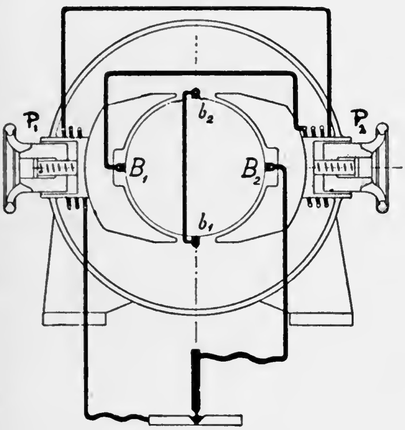


FIG. 9. Rosenberg cross-field generator.

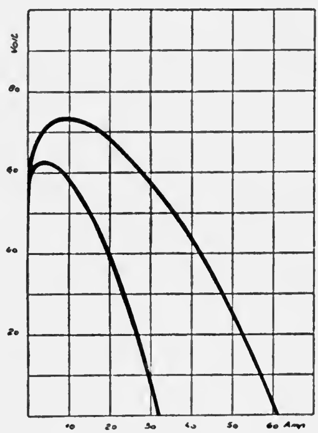


FIG. 10. Voltage current relations for the Rosenberg generator with different pole piece settings.

The commutator has four brushes (Fig. 9) of which two, b_1 and b_2, are short circuited. P_1 and P_2 are the magnetic poles, B_1 and B_2 are the main brushes. As a result of residual magnetism, when the armature is rotated, a low potential is induced between the short-circuited brushes, and a high current is generated in the armature. Hence there exists in the armature a strong magnetic field which is in the direction of the brushes, b_1 and b_2. In this field, which the armature itself generates, a high potential is generated at the brushes, B_1 and B_2. When the outer circuit is closed, a current flows through the armature and through the exciting coils of the poles, P_1 and P_2. There results a magnetic field in the direction, P_1P_2, and an armature field in the same direction. The two fields are, however, opposed. But the field, P_1P_2, is the more powerful, and the current is increased. If the current is very great, because of the unusual form of the iron poles, P_1, P_2, of small cross section, saturation of the iron occurs, the field strength of the poles increases slowly, but the field of the armature goes up rapidly since both oppose each other, the resulting field strength becomes weaker, the potential at the brushes, B_1 and B_2, grows less, and the current is lowered. The poles, P_1 and P_2, can be screwed out so that the cross section of iron is made smaller. It is thus possible to regulate the maximum current strength. The arc light is connected to B_1 and B_2. On striking the arc, a short circuit results, but only a small current is produced. As the carbons separate, the potential adjusts itself according to the strength of the current. Figure 10 shows the voltage-current curves of such a dynamo for different adjustments of the pole pieces. As we see, by this procedure, the characteristic action of the carbons is stable, as an increase in current causes a decrease in potential.

Advantages of the Rosenberg generator are as follows:

1. All the accessory apparatus in the arc lamp circuit can be eliminated, regulators, rheostat, voltmeter, fuses, *etc.*
2. The efficiency is about 20 per cent higher than that of the usual equipment with the stabilizing rheostat.
3. In the case of a short circuit, the current is only slightly higher than that usually drawn, hence the fire hazard is eliminated.
4. The potential for open circuit is not dangerous.
5. The generator voltage regulates itself automatically in accordance with the length of arc.

ABSTRACTS

The Editorial Office will welcome contributions of abstracts and book reviews from members and subscribers. Contributors to this section are urged to give correct and complete details regarding the reference. Items which should be included in abstracts are:

Title of article
Name of author as it appears on the article
Name of periodical and volume number
Date and number of issue
Page on which the reference is to be found

In book reviews, the following data should be given:

Title of book
Name of author as it appears on the title page
Name of publishing company
Date of publication
Edition
Number of pages and number of illustrations

The customary practice of initialing abstracts and reviews will be followed. Contributors to this issue are as follows: Clifton Tuttle, and the Monthly Abstract Bulletin of the Kodak Research Laboratories.

Ninety Million Feet of Color Photography Set as Colorcraft Yearly Output. D. Fox. *Ex. Herald World*, **98**, 26, Jan. 4, 1930. Twelve developing and dyeing units having a capacity of 23 feet of film per minute are being installed in the Long Island laboratory of the Colorcraft Corporation. Two negatives are used in exposing the film and a double coated positive for making the prints which are subsequently dyed. The technical description given is very vague.—*Kodak Abstr. Bull.*

Harriscolor Perfects Its Process: Adds Equipment. *Ex. Herald World*, **98**, 21, Feb. 1, 1930; *Mot. Pict. News*, **41**, 72, Feb. 8, 1930. A trade note states that equipment for the three-color process known as Harriscolor has been installed to take care of 15 million feet of prints during the next six months. No technical details are given though it is stated that the prints are made on a single emulsion film.—*Kodak Abstr. Bull.*

Problem of Distortion in Sound Film Reproduction. C. O. Browne. *Experimental Wireless*, **8**, 71, February, 1930. The frequency characteristics of a sound film recording and reproducing system are discussed with a view to producing a level combined frequency response. Various recorders, and the methods by which their frequency responses can be brought into line with that of the reproducer, are described briefly. Correction can also be made for recording and reproducing slit attenuation. A recording system producing a twin wave track variable width record is described in some detail. The essential points of variable density recording are considered.—*Kodak Abstr. Bull.*

Electroacoustic Transmission Systems with Special Reference to Distant Telephony and Sound Films. F. LÜSCHEN. *Elektrotech. Z.*, **50**, 1693, Nov. 21, 1929. Electric filters are discussed, and their use in correcting the damping and phase characteristics of the recording and reproducing units is demonstrated. Frequency amplitude characteristics of different types of sounds are shown graphically.—*Kodak Abstr. Bull.*

Electroacoustic Transmission Systems with Special Reference to Distant Telephony and Sound Films. F. LÜSCHEN. *Elektrotech. Z.*, **50**, 1728, Nov. 28, 1929. Amplitude characteristics are treated and effects of nonlinear distortion shown. Various systems of recording and reproducing are described in some detail.—*Kodak Abtsr. Bull.*

Running the Talkies. XX. Symplaphone. R. H. CRICKS. *Kinemat. Weekly*, **155**, 64, Jan. 23, 1930. The synchronizer is a direct driven unit coupled to the projector. British Thomson-Houston pickups are used. The novel system of speed control and the amplifying unit are described and criticized.—*Kodak Abstr. Bull.*

Running the Talkies. XXI. British Thomson-Houston. R. H. CRICKS. *Kinemat. Weekly*, **157**, 71, March 13, 1930. A description is given of the British Thomson-Houston projection equipment for sound films.—*Kodak Abstr. Bull.*

Making Sound Films. V. Some Recording Problems and Principles. T. T. BAKER. *Kinemat. Weekly*, **156**, 60, Feb. 13, 1930. The principles involved in methods of sound recording by variable density or variable width are outlined.—*Kodak Abstr. Bull.*

Synchronizing Record Starts. A. B. REEVES. *Mot. Pict. Projectionist*, **3**, 15, December, 1929. The author has worked out a method whereby the needle of the pickup device may be replaced into the proper groove of the record when starting the projector to insure synchronizing in case some film has been destroyed. A label pasted or stamped in the center of the reel contains a scale indicating the number of frames per complete turn of the record. There is also a table indicating the number of turns of the disk and the number of frames (counted on the scale) it is necessary to correct for in order to synchronize the disk for the loss of a known number of feet of film.—*Kodak Abstr. Bull.*

Modern French Factory. G. M. COISSAC. *Cinéopse*, **12**, 47, January, 1930. An account is given of the most important products of the Établissements André Debrie. The adaptation of their camera "Parvo," model L, for the taking of sound pictures has been effected, and the former printer has been modified so that sound and pictures may be printed simultaneously. A new apparatus for making animated drawings has recently been perfected. The equipment built for microcinematography is notable in that exposures are made automatically at the desired rate, while the opaque sector of the shutter is only 60 degrees, so that a minimum of light may be used on sensitive specimens. Special effects, such as enlargements, reductions, fade-outs, and double exposures are obtained by printing with the "Truca." Finally, mention is made of a recent invention which records longitudinally on motion picture film a continuous image of a freight train as it passes the camera.—*Kodak Abstr. Bull.*

Measurements on Sound Absorbing Materials. E. MEYER AND P. JUST. *Elektrotech. Z.*, **51**, 97, Jan. 16, 1930. A small model room was set up and the reverberation time measured with an oscillator driven loud speaker as source and a microphone-rectifier-galvanometer arrangement as the measuring device. A portion of the wall was covered with a sound absorbing material and the reverberation time again measured. The two reverberation values made possible the calculation of the absorption coefficient of the material.—*Kodak Abstr. Bull.*

Protection of Film: Methods of Preventing Surface Marking. *Bioscope* (*Mod. Cinema Technique*), **82,** March 5, 1930, p. iii. In the Henderson method of film treatment the films are not coated, but are impregnated with the preserving solution. Film treated by the Henderson method may subsequently be freed from oil or dirt by means of a dry cloth or damp leather, without the use of spirit or cleaning solutions such as are necessary for untreated films. The treatment may be applied not only to new films, but to the reconditioning of old copies.—*Kodak Abstr. Bull.*

Making Sound Film. IV. Frequency Range. T. T. BAKER. *Kinemat. Weekly,* **156,** 67, Feb. 6, 1930. The importance of the grain size of the photographic emulsion in sound recording is explained. An apparatus is described by means of which, it is stated, the maximum number of sound waves per second which a film will record when traveling at a given rate can be determined.—*Kodak Abstr. Bull.*

Making Sound Films. III. Sensitometric Tests. T. T. BAKER. *Kinemat. Weekly,* **155,** 67, Jan. 16, 1930. The significance of sensitometric curves and of gamma-time curves is explained, and image quality (graininess, fog, scratches, and uneven development) and its examination are discussed. The following formula is given for a fine grain developer in which tribasic sodium phosphate is the accelerating alkali:

Metol	4 grains
Hydroquinone	10 grains
Sodium sulfite (crystal)	400 grains
Tribasic sodium phosphate	1 grain
Potassium bromide	2 grains
Water to	2000 cc.

(In the above paper the weights are called "grains." This appears to be a misprint for "grams.")—*Kodak Abstr. Bull.*

Lighting the Studio: Use of the Incandescent Unit. *Kinemat. Weekly,* **155,** 64, Feb. 20, 1930. A summary of a paper read by W. C. Villiers before the Illuminating Engineering Society is given. For general lighting, 1500 watt lamps are becoming standard. They are arranged in banks, the largest of which take about 1800 kilowatts and are fitted with reflectors of aluminum. For spot lighting, 3000 watt lamps fitted with parabolic silvered glass mirrors give the best results, while for sun lighting special 10 kilowatt gas filled lamps have been constructed with various devices for cooling the bulb and for avoiding the obscuration of the walls by metallic deposition.—*Kodak Abstr. Bull.*

The Cinema and Children. *Intern. Rev. Educational Cinemat.,* **2,** 43, January, 1930. This is a report and comment on the results of a questionnaire on the cinema submitted to Russian children by Elkin. The children were classified, most of them being either workers' children or waifs. The cinema was the favorite amusement of most of these children. Adventure films were preferred.—*Kodak Abstr. Bull.*

Function of the Picture in Science Instruction. A. HORN. *Ed. Screen*, **9**, 75, March, 1930. The motion picture may be a substitute for classroom demonstration experiment, giving better visibility of technical skill. Science courses are becoming an organized study of environment which is facilitated by motion pictures.—*Kodak Abstr. Bull.*

University Film Foundation of Harvard University. *Science*, **71**, 381, April 11, 1930. The University Film Foundation has been established at Harvard University by the aid of John D. Rockefeller, Jr. A sound proof studio, sound-on-film and sound-on-disk recording equipment, a processing laboratory for standard and amateur standard film and editorial rooms are provided. A number of scientific films have already been produced, and its is planned to make sound pictures of eminent professors and others as historical records.—*Kodak Abstr. Bull.*

Evolution of Sound Pictures. M. CRAWFORD. *Intern. Phot. Bull.*, **3**, 20, March, 1930. A historical summary from 1878 to the present day of inventions and devices used to record sound in conjunction with motion pictures. Among others, the work of Demeny, Edison, Gaumont, Lauste, De Forest, Case, and Hoxie is mentioned. Credit is given to Lauste for the invention of the sound-on-film record and to De Forest for making it a commercial success. Recently, Madelar has developed a method of recording on the base side of film by means of a diamond stylus producing a sound record similar to the sound-on-disk record. The picture is photographed as usual on the opposite side. A somewhat similar method was worked out by White, of the Edison Company, in 1903 or 1904.—*Kodak Abstr. Bull.*

Present Position of Sound Film. E. STENGER. *Camera* (*Luzern*), **8**, 113, November, 1929. A brief history of photography, cinematography, and sound pictures is presented. An outline is given of the following three systems of sound reproduction: (1) the phonograph record system; (2) the film sound record using a light-sensitive cell for reproduction; (3) the magnetized steel band method. The changes brought about in studio technic are described.—*Kodak Abstr. Bull.*

Wide Screen by New Method (Victor Talking Machine Co.). *Bioscope* (*Mod. Cinema Technique*), **82**, Jan. 29, 1930, p. i. A lens system fitted to the camera condenses the lateral range of the latter about three times, standard film being used. In the projection apparatus the image is expanded to its proper dimensions. Thus a wider sound track is made possible without the risk of film buckling which is experienced with wide film. The device can be fitted to the ordinary projector for about 25 dollars.—*Kodak Abstr. Bull.*

Wide Film Problems. R. H. CRICKS. *Kinemat. Weekly*, **156**, 67, Feb. 13, 1930. It is contended that the only real advantage of wide film, namely, improvement with regard to the emulsion grain size problem, does not justify the enormous expense of new projection apparatus and new screens in every cinema. A simple and less expensive method of overcoming the grain size problem would be to photograph on double width negative material, afterwards printing on standard size slow speed, fine grain positive stock.—*Kodak Abstr. Bull.*

BOOK REVIEWS

Sound Pictures and Trouble Shooters Manual. James R. Cameron and John F. Ryder. *Cameron Publishing Co.*, Manhattan Beach, Brooklyn, N. Y., 1930, 1120 pp., $7.50. The first part of the book is devoted to general electricity, vacuum tubes, and vacuum tube circuits. The material contained in these pages is not advanced enough to be very instructive to anyone familiar with the field, and careless wording and proof reading errors would make the subject matter unnecessarily difficult for the conscientious beginner. There are a few chapters on recording which may be interesting to the lay reader. Projection equipment, its maintenance and operation, is treated quite thoroughly; and we assume that the information given agrees with that furnished by the manufacturer of the apparatus. There are a hundred pages which treat of "trouble shooting" and which should enable the reader to trace down trouble in theater reproducing equipment.
C. M. T.

Agfa Kine Handbook. Parts I-IV. The Agfa Kine Handbook, in four parts, describes the manufacture and use of the products of the Agfa film factory, which are related to the motion picture industry. Part I includes a brief history of the Agfa Company, a description of the manufacture of raw motion picture film and instructions for the handling of film. Part II explains the various grades of motion picture negative film which are suitable for different types of photography, such as ordinary and color motion picture work, aerial photography, and photography in the tropics. Formulas of developers and fixing baths suitable for processing the films are given. Part III deals with the properties of the positive motion picture film. General instructions are given for developing, fixing, drying, toning, and tinting of this film. Part IV contains specimens of tinted and toned positive film and specimens which show the effects of various treatments on the quality of negative film.—*Kodak Abstr. Bull.*

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Membership Committee

J. COURCIER, *Chairman*
E. JEWELL

Papers and Programs

E. HUSE, *Chairman*

PRESIDENTIAL ADDRESS

It is a pleasure to welcome you to this, the twenty-ninth convention of the Society, and especially those who are attending for the first time. In former days, when the Society was not so large, it was possible for your chief executive to know each member personally but with our present membership of about 800, this is not possible. However, I shall endeavor to meet every new member attending this convention.

I think I can say without fear of contradiction that the Society has made great progress since our last convention at Toronto. Perhaps we can get a measure of this progress by considering to what extent we have been fulfilling the objects of our Society as set forth in our constitution. These objects are as follows:

(1) Advancement in the theory and practice of motion picture engineering and the allied arts and sciences. I think that the large number, and high technical and scientific merit of the papers to be presented at this meeting are ample assurance of this, while the increasing eagerness on the part of the trade and technical press to publish our technical papers is an index of their value to the industry.

(2) The standardization of the mechanisms and practices employed in the motion picture arts and sciences. One of the most difficult problems in standardization ever undertaken by this Society has been that of the determination of dimensional standards for wide film. The Society was fortunate in obtaining Professor A. C. Hardy of the Massachusetts Institute of Technology to accept the chairmanship of the Standards and Nomenclature Committee, and a subcommittee under the chairmanship of Mr. M. C. Batsel and consisting of the chief engineers of all the interested producing organizations has been meeting at bi-weekly intervals during the past three months, wrestling with this problem. Although at this moment no definite standard has been arrived at, the prospects of an early agreement are extremely promising.

At any rate, the Society has rendered a valuable service to the industry by virtue of preventing the producers from plunging blindly into this new development in the absence of a suitable standard and the danger of the recurrence of the chaos which prevailed in the early history of the film business, when each producer used a different size film, I believe, has been averted. The committee is dealing with many other standards and has published a booklet which includes all the standards adopted by the Society to date and which have been approved by the American Engineering Standards Committee.

(3) The dissemination of knowledge by publication. Our Society took a great step forward when it decided to publish the scientific papers presented at our conventions in a monthly JOURNAL instead of in quarterly *Transactions*. By this means, papers are published promptly and the more important ones are made available with a minimum loss of time after presentation while it is now possible for the Society to publish contributed papers not presented at conventions, translations of papers in foreign languages, abstracts, book reviews, patent abstracts, and Society notes.

The value of the Society to the industry is largely determined by the extent to which the industry makes use of the scientific information which we make available and this is determined by its degree of distribution. Our JOURNAL is now reaching a much larger number of technicians than was formerly the case with our *Transactions* and the industry is benefiting accordingly.

One of the most pressing needs of the Society is a focal point in the form of permanent headquarters with clerical assistants to take care of the routine work of the Secretary and Treasurer. Through the generosity of our sustaining members, sufficient funds are now available for such headquarters and a paid editor for the JOURNAL.

The increasing value of the Society to our members has been manifest by the formation of a local section in New York City in addition to those now existing in London and Hollywood. Yesterday the Board of Governors also approved the formation of a section of the Society in Chicago. Such sections permit a more thorough discussion of the many perplexing technical problems now facing the industry and afford a means of discussing papers of immediate interest. The sections have already contributed a number of valuable papers to our JOURNAL.

Three new committees have been appointed as follows: The Color Committee under the chairmanship of William V. D. Kelley, which will keep the members informed of progress in this important field; the Historical Committee under the chairmanship of Frank J. Wilstach, which has made investigations on the early history of the industry and is collecting valuable films and apparatus which are to be placed in a suitable depository; the Solicitations Committee under the chairmanship of Mr. E. P. Curtis, which has performed a service to the Society by persuading the various manufacturing and producing interests to bear their fair share of the burden of the work of conducting the business of the Society by contributing financially through the medium of sustaining memberships. The Constitution and By-Laws Committee under the chairmanship of W. C. Hubbard has recommended a modification of the by-laws so as to bring them in conformity with the increasing size of the Society.

The Society owes a special debt to Mr. L. A. Jones and the JOURNAL Committee for conducting the Herculean task of publishing the JOURNAL with consistent promptness. This committee has issued three booklets which are available to members, namely (*a*) List of Members, (*b*) Instructions to Authors, and (*c*) Standards Adopted by the Society.

One of the most important technical aspects of this great industry is that of reproducing sound satisfactorily and the placing of the best possible picture on the screen from the film supplied by the producer. Our Projection Committee is investigating this great problem of getting improved sound and picture quality with an enthusiasm worthy of emulation. To give you some idea of this enthusiasm, the chief engineer of one of the large producing organizations sustained an injury the day previous to a meeting of the Projection Committee, but rather than miss the meeting he attended on crutches.

The Publicity Committee has consistently secured space in the trade papers. The Society has frequently obtained front page notices. A joint meeting of the Publicity and Membership and Subscription Committees was held in Schenectady on March 4th to outline plans for the extensive arrangements for publicity which have been made for this convention.

The resignation of our former secretary, Mr. R. S. Burnap, caused a deep feeling of regret but the Society has been fortunate in securing the services of Mr. J. H. Kurlander to continue this office and he is well known to most of you.

The future activities of the Society must be focussed on the one object of rendering increasing service to the industry. The acquisition of a paid editor with permanent headquarters and organized assistants will contribute materially to this end.

Of the pressing technical problems, that of getting better sound both on and out of the film or wax record is the most important. The marvelous realism of the sound being reproduced in one of the smaller Broadway theaters by way of reproduction of the voice of a Metropolitan star is a sufficient indication that with existing equipment it is possible to record and reproduce sound with a much greater degree of realism than is manifest in many theaters today. One of the aspects of this problem is that of the education of the projectionist and theater manager. Projection has become so much more important and difficult and the projectionist must become so much more expert.

I feel sure that our Society will continue to participate increasingly in the advancement of scientific knowledge and the improvement of the realism of the motion picture, and thereby contribute to the education and enjoyment of the vast army of motion picture patrons throughout the world.

J. I. CRABTREE, *President*

THE BANQUET
Wardman Park Hotel, Washington, D. C.
May 7, 1930

SPEECHES DELIVERED THROUGH THE MEDIUM OF THE TALKING FILM

Mr. Chairman, Ladies, and Gentlemen:

It gives me a great deal of pleasure to bring to you tonight the greetings and the congratulations of the Academy of Motion Picture Arts and Sciences in Hollywood and to congratulate you on the tremendous strides of achievement that you have been responsible for within the last two years.

When I first started making a talking picture only a year and a half ago we were terribly tied up, the directors couldn't move, the sound engineers would tell us how our people must turn, how they must speak, where they must go, and sometimes even what they must do. They soon got the idea, however, that that couldn't go on and still be an art. A year later I started my third picture and I was remarkably surprised and delighted to see that in that short space of time you gentlemen had revolutionized the whole art, we could go anywhere we wanted to, we could say what we wanted to, our characters could talk with their backs to the camera or move, and I certainly congratulate you gentlemen on having in that space of time adapted a very difficult and intricate science to the needs of this art.

We tried to help as best we could in the Academy through our special committee, the Producers Technicians Committee under the chairmanship of Mr. Irving Thalberg, which has tried to coördinate the work of the various studios as far as it applied to the whole. Mr. Thalberg couldn't be here with you tonight but I have pleasure in introducing to you another member of the Producers Technicians Committee who will speak to you for a moment, Mr. Mike Levy of Paramount.

W. DeMille

Gentlemen:

There is very little I can say about the Producers Technicians Committee because Mr. Thalberg is going to cover that in a detailed report which I believe one of the engineers is going to read as a sort of impromptu speech. I am pretty sure that Mr. Thalberg's report or rather the Report of the Committee is going to be very enlightening to even you engineers. When Mr. DeMille tells you that a great advance has been made in the art of talking pictures he is stating an absolute fact but it is my opinion that you have just started. There is a great deal more to be accomplished and I am sure that if the same progress that has been made in the last year and a half can be accomplished in the next year and a half, we will have so much greater latitude than we enjoy today that Mr. DeMille won't even have to come to the studio to direct his pictures.

M. LEVY

Members of the Society of Motion Picture Engineers:

A little girl in school was once asked to give her definition of "man." The definition that she wrote down ran as follows: "Man is what woman has to marry; he drinks, smokes, and swears and woman has to pick up after him. Both sprang from apes but woman sprang the furthest."

I sometimes have a sneaking suspicion that it was woman who really invented speech. I feel quite sure that it was Mr. Edison's wife who instigated Mr. Edison to invent the phonograph and I am not at all certain that it isn't the wives of you engineers who have forced upon us the talking picture. However that may be, Mr. Watson, the well known psychologist whose behaviorism has become very popular, has made it a point in his psychology to express the idea that thought is really incipient speech reaction. Whether that is true or not, speech is certainly one of the most important forms of reaction which human beings indulge in—woman perhaps more than man.

For a long time the screen suffered from the great handicap of not being able to project speech. Fortunately for us actors, for the directors, and for the public at large, more especially for the writers, you have given us a means of projecting speech along with the photographic images on the film. We, as actors, have had to learn a new technic but we have found that in learning that technic our art has been enlarged and enhanced in innumerable ways. The dramas of

Shakespeare and the plays of Bernard Shaw would mean very little as silent dramas. You have given us, to my mind, what the screen never had before. It always had the dimensions of space and time; you have given it a brand new dimension, that of speech, and along with Mr. DeMille we heartily congratulate you and thank you for your gift to our industry. Thank you.

MILTON SILLS

Hello, Everybody!

I am glad to be here and to wish you on behalf of Paramount a happy and successful convention. I think that you engineers who are responsible for giving to us this wonderful equipment for recording the voice as well as the action of the players deserve the thanks of the entire motion picture industry and have required a more exacting attention on our part. However, the results are worth the effort. Good luck. Thank you.

JUNE COLLYER

Gentlemen:

I consider it quite an honor to be given the privilege of addressing you all, although I am not at the dinner. I don't know whether you know what a great part you have played in my career, such as it has been or is going to be, because wherever I went, when I wanted to go in pictures they'd say "Nope, you haven't got a picture face." I used to look at myself in the mirror and I used to like me and I think I'm all right but they said "No, no picture face." and then you came along with this talking device and now I get along fine, very good in pictures I think, and I wish to thank you very very much for the most important part you have played in my career.

H. GREENE

Mr. Chairman, Ladies, and Gentlemen:

This is an unexpected pleasure. I must necessarily make my speech entirely extemporaneous; I had no chance to prepare anything at all.

I find that everything I was going to say in compliment to your advance in the past year has been very capably and ably said by Mr. DeMille. I want to bring best wishes for a happy convention from Universal, from Mr. Carl Laemmle, from our staff, and from the actors. Thank you.

GLENN TRYON

Good evening, everybody! Now I wonder where my friend Mr. Merwin Palmer is. Oh there you are—"Hello," and that goes for all of you. But really I do want to wish you, on behalf of Metro-Goldwyn-Mayer and myself, a very, very successful convention. Thank you.

ANITA PAGE

I am very glad to be here tonight and be able to wish you great success with your convention and thank you and congratulate you on your achievements in the past two years. Coming from the stage, I find pictures most interesting and quite different in a number of ways. I found the very first week I was here, that whereas on the stage you could go over in a corner and have quite a confidential chat about anyone and most anything you desired and no one except the person you were talking to would hear—on Metro-Goldwyn-Mayer sound stages—not a chance. Anyway, the very best of luck to you. Good night.

D. JORDAN

I have been sitting off side here listening to everyone compliment you and tell you what a bunch of smart men you are, how clever, intelligent, and brainy you are but I don't think you are so hot. In fact, as long as you are so brilliant why don't you think of a way in which you can use old safety razor blades?

But, inasmuch as I hadn't intended saying that when I came out, I would like to say that I think you boys have done marvelously and my little part toward complimenting you seems very inadequate in view of the fact that Mr. DeMille, Mr. Sills, Mr. Green, and Mr. Tryon have all made remarkable speeches and I am quite sure anything I could say wouldn't be up to snuff.

E. NUGENT

We have been indebted to the Fox Studios for recording our part of this entertainment. We are very grateful to them in the name of the Academy and now I want to introduce to you one of your own boys and if you send many more out here like him we'll be that much better pleased. Mr. Peter Mole of your own body.

W. DEMILLE

Mr. DeMille—on behalf of the Society of Motion Picture Engineers I want to thank the Academy and you personally and the members of

your organization for arranging this splendid feature for our program.
Fellow Members:

We had the great pleasure in 1928 of having the convention here in Hollywood and I hope in the very near future you will decide to come to Hollywood again. I thank you.

PETER MOLE

It is a pleasure to extend a word of greeting to members and guests of the Society of Motion Picture Engineers. During the last few years the industry has been employing more mechanical, electrical, chemical, and optical equipment in the production and exhibition of pictures with the result that engineering and the engineer have become of greater importance to the industry. In providing a common meeting place for the various engineering interests associated with the motion picture business your Society is fulfilling a need and the industry is indebted to you individually and collectively for your contribution to the motion picture art.

Warner Bros. welcome this opportunity to express their appreciation of your part in the rapid development and growth of the industry and wish you success in your efforts to increase the pleasure and enjoyment of mankind by conquering and subduing the forces of nature. As I stand and think of what I first saw and the development that has taken place today, I can't help but think of what you will see in years to come and if you will look back, only then will you realize the great part which you have played to make this invention possible. Thank you.

H. M. WARNER

I am pleased to have the privilege of briefly greeting the Society of Motion Picture Engineers through the medium of this talking picture and I am sure you will be pleased in proportion to the brevity of the greeting.

The General Theaters Equipment Company which, as you probably know, I represent, has lately expanded its activities into the theater field itself. This company has always stood squarely for your motto of better pictures, that all-embracing term signifying better lighting, better projection, better screens, better sound, better everything pertaining to scientific and mechanical development of these arts. It may not, therefore, be construed as a mere nicety of expression for me to say that our companies owe their existence primarily to the accomplishment of the things for which this Society stands. Because of the particular branch of the motion picture business in which I have been most keenly interested for many years, I do not think I exaggerate when I express my belief that the present enviable position of this industry among all industries is due entirely to the untiring efforts of its research and scientific men. The scientist, the manufacturer, the producer, and the exhibitor, balanced with good business methods have created an industry so large and so close to the every-day life of the American people that our obligation to them for greater service is ever increasing. I believe the future of this industry lies to a very large degree in the creative power of you gentlemen of this Society and whatever recommendations you may give us we shall be glad to receive, and whatever assistance we may give to you we shall unhesitatingly give. The big picture, the wide vision picture if you please, is rapidly progressing. Its orderly adoption with due regard to all interests, the minimum loss to the industry, and the maximum benefit to both the industry and the public will soon be brought about. I am just as strong an advocate of big pictures as I ever was of little pictures but I am also an earnest advocate of the peaceful and harmonious advent of the big picture into the industry.

May I thank you for your past coöperation and conclude by saying that the interests which I represent earnestly hope that we shall have sufficient prestige for the future to make our contributions not merely expedient but of such a nature that the public may always be better served. We shall endeavor to make our contributions to your scientific developments a worthy tribute to you all.

H. L. CLARKE

I am happy to greet this gathering of motion picture engineers. It is a great privilege to be able to speak to you through the medium of this wonderful invention—the talking film. During the past fifty years I have witnessed with the greatest interest and satisfaction the growth of the motion picture industry. Of recent years that industry has demanded to an increasing extent the application of scientific and technical knowledge and will be far more dependent upon the work of the engineer in the future than in the past. I hope that the Society of Motion Picture Engineers will continue to flourish and to serve the industry.

GEORGE EASTMAN

Mr. Chairman and Fellow Members:

I have been invited by Mr. Crabtree to say a few words to you through Movietone, and although this request comes during a rush visit in New York, I could not pass up this opportunity to prepare these few words.

In the progress that the motion picture industry has made there never has been a period so great and promising as the present. With your help our industry is being reborn, offering possibilities for the future that stagger the imagination. The motion picture went much further as a medium of expression than any one originally dreamed it could go. This has been so with other great inventions. It has exercised a world-wide influence both social and commercial and was the greatest medium for the exchange of ideas and ideals that the world ever saw. The talking picture, however, will prove more effective and influential because speech has made living people out of legendary shadows. Within a single year the entire entertaining world has changed; the transmission from the silent motion picture to sound motion pictures of today has been accomplished and has brought a wealth of new entertainment and joys. Its further progesss will, to a great extent, depend upon the contributions of the technical branch of the industry in which you are so vitally concerned. Until the motion picture has the reality of life itself your task remains undone. This result will eventually be brought about through the coördination of movement, sound, color, and the third dimension on a wide screen. If we can judge by the past, we can feel with a certain degree of confidence that all of this will be accomplished. Color is here and recent developments indicate that greater perfection will eventually be achieved in this connection. The wide screen is not alone a positive accomplishment but has actually shown subjects and scenes to great advantage indicating the possibilities of this broadened scope. When we have the dimension of depth and blend the different developments into one whole we will have the perfected motion picture that will surpass any other medium of expression in beauty and reality. Because of this new medium, the peoples of different nations will be brought together more directly and become even more familiar with each other's literature, humanisms, and ideals. Who knows but that perhaps through this medium not alone a world-wide understanding but a world-wide language may eventually result?

H. B. FRANKLIN

Members of the Society of Motion Picture Engineers and friends of the Motion Picture Industry, since this is the first time that I have appeared before you, it seems proper that in a spirit of frankness I should tell you that in fact I am an engineer. This is a fact which I have carefully tried to conceal from my associates in the telephone industry, because they hold the belief quite strongly that in order to sell an engineering service and an engineering idea to the motion picture industry, it is necessary that one should be a business man. If I can persuade you that I am either an engineer or a business man, then it follows that I am neither, I am in fact a salesman.

Someone has said that salesmen are born, not made. I am sure that this can't be true of engineers, because the good Lord in his wisdom in creating man in his own image would never have had in mind the creation of an engineer. So intimately is the work of the engineer and the business man interwoven in every modern business undertaking that no engineer can be successful in his calling unless he has about him something of the business man, and in turn no business man can be successful unless he is somewhat of an engineer.

The engineer in the motion picture industry has come into his own largely since the introduction of sound, and it is the introduction of sound that has given us our opportunity for making to the motion picture industry an engineering contribution which is the foundation of the success of so many business enterprises today of national scope and importance, and I want to congratulate you upon the work which you have done in the past, but more particularly upon the opportunities which lie ahead of you in the future for performing that service which is characteristic of the engineer. If it is important that the engineer and the business man should work shoulder to shoulder, how much more important is it that we engineers should stand together and work in coöperation and in harmony; and I want to assure you on behalf of the American Telephone Company and its subsidiaries, the Western Electric Company, Electrical Research Products, and the Bell Laboratories, the largest engineering research organization in the world, that, it is our steadfast purpose, it will be our constant endeavor to work shoulder to shoulder with you for the progress of science, for the greater glory of the engineer, and for the greater prosperity of the motion picture industry. Thank you.

JOHN E. OTTERSON

It is a pleasure to greet fellow-craftsmen of the engineering profession at this dinner of the Society of Motion Picture Engineers. To those who enjoy the difficult and often doubtful process of thinking their way into an ever-expanding world the influence of our modern technical sciences upon the progress of the arts must be an interesting subject indeed. Science has made man a versatile creature. Relatively speaking, man has poor eyesight yet invention has enabled him to peer into the remotest heavens; his sense of hearing is limited yet a mere whisper spoken into a microphone reaches him across the expanse of an ocean; he is heavily limbed yet he has developed modern transportation units that enable him to travel 300 miles per hour; he is a land animal, yet he can explore the bottom of the sea; he lacks wings, yet he can soar through the air with the speed of a bird.

You of the laboratories and workshops of the motion picture industry have the opportunity to re-create nature and man if not through substance, at least through shadows. The influence of modern electrical and technical development already is apparent on the motion picture screen. The future holds the promise of scenes reproduced with life-like fidelity in color, perspective, and stereoscopic effect, of art forms that will include the opera, the stage, and the concert hall, and of the development of a medium that will be not only an instrument of entertainment but a great instrument of education and information as well. Thank you.

DAVID SARNOFF

SPEECHES PERSONALLY PRESENTED AND BROADCAST OVER THE COLUMBIA NETWORK OF THE NATIONAL BROADCASTING COMPANY

Fellow Members, Guests, and Radio Listeners:

On the occasion of the last birthday celebration of Mr. Edison, one of the questions asked him by the newspaper representatives was—"What is the biggest thing the American people can accomplish during the next year and why?" and the grand old man said, "Pay more attention to engineers than to politicians."

As you know, Mr. Edison played a very important part in the development of the motion picture industry and I venture to think that when he gave this answer he had particularly in mind the motion picture engineer. As for the politicians, I am sure that he didn't have in mind the many representatives that it has been my pleasure to meet here in Washington who are emulating Mr. Hoover by their interest in technical matters.

For the benefit of our radio friends, I want to explain the meaning of the letters, S. M. P. E. They mean the Society of Motion Picture Engineers, the word, "engineer," being used in its broadest sense as including everyone who contributes to the building of a motion picture. We are united in fellowship because we realize that although when two men exchange dollars they have only one each, when they exchange ideas each one has two.

The Society includes among its members some of the most able technicians and scientists of the age, whose researches have made the talking motion picture possible. I refer to such men as Eastman, who was the first to manufacture motion picture film commercially, Edison, who not only contributed to the early development of the motion picture projector but who made the pioneer experiments on recording sound on wax, Jenkins, who likewise has contributed many original mechanical devices to the industry and has assisted in the development of television, and Lee DeForest, who was largely responsible for the development of the vacuum tube which is the keystone of all sound recording and reproducing equipment. With this new tool DeForest, Hoxie, and others of the Research Laboratory of the General Electric Company at Schenectady, Case and Sponable at Auburn, and members of the Bell Telephone Laboratories, Inc., developed the modern technic of recording sound photographically on film. It is the efforts of our members such as Capstaff, Ives, Kelley, Mees, Troland, and others which have made the color motion picture possible.

With this brief introduction it gives me great pleasure to present the master of ceremonies, the Honorable William P. Connery, Jr., Representative of the Seventh District of Massachusetts.

J. I. CRABTREE, *President*

THE ENGINEER AND HIS TOOLS

C. FRANCIS JENKINS

We are here tonight for a recreational hour in a convention of the Society of Motion Picture Engineers, a group of specialists gathered together with a basic thought, namely, to improve the tools of the profession.

The line of our particular activities is picture entertainment, but all such conventions of engineers in every line have a like purpose, namely, to improve the facilities of their particular employment.

Has it ever occurred to you that we act like civilized beings only because we have such a great and varied collection of tools—such a collection of tools that we can live together in communities of common interest?

The tools available to us and our engineers are the things which enable us, we moderns, to live at all, although we usually think of them as means to decrease our labor and increase our leisure.

As a definition I refer to "tools" as any physical aid to an end; and any clever applicator as an engineer, whether he be of uncultured mind or of a trained intellect; but each is helpless without tools.

Tools have been the most civilizing influence in all man's history. It has changed him from a selfish food robber to a sympathetic neighbor.

I cannot agree with some of my evolution friends. The preponderance of evidence proves there has been no evolution of man, but only an evolution in his tools.

The stone age man was as clever and ingenious as modern man. His earliest handicraft was as adaptable and symmetrical as that of today.

The scope of his works, and the fineness of detail of the product has developed with the refinement and additions to his available tools.

Man's first aids doubtless were devices employed to obtain food and clothing more easily than he could do with hands and teeth alone; to be followed by tools to improve his shelter and security.

Later he began to impress his will on others, requiring them to use these tools to the master's advantage; and so slave labor became an established institution. Next he turned to his personal use the natural forces about him, *i. e.*, "fire, water, earth, and air."

The known works which early man performed with an abundance of slave labor and more and more ingenious tool equipment are marvels to this very day. Nothing in modern times exceeds these early examples in majesty, in beauty, or in symmetry.

Scientists of the National Museum tell me that "the beautiful leaf-shaped flint blade has never been made by modern man;" and that "today's quarryman cannot even guess how his predecessors removed and set up the great monuments of the past."

But eventually tools were so many and so varied that they could not be learned unaided in a single lifetime. So institutions were set up to teach the young the artifices available to make easier for him the getting of food, clothing, and shelter; for example, an alphabet; the three R's; the multiplication table; pi times the diameter; the hammer; the level; the transit; the telescope, *etc.*

But eventually tools became so numerous and so varied that no one man could master them all, even with every possible instructional aid, so he must learn the tools of a single trade; and thus specialists became common.

The modern machine age really began when America was settled by the white man, for from that date the evolution of machine tools has grown with unprecedented rapidity.

Soon the perfect slave of man was the machine; and as it developed into an aid a thousand times more efficient than the human slave, the human slave was liberated.

Our food, our clothing, our shelter, our transportation, our communication, which make living together possible for us, are products of tools, tools, tools; the human hand only guides the tool.

But man is the same man he has always been; he is of the same stature, he is no more clever, is no more ingenious today than was primitive man. All known evidence is to that effect, and no evidence to the contrary exists.

Why, if his evolution had been in stature, comparable to the evolution of his tools, he would today be taller than the mountains; or if his evolution had been in mental attainment, he would be a superman indeed, even a super-god.

There has been no evolution of man, but only an evolution of his tools; and this fact is irreputable proof that man is a spiritual being, sprung from a discrete gens, not an offshoot from some early animal plasm. His evolution of tools differentiates him from all other living creatures.

And as tools accumulate, more tools are available with which to make more tools, a tool evolution which equips the inventor to evolve newer tools for the use of the engineer in his attainments of greater and greater feats. Tomorrow's tool equipment is inconceivable today, and what can be done therewith is impossible of prediction.

With this infinite evolution of tools we have put more and more of nature's forces to work for us; coal, oil, gas, water; all of them sources of energy we can see and touch.

Tomorrow we will put to work those sources of energy which could rather more properly be spoken of as the intangible forces of nature; —"a double bit on the teeth of the lightning."

And these new forces will be distributed over like intangible channels. Long copper wires will not be so essential as today. And over these intangible channels power can then be delivered where wires cannot reach.

In 1837 a wire was stretched from Washington to Baltimore over which enough energy was transmitted to operate a telegraph recorder. But now a similarly stretched wire carries the power to drive heavy interurban railway trains between these cities, and with the swiftness of the wind.

Comparably, today, over an intangible radio channel, we send aloft energy enough to operate a communication device aboard an airplane in flight. Tomorrow we will transmit over this same intangible channel enough power to drive the motors of the plane itself.

The next age is the age of electronics, the age of intangible contacts of man with man, and over channels against which physical obstacles will have little effect. Energy to light, to heat, and to cool our houses, and for general communication, transportation, and control, may then be distributed without limits over the whole earth.

As far as our picture engineers are interested, I confidently assert that the tools are now within sight when distant scenes and notable events may be reproduced in our homes and on the screens of our theaters simultaneously with their happening; and when motion pictures will be distributed from Hollywood directly by radio instead of by film.

The Society of Motion Picture Engineers, in the fourteen years since its organization, has seen tremendous developments in this greatest of human entertainment, motion pictures; but the next fourteen years will see even more startling developments, and the audience many times multiplied, as radio is substituted for film as a carrier of this entertainment.

SCIENTIFIC PROGRESS AND THE NEW ERA IN MOTION PICTURES

WILL H. HAYS

We live amid infinite resources. Human ingenuity and human patience are the touchstones which discover those resources and transform them into tools for our progress, convenience, and pleasure.

Addressing a gathering of engineers, research workers, and technical experts, and discussing the tremendous impetus which scientific development has given to the motion picture, I shall presume to review these achievements only in the light of the greater promise which the new art brings weekly to 250,000,000 people—a world multitude that finds recreation, inspiration, and satisfaction in the play of sound and sight now reflected by the screen.

You, who have worked quietly in laboratories to develop the chemical, mechanical, and electrical processes that have made motion pictures the world's first universal form of entertainment, need no stimulus from me. The future is the blazing goal that continues to beckon to you. Your contributions to motion picture development have followed each other in amazing succession. Writers, directors, and artists have had to tax their ingenuity to absorb and utilize the expanding powers and the new devices which you have put at their disposal. Producers have added a new and brilliant chapter to the history of industrial achievement, by their rapid and universal adoption of sound, your latest contribution. The financial fabric of our nation has responded to the stability and good management which the motion picture industry has achieved during the last decade and has put behind you and us the millions necessary for further research and for marketing the product you have made possible. The public has responded with an increased patronage of millions weekly to the appeal of the new art created by sound.

Crossroads of Progress.—A few years ago the motion picture industry stood at the crossroads of progress in picture development. An art had been created based on the pantomime of lights and shadows. Photography, apparently, had lavished its greatest resources on the screen. The progress of studio technic had made silence eloquent with action. The spectacles of ancient and modern history had been reconstructed for motion picture backgrounds. Talented men and women had developed a new artistry of acting for the screen. Writers and dramatists had learned to create special forms of entertainment based on the opportunities of the motion picture art. The fields of literature, history, and drama were combed for source material to inspire picture production.

In a few years the industry had passed from the peep show to the motion picture palace, forging ahead with giant strides to create a new and ever-growing art for the world's democracy of entertainment. This was a great achievement indeed.

But for those who take the helm of leadership there is no stopping on the road of scientific and technical progress. The word "stabilization" does not exist in the lexicons of science or of art. One scientific discovery either prepares for, or makes way for, another. A true art form is a living, growing thing.

The Screen Finds a Voice.—Sound came to the industry, and almost overnight the screen found a voice. Silence no longer stood in the way of film development. The motion picture screen, which had reflected through pantomime, life, literature, history, and the stage, found new reservoirs of material. The whole world of opera and music was opened to the movies. In a marvelously brief period new forms of entertainment were actually created that increased the motion picture audience of the United States last year by more than 15,000,000 people weekly—making the total weekly attendance 115,000,000.

The sound motion picture will become equally the servant, the universal servant, of education. I doubt whether even you, who have been fashioning the implements of the new magic, have had time fully to realize what you have done for the education of the world. The truth is that you have created the textbook of the future, a contribution to the spread of greater knowledge unequalled since the Gutenberg Bible became exhibit "A" in the history of movable type.

You heard on Monday from Mr. Tuttle of the special lights and camera processes which have been developed for the particular purpose of making colored motion pictures of great surgical operations.

Progress of Medical Films.—The medical profession has been splendid in seeing the possibilities of the motion picture as an implement of instruction, and the important experiments which have been conducted at the Eastman laboratories are in response to a demand which grew out of conferences as early as 1926, when the industry let it be known to leaders in medicine and surgery that the wonders of the motion picture were at their disposal. In that year the American College of Surgeons appointed a distinguished committee to develop the matter consisting of Squier, Chipman, Crile, Charles Mayo, Crowell, and Dr. Franklin H. Martin, now president of the College and a consistent leader in the entire movement. Mr. Eastman generously supplied the funds, and the experimentation to lead to a certainty of surgical films began.

In those early conferences we were thinking in terms of the silent picture, unaided by the great corollary advantages of sound and color. Next September the College of Physicians at Columbia University will have ready a series of sound films for instruction and the medical schools of Johns Hopkins, the University of Pennsylvania, the University of Michigan, and Ohio State are part of a group which expect to make and distribute these films.

No longer will the country doctor be handicapped by his inability to travel to the medical education centers and take an unending series of post-graduate courses in a science which progresses steadily from year to year. He can see the newest in technic, vividly portrayed on the screen, with each movement of the skilled hand displayed and every reason for the method concurrently explained by the master who is performing the operation.

Imagine the value of a close-up, slow motion picture in color of a Mayo, Crile, or Squier performing a difficult operation and describing it minutely, so that instead of 20 students watching from a balcony it could be shown to 100,000 students a score of times if necessary!

The Textbook of the Future.—This great contribution to the advancement of surgical science is an impressing way but only one of the myriad ways in which the talking motion picture in colors will become the textbook of the future. In September of last year I wrote a letter to 573 university and college presidents, asking them to outline fields of activity and detail in which the motion picture might serve the cause of pedagogy. All replied, and more than 300 contributed useful and inspiring suggestions. These suggestions are being studied and will be applied.

What would it add to the pageant of history, if Washington were to speak to us from his own time through the medium of the films? If, here, tonight you could see and hear Faraday discuss electricity, if Steinmetz through the living sound and motion of the screen could confront you tonight? If the nation, through a film broadcast, could hear Lincoln tonight? If, in addition to the facts gathered from books, we could feel the vibrant force of other famous personalities of the past and the tempo of their age?

These vast possibilities inherent in the audible motion picture will be your gift and the motion picture industry's gift to the future—and these possibilities, I submit, challenge us all to make certain of the full use of their values.

President Hoover Coöperates.—Specifically, I desire to announce on this occasion that on behalf of the Motion Picture Producers and Distributors of America I have this day offered to the United States Government our aid in collecting and permanently preserving the picture records of historical events now available and which will hereafter be made by the American motion picture industry.

By this means the United States will take deserved leadership in the creation and development of the great library of the future. To the records of printed and written words which now comprise the pages of history, will be added the living records of sound, movement and color that will picture significant contemporary events to the coming generations with the vividness, realism, and certitude of life. The pageant of history, of education, of national events, and great local happenings will hereafter be recorded in the living tempo of the time in which the events occurred.

This will be brought about by the joint action of our Government and of the motion picture industry. Committees will be appointed both by the President and by our industry to make this coöperation most effective. With the President this coöperation has been developed and by him this afternoon I was authorized to make this announcement.

In the vaults of our member companies are the negatives of all the principal contemporary historical events since the news weeklies made their record possible. Prints of these we will present to the Government to be preserved under its auspices in keeping with the best scientific practice.

You of the Society of Motion Picture Engineers can aid the project with your technical coöperation, possibly by the appointment by your President of an appropriate committee of your organization. The best method of preservation you will develop.

The Governmental storing facilities will be hastened, located in the place best suited for the purpose. In such building, also, may be preserved the splendid war and other pictures taken by the Government agencies and now handled as effectively as is possible under the facilities available.

Religion Profits from Films.—I have had the pleasure, too, of placing at the disposal of the International Motion Picture Institute at Rome the facilities of the industry to aid in cataloguing the world's present supply of educational films. That supply is only the alphabet of a literature, the spring freshet which will grow into a great river adding to the ocean of human knowledge.

Culture, education, even religion are in heavy debt to you. Under the chairmanship of Dr. Howard LeSourd, of the Boston University School of Religious Education and Social Service, a committee of leaders in the field of religious education has just made public a study of the growing value of motion pictures to our churches and Sunday schools. They found that more than 2000 churches in the country now make some use of motion pictures in connection with services or teaching, and this number is growing every week. "The future is bright," the committee report says, adding, "The opinion of ministers experienced in the use of motion pictures as to their future possibilities for religious education in its broad sense is overwhelmingly positive. It seems to them that a mere beginning has been made and that the church should look forward to an ever-increasing and more efficient use of pictures in its program. There is every prospect of the church utilizing to the full this marvelous new art for the realization of its highest objectives."

Entertainment a Vital Purpose.—I need but add to the statement of these distinguished leaders in the religious field that the motion picture industry will continue to coöperate to the full in their high purpose.

If I have stressed the great collateral values and services of motion pictures—in education, in culture, in the broad aspects of religion—it is not because I underestimate for a moment the progress of the motion picture art in the field of wholesome entertainment. Entertainment itself is a vital purpose in modern life. It is a re-creating and rehabilitating influence that the world cannot do without. In the drab routine that covers the lives of so many millions of people, the entertainment picture comes to create a new will to do and a new viewpoint of life. It is not a luxury that pampers the eye and the ear; it has become a necessity to the life of the world.

It is inevitable, perhaps, that you of the Society of Motion Picture Engineers, who have fused many sciences to create these possibilities, should work largely unseen and unheard, in so far as the public is concerned. All the more the tribute of achievement is yours.

Starting with the physical material on which the motion picture depends—the film itself—the research engineer has been the agent of the fundamental, essential progress. Next you have constantly improved the photographic eye which registers every scene and detail. The skill, thought, labor, and microscopically exact machinery required to make camera equipment are in themselves miracles of high precision. The lighting problems presented by motion picture requirements have taxed the utmost resources of electrical science.

Tribute to the Engineer.—Through your accomplishments, the motion picture now walks and talks and acts and sings.

To all this you are adding the tonal qualities of color, making great progress in translating nature in many of her glorious color effects. Your latest efforts are engaged in the problems involved in the perfection of the wide-screen that would reproduce the scale and perspective of life.

Nor will you be satisfied with that; your vision is already sweeping toward three-dimensional effects or the illusion of stereoscopic reproduction. That indeed would be life in motion on the screen.

Through the technical developments which you have brought, we, who are entrusted also with the responsibilities of translating into performance the social and community factors involved in motion picture production, found more problems to solve.

Sound brought a new army of authors, writers, dramatists, and artists and a vast field of new material to the motion picture studios, and the principles governing the maintenance of social and community values in the production of pictures had to be amplified, and new provisions added, in order that we might carry out our public responsibility.

The Production Code recently announced on behalf of the motion picture industry crystallizes the production policies evolved by the industry during the past eight years. It is a tribute to the vitality and importance of the motion picture art that few subjects have been so widely discussed.

Nation Backs the Code.—The public and editorial opinion which speaks for the fatherhood and motherhood of the nation, and which stands by the modern industrial dictum of public responsibility, has applauded the motives, the principles, and the aims which have led the motion picture industry of the United States to adopt such a Code. The overwhelming weight of opinion has been in this direction.

The new Production Code is a challenge to the creative genius of all those who serve the art of the screen. It is a great step toward new artistic heights in motion picture production. It is a milestone in the progress of wholesome entertainment. The Code expresses the requirements of propriety, of good taste, and of public morals, in the production of motion pictures. It places no frontiers upon the progress of art. It restricts no man or woman with a worth-while message to deliver. It puts no bars upon the creation of wholesome entertainment. In banning vulgarity of scene or suggestion the motion picture industry is serving the public and serving itself. The virility of the art is not dependent upon vulgarity.

No code, no regulation, no set of principles, is worth the paper it is written on unless there is a considered will and determination to observe it. The determination already expressed by producers, the enthusiastic support of picture directors, writers, and actors, the solid way in which the recent sentiment of the country is lined up behind the Code, will prove the strongest factors in its realization. We remember the necessity of a demand for good pictures as well as the necessity of a supply. Personally, I know the American public will support the best standards and I assure you that the supply of pictures so generally good now, will completely square with the promise of the Code when next fall or early winter the pictures made under this new and democractic instrument of self-regulation are released to the public.

A Look into the Future.—The future of the motion picture art is indeed brilliant in its promise of entertainment, cultural development, and of technical progress. Let us step for a moment into the cinema of tomorrow. It is a theater that surpasses the finest architectural achievement of the present, built solely for sound-picture entertainment. Magnificent orchestration, superb lighting, natural backgrounds of surpassing beauty prepare the eye and ear for what is to come. The curtain rises on a screen as wide as the theater's arch permits. Color and sound are blended in the brief prelude which sets the motif and tone for the evening.

Music, composed for the film, in rising and falling tempo with the action, flows uninterruptedly during the performance, save when it dies away to permit the accentuation of voices. The photographic effects are no longer those of the flat screen; they have a marvelous illusion of third dimension, far transcending the stereoscope of childhood memories.

To all this is added the final charm of color in Nature's true shades. Sunlight seems real sunlight, the tiniest variation of the shades of green in the leaves is there—nature brought within doors. You hear the faint caress of the breeze on those leaves, the hum of insects, the twittering of birds, the light note of laughter of the boy and girl who start on the great adventure which is to be the film's story.

You will deserve the first meed of praise for this miracle theater of the future, but there will also be praise due to the component parts of an industry that has with courage and patience absorbed every new invention and every refinement made possible by technical achievement. You have learned to trust the courage and willingness of the industry to go ahead; the industry, in turn, has learned to look with confidence to you for ever new and greater inventive progress. To your work and to the work of those who make the pictures with the scientific wonders you provide, the American public and the world public has given an endorsement unparalleled in history. Such endorsement must keep us alert and alive to our great public responsibilities.

REPLY TO MR. HAYS

Mr. Hays—I shall be glad to appoint a committee of the Society of Motion Picture Engineers to make recommendation on the best method of storing motion picture film records to insure their perpetuation. It is somewhat of a coincidence that a scientific paper giving the results of extensive research on this subject was presented at this convention by one of our members.

Earlier in the evening we had the privilege of listening to speeches from well-known executives in the industry through the medium of our own invention—the talking picture. We were addressed by H. L. Clarke, President of the Fox Film Corporation, George Eastman, Chairman of the Board of the Eastman Kodak Company, H. B. Franklin, President of the Fox West Coast Theaters, J. E. Otterson, President of the Electrical Research Products, Inc., D. Sarnoff, President of the Radio Corporation of America, and H. M. Warner, President of Warner Bros. Pictures, Inc.

We were also addressed by some of our fellow members on the Pacific Coast and by the president and other members of the Academy of Motion Picture Arts and Sciences in Hollywood and after hearing all these eulogies, we realize more keenly than ever our future responsibilities. We shall continue in our efforts to improve the quality of sound reproduction and thereby add to the realism of the screen picture. We are fully aware that the theater patron is much more critical of sound quality than he is of the excellence of the photographic image and the reason for this, I think, is that from the early ages we have been accustomed to accept the crudest drawings as representing the finished object. However, by no stroke of the imagination can you imagine that when I clap my hands the resulting sound is symbolic of an orchestra. Anything but a perfect facsimile of the sound we are endeavoring to reproduce is unsatisfactory to the ear. However, the ability of different persons to detect the finer points of musical appreciation varies greatly, but the public is rapidly becoming educated. We must keep ahead of this public appreciation. The improvement in sound quality during the past six months has been remarkable and this only as a result of the concentrated efforts of the technicians in the research laboratories and studios, and the projection and acoustical engineers in the theaters.

We realize that the scope for technical advance in the field of color motion pictures is almost unlimited. The definition or sharpness of the color motion picture must be improved and we must be able to render the colors of nature more truthfully. Also, many of the problems of the wide screen are as yet unsolved. Our Society has rendered a valuable service to the industry in preventing the producers from plunging blindly into this new development in the absence of a suitable standard. The danger of the reoccurrence of the chaos which prevailed in the early history of the film business, when each producer used a different size of film, I believe, has been averted. Our Society is serving as a common meeting ground for the producers to agree upon a standard.

The discrepancy of seeing shadows talk will eventually be overcome by the addition of depth to the picture. We are embarrassed by the optimism of the lay press with regard to an early solution of the problem of television. The public is becoming blasé and is surprised at nothing. The problem of televising so that the picture will be as large and as clear and rendered in color like the picture in the theater is an extremely complicated one and much more difficult than that of reproducing sound. I feel that before our pictures are televised in color and relief some new fundamental scientific discovery will have to be made. Even then, the problem will only be solved by combined efforts on the part of many workers.

There are two distinct kinds of research work: pure or fundamental research, or the pursuit of knowledge for its own sake and without regard for its immediate value. For example, the vacuum tube is based on the electron theory of electricity—a scientific discovery. There is also industrial research or the application to industry of principles discovered by pure research. There is a great need for more fundamental investigation and the incentive of profit is a safe guarantee that the new discovery will be applied.

The industry needs a constant flow of new and vigorous blood into its veins and the logical fountain for this blood is the youth of the nation. To the ambitious sophomore who is technically inclined, I know of no better goal at which to aim than the motion picture industry. This industry is unique in so far as it embraces more of the arts and sciences than any other industry with which I am acquainted so that a wide knowledge is necessary for success and the student should not attempt to specialize too much before leaving college. He should acquire as complete a knowledge as possible of optics, mechanics, electricity, mathematics, and some chemistry. This is said to be the age of specialization but no matter what scientific problem is tackled today it is necessary to draw upon knowledge from practically all the pure sciences. The successful scientist of today must be a "jack of all trades" and master of many of them.

Up to within recent years the economics of the motion picture industry have been on an unstable foundation largely because of the lack of technical knowledge within the motion picture organizations but I predict that the successful motion picture executives of the future will be those having a technical or engineering training.

In conclusion we, the members of the Society of Motion Picture Engineers, pledge ourselves to the advancement of motion picture engineering and the allied arts and sciences, thereby contributing to the increasing enjoyment of the motion picture patron upon which the success of this industry largely depends.

J. I. CRABTREE, *President*

NEW YORK SECTION

At a meeting held in the Engineering Societies Building on June 12, 1930, Mr. L. M. Townsend, chairman of the Projection Committee, presented the report of his committee in extenso. It will be recalled that owing to the crowded program at Washington it was unfortunately necessary to abridge the report of this committee but in view of its great importance the suggestion was made that the report be subsequently presented before the New York Section.

An interesting discussion followed the presentation of the report which will be published in the next issue of the JOURNAL.

Mr. S. K. Wolf of the Electrical Research Products Inc., also presented a paper entitled "Factors Governing the Size of Sound Reproducing Equipment in Theaters."

The chairman announced that the next meeting will be held early in October and arrangements are being made for a visit to the Radio Victor Corporation, Camden, N. J.

CHICAGO SECTION

The second meeting of this section was held on June 19, 1930, at the Webster Hotel, Chicago, Ill. A lengthy discussion regarding papers to be presented before the section took place and several papers were promised.

Chairman Dubray announced the appointment of the following committees:

Membership and Subscription

Mr. Eugene J. Cour, *Chairman*
Mr. E. A. Bertram
Mr. M. W. La Rue

Progress

Mr. L. P. Langford, *Chairman*
Mr. R. H. Ray
Mr. D. Tattenham
Mr. E. J. Cour

The chairman announced that the next meeting will be held at the Adler Planetarium, Chicago.

THE NEW CONSTITUTION AND BY-LAWS

The amended constitution and by-laws were printed in the July issue of the JOURNAL. These contain a large number of amendments to the previous by-laws and attention is especially drawn to the following:

(1) An applicant for Active membership must now be sponsored by three Active members instead of two as formerly.

(2) A new class of membership, namely, "Sustaining members" has been instituted.

(3) The new method of electing officers permits the entire Active membership to participate in the nomination of officers.

(4) Commencing October 1, 1930, the initiation fees for both Active and Associate membership will become universal. During the past two years persons residing in territory other than the United States and Canada have enjoyed the privilege of half rate initiation fees, namely, $10 for Associate and $15 for Active membership. On the date above mentioned a universal initiation fee of $20 for Associate and $30 for Active membership will be in effect.

(5) Petitions for the formation of local sections must now be signed by 20 Active members instead of 10 as formerly.

(6) Members become delinquent when their dues remain unpaid for 4 months. Two months after becoming delinquent, members will be dropped from the Society roll if non-payment is continued.

JOURNAL
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LOYD A. JONES, EDITOR *pro tem.*

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A PROPOSED NEW SERIES OF STANDARD FOCAL LENGTHS FOR MOTION PICTURE PROJECTION OBJECTIVES

WILBUR B. RAYTON*

In the early days of motion pictures, projection objectives were supplied in a series of focal lengths which differed from each other by only an eighth of an inch. The burden of making and carrying in stock so great a variety of focal lengths became oppressive for both the manufacturer and the dealer and, in consequence, the Society at its Chicago meeting in 1917[1] adopted as standard a series of focal lengths in which the interval between numbers was a quarter of an inch. This practice has been followed up to the present day. The only further attention given by the Society to the subject of projection lens focal lengths consisted in adopting a standard permissible tolerance of plus or minus 1 per cent.[2]

At the present time the popular numbers include the range from 4.0 in. to 8.0 in. in focal length. A variation of 0.25 in. in 4.0 in. amounts to 6.25 per cent; in an 8.0 in. focal length the same change is only half as great in per cent or 3.125 per cent. This range of focal lengths is required not so much because of any corresponding range in screen sizes as to accommodate a wide variation in projection distance. A lens of 4.0 in. focal length will project a 20 ft. picture at a distance of about 90 ft. If a change is desired it must be to either a 3.75 or a 4.25 in. lens if we take the shortest available interval on either side. The corresponding change in screen size will be about 1.25 ft. If the projection distance is 180 ft. it will require an 8.0 in. lens to give the same size picture and the nearest focal length on either side will permit a variation of picture size of about 0.6 ft. The question arises as to why a minimum variation

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* Scientific Bureau, Bausch & Lomb Optical Company, Rochester, New York. (Read before the Society at Washington.)

[1] "Report by the Committee on Optics," *Trans. Soc. Mot. Pict. Eng.*, No. 4 (1917).

[2] "Report of Committee on Standards, May, 1923," *Trans. Soc. Mot. Pict. Eng.*, No. 16 (1923), p. 314.

of picture size which is satisfactory when dealing with a 4.0 in. lens should not be satisfactory if a lens is required of double the focal length. In fact, why should the series of focal lengths be based on an arithmetical increment at all except for convenience in remembering what lenses are available? It would seem much more sensible to make the series of focal lengths a geometrical series in which each focal length differed from the one before it by a fixed ratio.

Under any circumstances this suggestion would merit consideration, but at the present time a new complication is introduced by the deplorable state of affairs introduced by the talking pictures.

It is difficult to imagine just how the solidly entrenched ranks of directors, cinematographers, and exhibitors ever permitted themselves to be manipulated into the position in which they now are as a result of the manner in which the sound-on-film process was developed. The appropriation of that relatively small area on the film for the sound record has played havoc with photography and projection. From the projectionist's standpoint, the attempt to project from the complete sound-on-film picture requires a movable mask at the screen to hide the empty space otherwise plainly visible and makes the projected picture so nearly square as to be decidedly displeasing. If, on the other hand, a mask is employed in the aperture in the projector to restore the original ratio of height to width either a smaller picture results or a projection lens of shorter focal length must be used. If the latter expedient is adopted we can restore the picture size, to be sure, but the center of it no longer coincides with the center of the screen and the lens must be shifted in a direction perpendicular to its axis to restore the center of the picture to its desired place on the screen. This violates all good optical practice and is responsible for some pretty bad projection. Ignoring the troubles of the studio, it is easy to see that the sound-on-film process has not filled the life of the projectionist with joy and it is to some degree surprising he has not made a more effective protest.

To add to his troubles, the careful projectionist who tries to find combinations of focal lengths which will give pictures of the same size from Vitaphone and Movietone or Photophone film finds that in only a few cases is it possible. His film apertures differ in a definite ratio but available focal lengths differ in an arithmetical progression. The difference in film apertures is 11 per cent and if projection lenses could always be found which differ in focal length by just this amount he could always project pictures of at least the same size.

A series of focal lengths in which the interval was as great as 11 per cent would be totally unsatisfactory because of too great change in picture size in passing from one lens to the next. Architects and exhibitors would undoubtedly raise violent protest. Two other possibilities exist, however, which should be considered.

TABLE I

Proposed Series of Focal Lengths, Interval 5.5 Per Cent

3.00 in.	4.46 in.	6.62 in.
3.17 in.	4.72 in.	7.01 in.
3.36 in.	4.99 in.	7.42 in.
3.55 in.	5.28 in.	7.85 in.
3.76 in.	5.59 in.	8.31 in.
3.98 in.	5.92 in.	
4.21 in.	6.26 in.	

The first is to make the series of focal lengths differ by half of the 11 per cent, or 5.5 per cent. This leads to the series shown in Table I wherein each focal length is 5.5 per cent shorter than the next longer. The constant difference of 5.5 per cent is matched in the present series at the lens of 4.5 in. focal length with a 0.25 in. interval between it and the next number. It would correspond to a change of picture size of about 1.1 ft. in a 20 ft. picture. It leads to a series containing nineteen numbers between 3.00 in. and 8.31 in., inclusive, and seems to the writer adequate.

TABLE II

Proposed Series of Focal Lengths, Interval 4 Per Cent

3.00 in.	4.25 in.	6.00 in.
3.12 in.	4.41 in.	6.25 in.
3.23 in.	4.58 in.	6.50 in.
3.37 in.	4.75 in.	6.75 in.
3.50 in.	4.95 in.	7.00 in.
3.63 in.	5.15 in.	7.30 in.
3.78 in.	5.34 in.	7.58 in.
3.93 in.	5.56 in.	7.86 in.
4.08 in.	5.79 in.	8.20 in.

The second possibility consists in dividing the 11 per cent into three parts, making the constant difference one of about 4 per cent. This suggestion leads to the focal lengths set forth in Table II containing twenty-seven focal lengths between 3.00 in. and 8.20 in., inclusive. The minimum change in picture size computed on the basis of a 20 ft. picture would here amount to about 0.8 ft.

The difference between the two is that the manufacturer would have to make and the dealer to stock nineteen numbers to cover the range in the one case and twenty-seven in the second case. Since the success of the manufacturer and dealer both is to some extent at least essential to the success of the motion picture industry it should not overlook the possibilities of economy offered by the first suggestion. For comparison it is to be noted that at the present time there are twenty-two numbers in the series from 3.00 to 8.25 in. The first proposal involves only three fewer numbers.

DISCUSSION

MR. DUBRAY: What are the permissible variations in focal length?

MR. RAYTON: The Society adopted at one time a variation of 1 per cent from the indicated focus as the maximum permissible tolerance with the provision that if the lens is too long in focus it be marked plus and if too short it be marked minus.

MR. TAYLOR: As one might wish to change from full aperture to reduced aperture, why is it not feasible to use a supplementary lens to increase the magnification in order to cover the original screen area?

MR. RAYTON: This depends on the aperture of the illuminating system. If we are dealing with an illuminant making use of only a small part of the projection lens it will produce passable results. The demand is, however, for more and more light. This will, I think, lead to a demand for projection lenses of greater aperture. With an illuminant that fills the full aperture of such lenses the use of supplementary lenses will cause a noticeable loss in definition.

THE BECQUEREL EFFECT AND ITS ADAPTATION TO TALKING PICTURE SYSTEMS

RUDOLPH MIEHLING*

At the mention of photo-electric cells, the mind usually visualizes a glistening silver bulb that serves the magical purpose in sound projection heads of converting a varying light beam into electrical impulses that eventually reach the audience as intelligible sounds. This electrical eye finds in the flickering light beams from the celluloid ribbon, voice, music, a pistol shot, or the murmur of the sea. In visualizing this every-day magical device, we neglect to include other types of photo-electric cells that have in the distant past and may in the near future have an important bearing on the development of sound picture systems.

Strictly speaking, the term "photo-electric cell" may be applied to any device in which an electrical effect is obtained when it is exposed to the action of light. Of later years, the term has been reserved almost exclusively for that type of photo-electric cell employing the Hallwachs effect. This phenomena, named for its discoverer, is based on the property of the alkali metals and some of their compounds of emitting electrons when illuminated.

The familiar photo-electric cell is then simply a glass bulb containing a hydride of an alkali metal, usually potassium, with a central anode. The light falling upon the cell controls the emission of electrons from the alkali metal coating on the interior, thus affecting the current flow through the cell.

Since the electrons moving in a gas atmosphere of low pressure are the factors determining the current flow through the cell, it follows that this type of cell is lightning-fast in response. With the electrons being emitted by the sensitive coating in practically direct proportion to the intensity of illumination, the photo-electric cell quickly displaced the selenium cell in the development of sound reproducing methods.

* Universal Sound System, Inc., Philadelphia, Pa. (Read before the Society at Washington.)

The selenium cell, now classed as a photo-conductive type of cell, was the hope of the earlier experimenters with sound systems. In this type of cell, the current change is obtained by the action of light in reducing the resistance of annealed selenium when made into thin films between metallic conductors. It was soon found that selenium cells possessed inertia and refused to respond to rapid changes in the intensity of the light falling on them. For that reason they have been considered of little value for sound-on-film reproduction in this country. Abroad, they have been used to a certain extent by employing some special construction.

There is a third group of cells which operate on an entirely different principle and which are classified as photo-voltaic cells. In the two former groupings, photo-electric and photo-conductive, it will be remembered the light impulses controlled the flow of current from some exterior source through the medium of the light sensitive cells. In the photo-voltaic group the cell generates a current when exposed to light and requires no outside source of current. This is the Becquerel effect and the adaptation of this type of cell to sound picture systems will be covered by the rest of this paper.

Generally speaking, a photo-voltaic cell consists of two electrodes immersed in an electrolyte which has no chemical action on either electrode while the cell is in the dark. There may be, however, a slight dark current due to impurities that are never entirely absent in commercial materials which introduce but slight error in operation. Upon illuminating the cell, an electrical potential is generated between the electrodes. This may be due either to chemical reaction in the electrolyte, or a reaction of the compound on one of the electrodes or to both causes. The particular phenomenon is controlled by the materials selected for the electrodes and electrolyte.

The particular cell to be considered here employs a homogenous film of cuprous oxide on a copper plate as the light-sensitive compound. The second electrode is pure metallic lead while the electrolyte is a one per cent solution of lead nitrate in distilled water. This type of cell is the result of the development work by Wein

The construction of the cell as developed for talking picture systems is shown in Fig. 1. The container is machined from bakelite or other inert material and by means of a conducting support the oxidized copper plate, circular in shape and having an area of $1^1/_4$ square inches, is mounted in the center of the container. A ring of pure lead is mounted on the shoulder turned in the casing. This is connected to the terminal on top of the case. A soft gasket to prevent leakage is placed over the lead ring and the glass front clamped into place by the clamping ring. The solution is poured into the cell through the filler plug shown in the bottom of the casing.

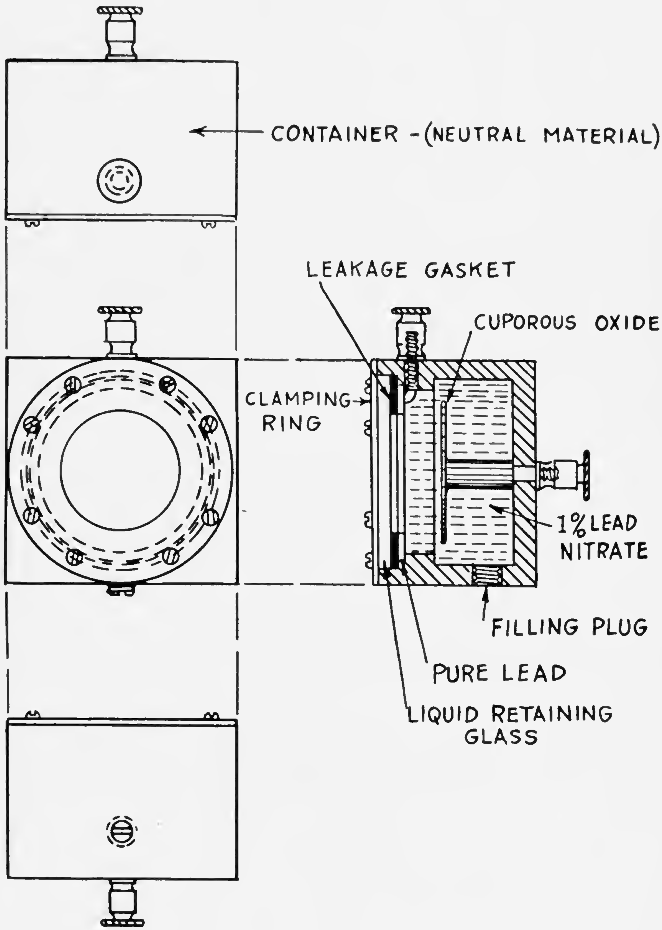

FIG. 1. Diagram of liquid voltaic cell construction.

The active electrode, being the oxidized copper plate would naturally call for some care in its preparation. A clean copper plate is heated to a temperature of 800 °C., resulting in the formation of oxides on its surface. The black oxide known as cupric oxide (CuO) is of no value and, since it is formed on the surface, it can be dissolved off by immersing the plate in dilute hydrochloric acid. The removal of the black oxide exposes the cuprous oxide (Cu_2O) just beneath which possesses the light sensitive properties desired.

The type of cell construction shown results in a sturdy device not subject to damage even with rough handling, the only breakable part being the glass window which is reasonably well protected by the clamping ring. The device is practically immune from danger of breakage always present when fragile glass bulbs are employed.

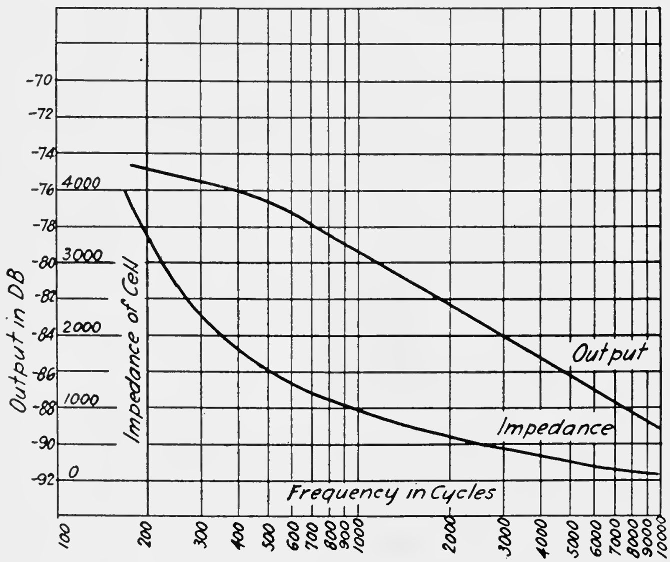

FIG. 2. Voltaic cell characteristics as a function of frequency.

The electrical characteristics of the cell indicate the possibility of its application to talking picture systems and will be discussed before details of its use for that purpose are given. Possibly of major importance is the fact that its light flux-current characteristic is linear. The output of the cell is approximately 20 micro-amperes per lumen which compares well with the average photo-electric cell now used. It is evident that no extensive changes need be made in amplifiers to adapt this cell to existing sound systems.

The frequency response of the cell further indicates its suitability for sound reproduction. There is no indication of inherent chemical lag although a marked capacitive action is present in the cell. To obtain the frequency characteristic curve shown in Fig. 2, a cell was coupled to a three stage transformer coupled amplifier. The cell was coupled to the first stage by a transformer having a d.c. resistance of approximately 45 ohms. (See Fig. 3.)

The output circuit of the amplifier consisted of a 171-A tube connected as a rectifier with a micro-ammeter connected in series with the tube and the secondary of the output transformer. This gave a reading proportional to the square of the output voltage.

As a variable speed light source, an involute tooth gear was revolved in front of a straight filament lamp. This gave an almost pure sine wave with no second harmonics and but about 5 per cent

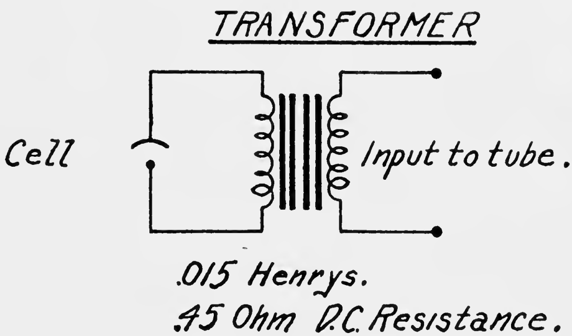

FIG. 3. Coupling of cell as used in test.

third harmonic. The output of the cell was then measured and the results plotted on the curve shown in Fig. 2.

The drop in impedance of the cell with increase of frequency demonstrates nicely the presence of capacity between the sensitive copper oxide plate and the electrolyte. The value of the capacity was checked by employing the discharge through known resistance and galvanometer method and was found to be in the neighborhood of 1.5 μf. The exact value varies somewhat with different light intensities of the higher order but at intensities present in sound heads the above value is reasonably accurate.

The photo-voltaic cell can be resolved into an analogous electrical network built up of resistances, capacity, pure voltaic batteries, and an alternating current generator whose current output at a given low light flux (0.2 lumen or less) is constant and independent of the resistance in series with it. Such a network, shown in Fig. 4, serves to indicate the relative positions of the electrical components making up the cell.

The capacity in the cell occurs between the Cu_2O plate and the electrolyte which have an ohmic resistance of 50 and 150 ohms, respectively. Due to voltaic action between the cuprous oxide and the electrolyte, a voltage of 0.2 is generated.

A similar voltaic action between the cathode and the solution gives rise to a potential of 0.17 volt. These two sources give rise to a dark current in the cell. The a.c. generator is analogous to the effect of variation in intensity of light reaching the cell.

The values of resistance given for the copper oxide and electrolyte were determined by means of an a.c. Wheatstone bridge.

The theoretical frequency curve of the analogous circuit checks

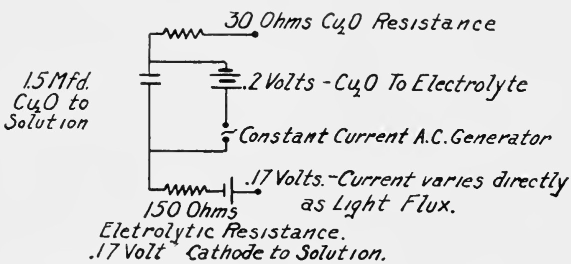

FIG. 4. The electrical circuit equivalent of the photovoltaic cell used in test.

with the frequency curve of the cell within the limits of accuracy of the experiments, which was about 5 per cent.

With such evidence of the characteristics of the cells, it should not be surprising to find they work with a high degree of satisfaction in a standard type of sound head, only requiring such modification of the input coupling to permit the use of the cell at maximum efficiency. Such changes as are found necessary result in a simplification of the assembly, eliminating all need of external batteries and coupling resistors. The latter are replaced by a coupling transformer with a primary impedance equal to that of the cell and a secondary suitable for direct connection to the grid of the first tube of the head amplifier.

The necessary connections are shown in Fig. 5 where 227 type tubes are employed. The elimination of coupling resistors removes one source of trouble often evidenced as background noise. No other changes are necessary either in equipment or mode of operation. Slightly different settings of the fader may be required and a slight readjustment of the master potentiometer to assure the fader control functioning over the proper portion of the volume range.

In summation, it can be said that the photo-voltaic cell employing the Becquerel effect has the following characteristics that make possible its adaptation to talking picture projection:

1. Its physical structure is such as to make it relatively inexpensive and immune to mechanical injury.

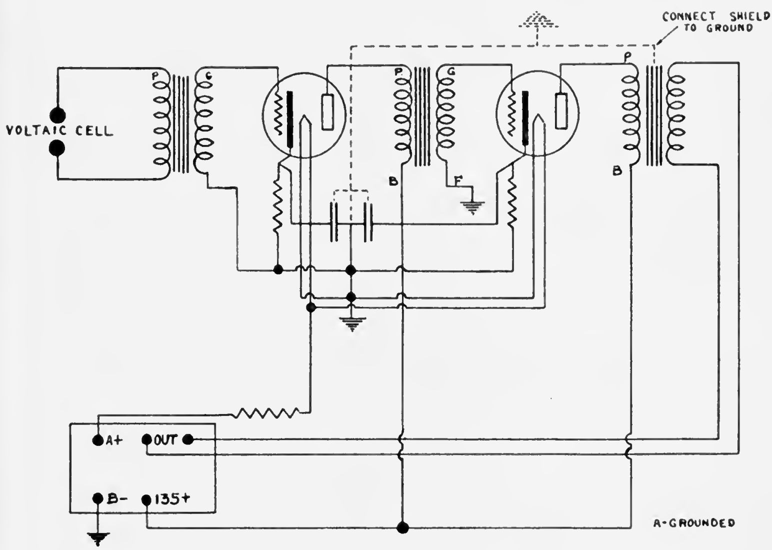

FIG. 5. Head amplifier circuit.

2. The elimination of external current sources and its low impedance coupling device likewise lead to greater simplicity.

3. Its frequency characteristic is such that the cell will respond satisfactorily to all sound frequencies that can be recorded at the present stage of the art and at present film speeds.

4. The cell can be readily connected into and used with any type of sound head without extensive or expensive changes.

5. Since it requires no adjustment beyond being properly mounted in the sound head, it actually reduces the responsibilities placed on the busy projectionist and service engineer.

DISCUSSION

MR. EDWARDS: How does this cell compare in size with those usually employed?

MR. MIEHLING: The size of this cell is about 1½ inches by 1½ inches. The size and shape do not make any difference as long as it is properly exposed to the light source.

MR. TAYLOR: The high frequencies fall off rapidly.

MR. MIEHLING: It is inherent in the cell to fall off at higher frequencies.

MR. TAYLOR: Ground noise is largely a matter of higher frequencies. Is it true that the falling off at the high end is the cause?

MR. MIEHLING: That is probably the truth.

MR. KELLOGG: I understand Mr. Miehling to say that the current sensitivity was about the same as a photo-cell. If this is true, the total power output is less than that of the photo-cell since the same current in a low impedance circuit represents less power.

MR. MIEHLING: That is correct.

MR. SANDVIK: It is true that the ground noise of this type of cell is much less than that of the photo-electric cell.

MR. TAYLOR: Of course it is possible to cut down the ground noise or the needle surface sound by shutting off the high frequencies making the sound, so that any claim for reduced ground noise for one surface or another should be made on the basis of quality response, because everybody knows how to make ground noise if they don't eliminate high frequency in musical notes.

MR. SANDVIK: If you use an equalizing network which results in a uniform gain up to 10,000 cycles, this cell still has relatively much less noise than the photo-electric cell.

MR. MAURER: I should like to ask Dr. Sandvik whether the type of ground noise to which he is referring is that heard when the film is at rest in the projector or when it is running.

MR. SANDVIK: The noise referred to is that due to the photo-cell and not to the surface noise of the film.

THE STORAGE OF VALUABLE MOTION PICTURE FILM*

J. I. CRABTREE AND C. E. IVES

The accumulation of valuable original negatives and master positives by the Eastman Kodak Company and the Eastman Teaching Films, Inc., during recent years has necessitated the construction of a suitable depository for this film.

To date, most film storage vaults have been designed merely with a view to protection of the surroundings in the event of a fire within the vault.[1] This paper gives an account of experiments made with various storage cabinets which have been designed so as to afford more protection to individual rolls of valuable film without increasing the risk to surrounding property.

CRITERIA FOR THE STORAGE OF VALUABLE FILM

At the outset it was considered that in the case of a vault suitable for the storage of valuable film the following conditions should be fulfilled:

(1) In addition to being immune to external fires, the vault should be so constructed that in the event of an internal fire only a minimum quantity of film would be destroyed, and that a minimum fire menace to the surroundings would be incurred.

(2) Each roll of film should be contained in a separate compartment and insulated so that one roll could be burned completely without setting fire to anything else. Each roll should be accessible separately so that the others would not be unnecessarily disturbed during inspection. Also, the different compartments should be vented in such a way that gases, soot, *etc.*, from one burning roll would not reach any other roll.

(3) The film should be shielded from water coming from any source. The most probable sources of water would be: (*a*) an automatic sprinkler discharge during a fire, (*b*) accidental discharge

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* Communication No. 447 from the Kodak Research Laboratories. (Read before the Society at Washington.)

of a sprinkler, (*c*) ceiling or pipe leaks, and (*d*) water on floor from leaks, sprinklers, and similar sources.

(4) The method of storage should insure that the film is not subject to mechanical injury. If wound on too small a core the film will be curled excessively while, if a large roll is stored on edge, the circular shape of the roll will be distorted.

Negative film should be wound on as large a core as is practical and should rest on its flat side. It is common practice to make a separate roll of each scene of a negative, the small rolls being placed on their flat sides in large square cans. In this condition it is very convenient to locate scenes by examining the ends. Obviously greater freedom from curl is insured if the film is stored in larger rolls.

It is customary to store motion picture positive film on metal reels placed on edge. For long time storage this is not desirable because ordinary iron reels are apt to rust and the rust particles offset onto the film on rewinding, unless the reels are made of fiber or other suitable non-rusting material. It is satisfactory to handle positive film in the same manner as negative film.

(5) The film roll size should usually be limited to 1050 feet unless the smallest handling unit is larger. A larger roll would mean unnecessary loss in case of fire. The rolls should be wrapped in paper or preferably in a sealed envelope which would not deteriorate rapidly in contact with the film. The wrapped roll should be placed in a round container made preferably of fiber, wood, or other non-heat conducting material which will not be damaged by nitrogen oxides. The container should have a loosely fitting cover and should not warp.

(6) The storage compartment should be capable of being built up in units as required. Each unit should occupy a minimum of space and also have a minimum weight per unit weight of film. Easy accessibility by the users and close proximity to a supply of electricity, steam or hot water, and brine will determine the location.

(7) The vault should be capable of being cooled to a temperature of 40°F. to 45°F., which temperature is considered sufficiently low to prevent appreciable decomposition of the film base with time.[2] A temperature of 32°F. or less would be very much more difficult to maintain and would introduce complications as regards fire protection and handling of the film.

(8) The vault should preferably be as immune as possible to

earthquakes, vandalism, or destruction in time of war, but in this respect protection can be insured by making duplicate copies and storing these in places widely separated geographically.

STORAGE DEVICES INVESTIGATED

(1) The approved type of storage vault for motion picture positive film consists of a fireproof room with open racks for supporting the rolls of film which stand on edge in separate cans, each containing 1000 feet of film.[3] Ample sprinkler equipment precludes the burning of large quantities of film or the explosion of decomposition fumes,

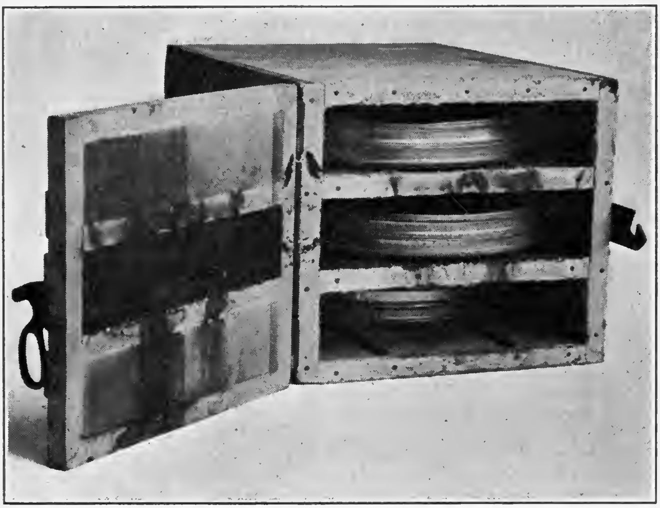

FIG. 1. Plain wood experimental cabinet (front view).

but if one roll becomes ignited, a number of others near it usually are decomposed or burned. Also in the event of fire a large quantity of film is apt to be damaged by water. These conditions make this type of storage vault undesirable for valuable film.

(2) Steel lockers with sprinkler heads fitted at the top are likewise unsatisfactory because the surroundings are imperfectly protected.

(3) Cabinets are available on the market in which the rolls of film are contained in separate vented compartments insulated from each other and from the outside. These cabinets afford satisfactory protection but the film rolls are stored on edge.

(4) The Geyer Film Laboratory[4] has designed and installed a series of cabinets made of wood or asbestos board on the principle of a sectional filing cabinet. The front ends of the drawers are covered by means of a large door and the rear ends open into a common flue which permits the escape of any combustion fumes. Each film roll (1000 feet) is placed inside a wooden box fitted with a telescoping wooden cover.

At the outset it was considered that a cabinet built on the Geyer principle would be most suitable for the purpose intended because this would not depend on the use of water which often causes more

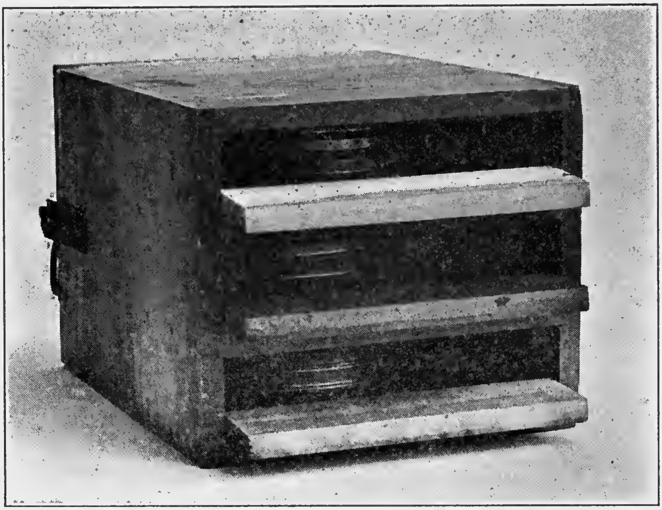

FIG. 2. Plain wood experimental cabinet (back view).

damage than the fire itself. When a roll of film once catches fire it is impossible to save it even if it is quenched in water because the convolutions are then apt to stick together. It was therefore considered preferable to allow the roll to burn up completely, providing the adjacent rolls are protected from the heat and fumes resulting from the film combustion.

Nature of Storage Cabinets Tested.—A number of experimental cabinets designed on the filing cabinet principle were tested by igniting bare rolls of nitrate film in one compartment while the remainder contained film both in the bare condition and enclosed in metal cans.

The first test cabinet of $^3/_4$ inch pine consisted essentially of several shelves separated sufficiently to allow the cover of the film can to be raised, to permit the free escape of gases. The rear opening of each compartment was closed by a flap while the front was covered

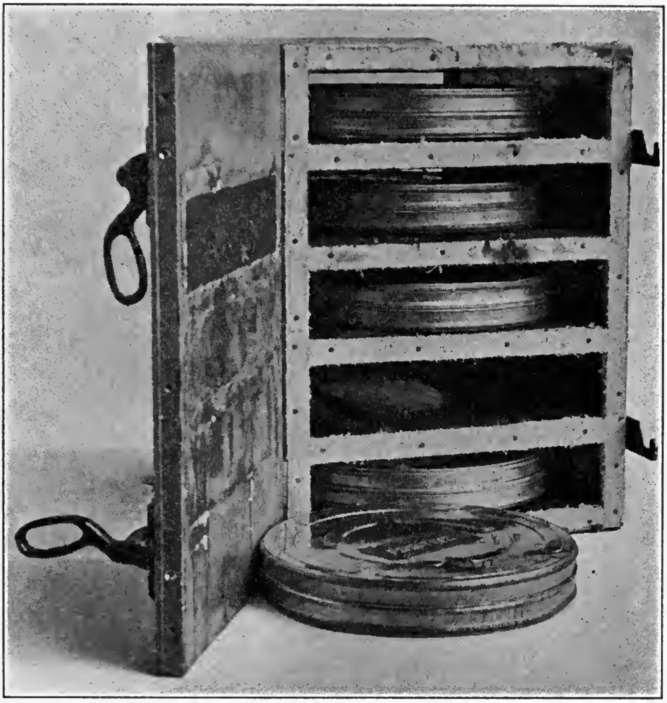

FIG. 3. Sheet metal covered wooden cabinet (front view).

by a single large door which could be closed tightly against an asbestos gasket (Figs. 1 and 2).

The design of a second wooden cabinet tested was similar to the above but this was covered completely with sheet metal. A series of holes were drilled through the metal at the ends of the shelves and uprights to provide vents for distillation products from the heated wood. Fiber rails, $^1/_8$ inch high and $^1/_4$ inch wide, were fastened to each shelf so as to create an air space between the film and the shelf (Figs. 3 and 4). The sheet metal awnings or guards fitted at the lower edge of each shelf at the rear of the cabinet served to deflect the flames from the burning film into the flue and prevent their access to the upper compartments.

Fire tests with the above cabinets indicated that the sheet metal covered cabinet adequately protected all other rolls when one was ignited, while in the case of the plain wooden cabinet the wood

FIG. 4. Sheet metal covered wooden cabinet (back view).

ignited while the first roll was being consumed and the remaining rolls eventually caught fire.

A fireproofing paint was applied to one of the plain wooden cabinets but this did not give any apparent protection from fire, the cabinet being completely consumed.

In view of the great expense involved in covering the wood with sheet metal, a cheaper cabinet was constructed consisting of a plain wooden cabinet fitted with sheet metal drawers as shown in Figs. 5 and 6. The drawers were open only at the end toward the flue, thus eliminating the necessity for a gasket-tight drawer, while at the back the sheet metal drawers extended beyond the cabinet into the flue spaces and were closed individually by weighted sheet metal flaps. This type of cabinet proved satisfactory and it was possible for a roll of film in one compartment to be completely consumed by fire while the remaining rolls were unaffected by heat

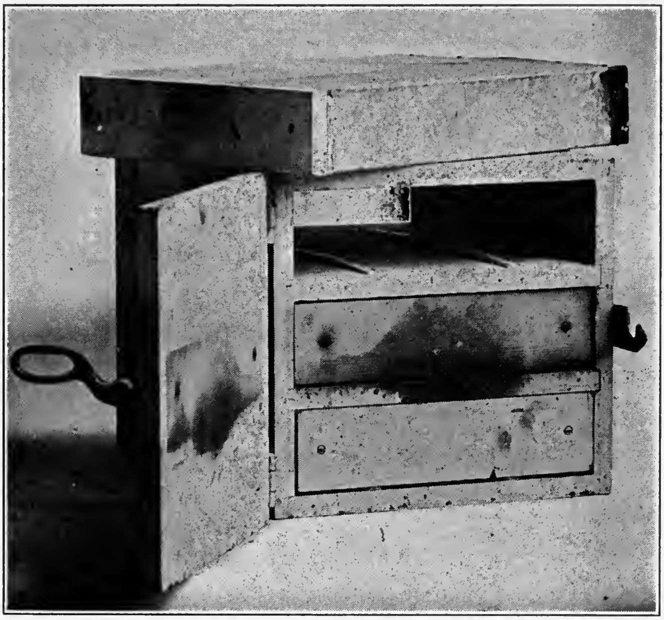

FIG. 5. Experimental cabinet with sheet metal drawers (front view).

or fumes although the woodwork abutting the rear flue was somewhat scorched.

At this point it was decided to make further tests with a storage cabinet of practically useful size with the sheet metal drawer type of construction. Figs. 7 and 8 show the design of a cabinet which has a capacity of forty 1000 foot rolls of 35 mm. film. This cabinet was tested by causing three 1000 foot rolls of 35 mm. positive motion picture film contained in three drawers to decompose simultaneously by the application of heat. Each of these rolls was contained in a sheet iron film can and had at its center an electric heater made by winding wire around a regular 2 inch wooden film spool. Decomposition was started by closing an electric circuit containing these heaters. The decomposition progressed without the need of applied heat after once being started.

When these rolls had decomposed completely, other rolls of film which had been placed in drawers adjacent to those where decomposition took place and at other points were examined. The protection

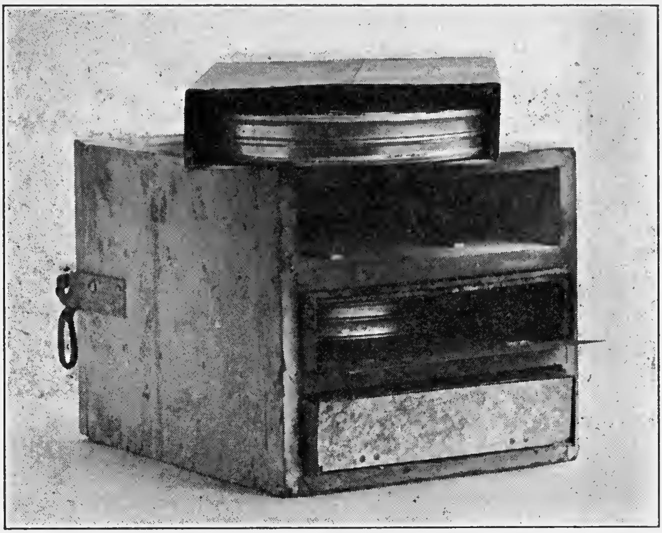

FIG. 6. Experimental cabinet with sheet metal drawers (back view).

afforded from heat and fumes was entirely satisfactory. Even cans in drawers adjacent to those where the heat was evolved were not sensibly warm when inspected within ten minutes after the fire.

A further test was made by exploding a mixture of the decomposition gases and air in the sheet metal chamber at the back of the cabinet by the use of automobile spark plugs. On the first trial one side was blown off from the wooden cabinet because the wooden dowels used to fasten it in place did not secure it sufficiently well. Parts of the cabinet made from ordinary oak were burned in the fire which followed the explosion but other parts constructed of chemically fireproofed oak did not flame or glow after the flame from the burning material was removed. A second cabinet constructed with bolts to hold the woodwork in place was tested in a similar manner by exploding the gases given off during the decomposition of three 1000 foot rolls of motion picture film. In this case the cabinet held together although the sheet metal was bulged on the sides. Several rolls of film in drawers adjacent to those where decomposition took

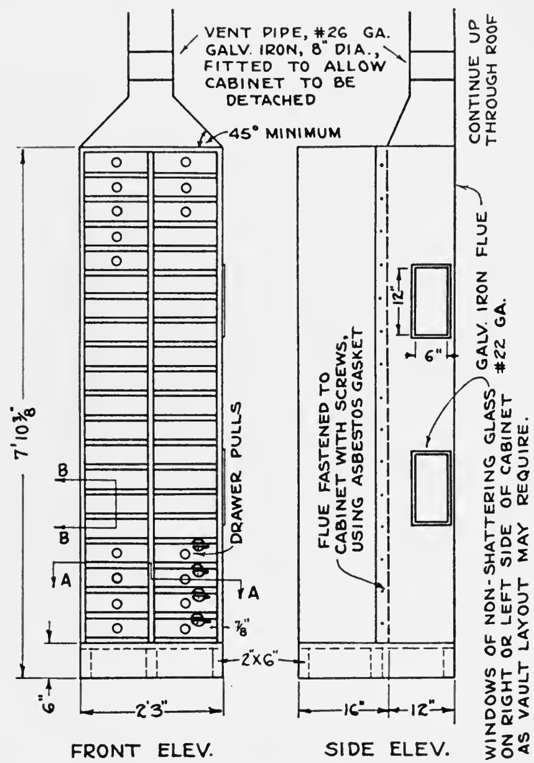

FIG. 7. Front and side elevation of unit cabinet.

place were unharmed. Some of the latter rolls were contained in fiber boxes and others in light weight tin plate containers. Inasmuch as no appreciable amount of heat reached this point the insulating properties of the fiber box were of no advantage and it was concluded that cheap metal cans, such as used by film manufacturers as containers for raw film, would be satisfactory from this point of view.

CONCLUSIONS FROM FIRE TESTS

The above tests indicated that:

(1) Cabinet compartments can be insulated from each other by a $^7/_8$ inch thickness of air-dried pine, but if the wood is not rendered fireproof it is ignited by the burning film and eventually the entire cabinet is consumed.

(2) It is necessary to protect the wood from fire, either (*a*)

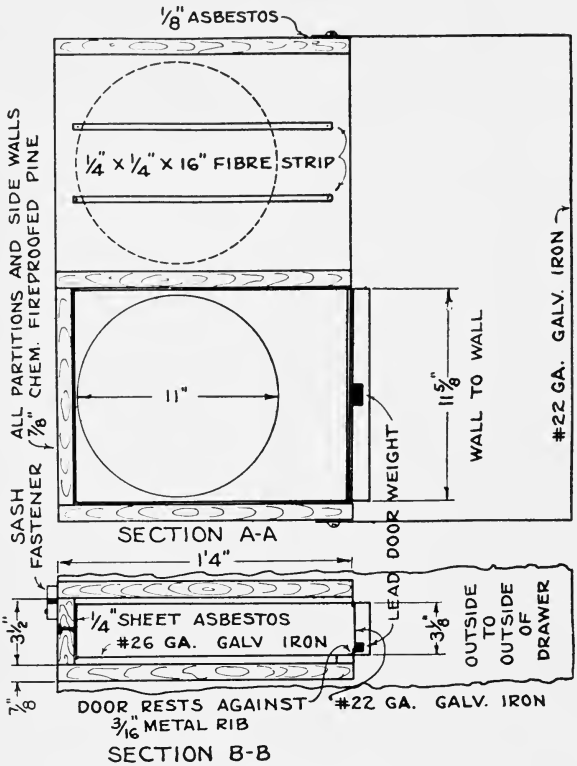

FIG. 8. Sections of cabinet showing arrangement of drawer and shelves.

by covering it with sheet metal completely or at least in all places exposed to flame during a fire, or (*b*) by treating the wood by impregnation with fire retarding chemicals so that it will not burn after it has been heated.[5]

(3) The fire retarding paint tested was found to give practically

no protection to the wood but it is possible that it would have given more protection if it had been allowed to dry and harden more thoroughly. A chemically fireproofed oak treated by the Batavia Woodworking Company, Batavia, New York, was found sufficiently fire resistant for the purpose. It is expected that fireproofing the wood by one of the methods recommended by the Forest Products Laboratory of the U. S. Dept. of Agriculture would likewise be satisfactory.[6]

(4) If the outside of the cabinets or the chamber where they are housed must be protected by regular water sprinklers, the film should be covered in such a way that the water cannot reach it. The sheet metal drawers described give adequate protection.

(5) Free vent must be afforded to gases arising from decomposition of the film as otherwise there is danger of the gas pressure increasing until the container bursts. A committee of the Royal Photographic Society of Great Britain[7] has recommended soldering the tin cans in which motion picture film is stored. This is an extremely dangerous procedure.

CONSTRUCTIONAL DETAILS FOR A FILM STORAGE CABINET

As a result of the above experiments, a cabinet of the following design for the storage of valuable motion picture positive or negative film was constructed.

The cabinet consists of two vertical columns of wooden shelves which are open at the front, and extend at the back into a galvanized sheet iron flue connected with the outdoors by means of a metal pipe (Fig. 7). The film is placed in sheet metal drawers closed at one end which slide between the shelves on $^1/_4$ inch fiber rails. The drawers (Fig. 8) are thus separated at the top and bottom from the shelving by a one-quarter inch air space but a wooden board separated from the metal by an asbestos pad is fitted on the front of each drawer and fits tightly into the front of the compartment. This prevents the escape of any more than a trace of fumes from the front end of the cabinet in the event of a fire.

The drawers are fitted with a metal flap at the flue end which is held shut by gravity. This serves to prevent the access of flames and gaseous combustion products to the adjacent compartments in the event of a fire in one compartment. The open ends of the drawers can be observed through wire reënforced shatter-proof glass windows fitted at one side of the flue so as to insure that the flaps are closed at all times. The completed cabinets of this design are shown in Figs. 9 and 10.

The cabinet has a 6 inch high base and is 7 feet 10 inches high. Each compartment for 1000 feet of 35 mm. motion picture film has the following inside dimensions: $11^3/_4$ inches wide by $3^1/_2$ inches high by 16 inches deep. The sheet metal drawer is $11^5/_8$ inches wide by $3^1/_8$ inches high by 16 inches deep. When the wooden front is pushed in flush with the front, the drawer extends about one inch beyond the shelf into the flue (see Fig. 8).

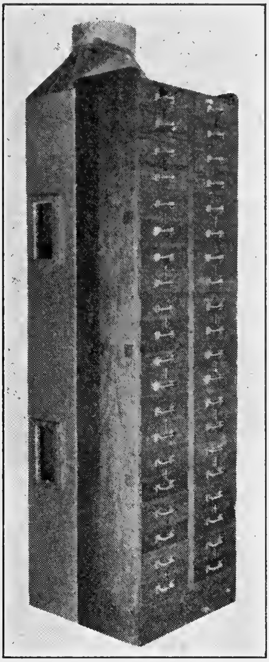

FIG. 9. Unit cabinet to contain 40,000 feet of film.

VAULT FOR CONTAINING THE STORAGE CABINETS

A number of the storage cabinets described above and which would come under the classification of "cabinets" under section D, article 17, of the Regulations of the National Board of Underwriters were placed inside a suitable concrete vault in order to protect the cabinets in the event of an external fire, to protect the surroundings in the event of an internal fire, and to enable the cabinets to be maintained at a constant temperature.

The exterior of a typical vault is shown in Fig. 11. The outside wall is of brick and concrete while cinder block walls were used for the vault partitions. The roof of the vault was constructed of gypsum which is fireproof and has satisfactory heat insulating properties. Constructional details of such a vault should conform with Regulations of the National Board of Underwriters as described in their publication referring to the production, storage, and handling of nitrocellulose motion picture film.[3]

The method of installing the cabinets is clearly shown in Fig. 10, while the vent pipes connected to each cabinet and protruding through the roof of the vault are shown in Fig. 11. The conical shaped cap fitted at the end of each of the curved vents serves to deflect any flames from the roof in the event of a fire within the vault.

The temperature of the vault is maintained at 45°F. to 50°F. by means of brine pipes and radiators thermostatically controlled

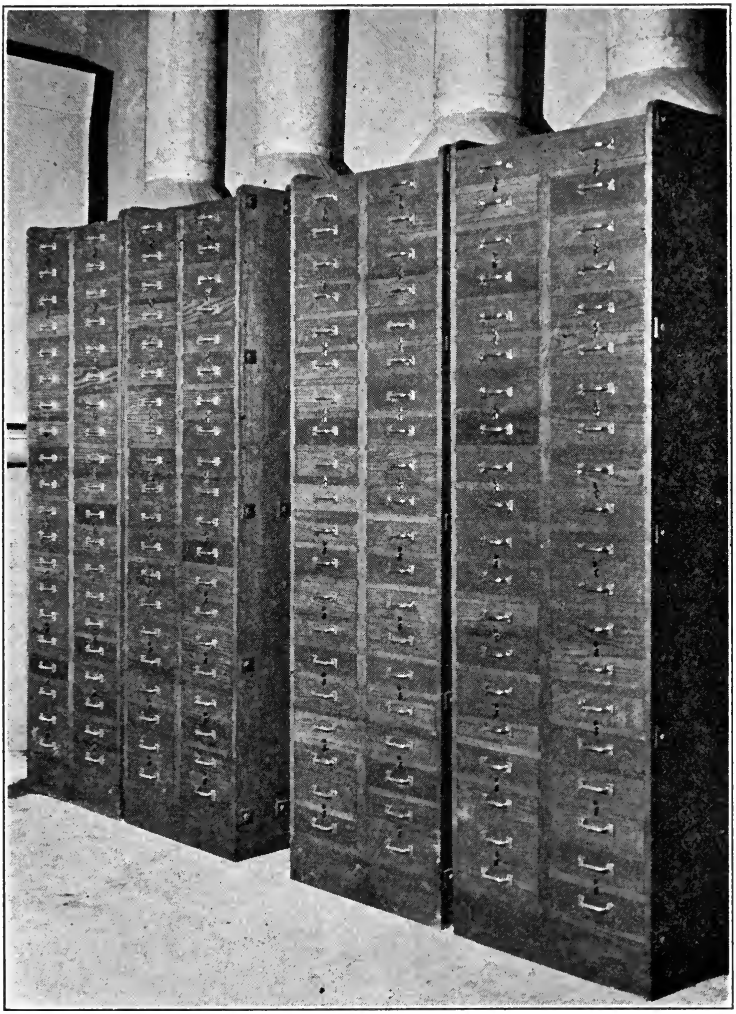

FIG. 10. Photograph of cabinets installed in storage vault.

and placed on the walls near the ceiling. An alternative method of cooling would be to circulate chilled air.

Attached to the vault in Fig. 11 is shown a small receiving room.

Both this room and the vault proper have adequate sprinkler protection.

CARE OF FILM PREVIOUS TO STORAGE

Both negative and positive motion picture film should be given careful processing in the laboratory before placing in the storage vault. After fixing in the normal fixing bath it should be immersed again in a fresh hypo bath to insure thorough fixation. Washing

FIG. 11. Exterior view of vault showing ventilators protruding through the roof.

should be thorough, the time required depending on the method employed, although from 45 minutes to one hour with suitable agitation of the film and adequate renewal of the wash water is usually sufficient.[7,8] A final soak for 5 to 10 minutes in distilled water is also desirable.

After drying thoroughly the film should be spooled on wooden cores (not on metal reels), wrapped in chemically pure black paper of the type used by photographic manufacturers for packing unexposed motion picture film, and placed in ordinary tin plate cans. The tin plate or other rust resistant metal container is satisfactory provided it is inspected frequently so as to permit replacement before the film and its wrappings become contaminated with the products of corrosion.

The moisture content of the film to be stored should preferably be such that it is in equilibrium with an atmosphere of 70 per cent relative humidity at 75°F. before storing. Under these conditions no serious trouble will be encountered as a result of condensation of drops of moisture from the air in the can when the temperature is reduced to 45°F. If, for any reason, film must be cleaned before storing, only liquids which do not attack the film should be used.[9]

EXAMINATION OF FILM AT INTERVALS

Before exposing a roll of the cooled film to room conditions it should be warmed to a temperature above the dew point of the atmosphere so that moisture will not condense upon it when it is rewound. Moisture condensed on the film as dew would otherwise cause sticking of the film convolutions. A suitable warming cabinet maintained at a temperature of 75°F. to 80°F. and containing dry air should be located conveniently near the film vault.

It is desirable to inspect all film by rewinding at least once every two years and if any signs of deterioration are visible a duplicate should be made.

METHOD OF KEEPING RECORDS

It is assumed that all film placed in the vault for storage is sufficiently valuable to merit considerable care in accounting for it. The following procedure for keeping records has been adopted by the Eastman Kodak Company.

Each cabinet drawer is numbered and the film accounted for by such drawer numbers. On receipt of the film the custodian makes out a storage ticket in quadruplicate. The first copy is filed in the head office which is remote from the vault; the second is filed in a safe within the vault; the third is given to the individual depositing the film; and the fourth is placed in the can of film. At the same time, a record is made in a bound book for reference in case of loss of the ticket records.

In order to withdraw film from the vault a duly authorized person whose signature is on file with the custodian signs the withdrawal requisition and the custodian then compares this with his record. If the signatures and descriptions check, he removes the record from his file and the film from the vault and the messenger or other person who takes the film signs for it in the space provided on the customer's record. The custodian then delivers the second and third copies of the record to the head office and these records are then stapled and filed by the owner's name in a "dead" file and retained as a permanent record of the transaction. The fourth copy is delivered with the film as an identification to the customer. All copies are cancelled with a rubber stamp marked "withdrawn" and dated to prevent "dead" records being confused with "live" ones.

SUMMARY

A description is given of a method of storing valuable motion picture film. The film is maintained at a temperature of approximately 50°F. and is stored in 1000 foot rolls in wooden cabinets which contain forty rolls of film. Each roll is contained in a sheet metal drawer, the rear end of which is closed by a hinged metal door which leads into a common flue.

Tests have shown that in the event of the ignition of any roll of film it is improbable that any of the other rolls of film will be injured.

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DISCUSSION

MR. R. C. HUBBARD: This is certainly a departure from the present recommended practice, and I think it has many good points. The capacity of the vault will be greatly reduced by this method of storing, and the size of the vault doesn't conform to the standard of the National Board of Fire Underwriters, which is a maximum capacity of 750 cubic feet of vault.

MR. BRAUN: I should like to ask Mr. Ives what the average useful life of positive film would be if stored under ordinary room temperatures.

MR. IVES: Mr. Jenkins has a film which he says is thirty or more years old and which is usable now. It depends a great deal on the degree of usage and the temperature of keeping. Some films have been given excessive heat treatment and have broken down in a short time.

MR. HUBBARD: As regards the life of the film under ordinary room temperature conditions, the matter of the condition of the air affects that; at high humidity there is more rapid deterioration of the film. I presume that Mr. Ives will take care of humidity as well as refrigeration in this storage vault. If there is too much moisture and it is condensed by refrigeration, it would cause serious trouble.

MR. IVES: The film is wrapped in paper in the cans, and there should be little change in the moisture content of the roll. It is not similar to the usual condition in a vault where the can is exposed to the free circulation of air.

MR. BRAUN: What causes the film to become brittle?

MR. IVES: Loss of moisture causes brittleness. Low relative humidity of the atmosphere produces this condition.

PRESIDENT CRABTREE: In reply to Mr. Hubbard about the volume of the vault, I don't think the regulation mentioned applies to a vault containing cabinets.

With regard to the life of film, this is determined by the shrinkage and the point at which decomposition has reached such a stage that the image is incapable of being reproduced. In our experience, the maximum shrinkage is about 2 per cent under conditions existing in Rochester and it has always been possible to make satisfactory prints on a step printer from negatives which have shrunk to this extent. When film is stored at 50°F. in an atmosphere which approaches saturation the degree of shrinkage will be less than at 70°F. to 80°F. at an average humidity of 50 per cent so that it can be reasonably expected that it would always be possible to make satisfactory prints from negatives stored in the vault under consideration.

WIDE FILM SHRINKAGE AND ITS EFFECTS AS A FACTOR IN DETERMINING PROPER DIMENSIONAL SPECIFICATIONS FOR A NEW STANDARD

A. S. HOWELL AND J. A. DUBRAY*

Mr. Roebuck, in 1918,[1] and Mr. J. G. Jones, in 1923,[2] presented to this Society papers in which the all-important matter of film sprocket design was discussed and formulas given which served as a basis for the calculation of the diameters of the film sprockets; the pitch, thickness, height, and shape of the sprocket teeth to permit the accommodation of a chosen range of film shrinkage.

The investigation was conducted for film of the standard 35 mm. size and for the standard Bell & Howell perforation 0.073 by 0.110 in. diameter, 0.08228 in. length of flat sharp corner, 0.1870 in. pitch, and 1.109 in. transverse gauge.

The ever-increasing demand for an increase in film width and the extensive experimental work already conducted in this direction apparently justify the presentation to this Society of a paper discussing the application of Messrs. Roebuck's and Jones' findings and conclusions to what is commonly referred to as the "Wide Film Development," and some recommended modifications in the arrangement of sound track and picture area for the appropriate widths which apparently have gained popular favor for the future sound film standards.

It is well known that motion picture film is subject to swelling during the "wet" laboratory processes and that it shrinks in both the longitudinal and the transverse directions during its drying.

Shrinkage continues for a long period of time after the drying process is completed, until at the end of its useful life it reaches a maximum estimated at from 1.5 to perhaps 3 per cent longitudinally, with an increase of approximately 10 per cent transversely over that of the longitudinal shrinkage.

The above figures are, of necessity, only approximate, since film

* Bell and Howell Co., Chicago, Ill. (Read before the Society at Washington.)

shrinkage is dependent upon many factors, such as manipulation in processing, atmospheric conditions to which it is submitted, and use and abuse in its manipulations during the exchange service period. Renovation also contributed to accentuate shrinkage as well as lack of proper storage facilities and improper attention as to humidification during the period of its useful life. Experience has dictated and proved Mr. Jones' contention that in actual practice the range of longitudinal film shrinkage can be confined between a minimum of 0.13 per cent and a maximum of 2 per cent, assuming the 0.13 per cent shrinkage to bring about the condition of perfect mesh and the range between 0.13 and 2 per cent to represent the zone of working conditions which can be considered as most favorable.

In order to maintain the best running condition of theoretical pitch during the period of the film's greater usefulness, the 0.13 per cent shrinkage has been decided upon as representing the condition of true pitch. The 0.13 per cent shrinkage value represents the condition in which the film usually leaves the processing laboratory.

Practice has, however, proved that a longitudinal shrinkage of 1.5 per cent can be considered as a maximum seldom surpassed at the end of the useful life of the film and therefore the discussion and illustrations of this paper will be confined within the limits of 0.13 to 1.5 per cent, although sprockets discussed and illustrated are designed to accommodate film shrunk approximately up to 2.5 per cent within the limited arc of contact length of 0.748 in.

The first problem which confronts the engineer is the determination of the size and pitch of the film perforation in relation to the arc of contact of the film with the periphery of the sprocket.

There is little or no theoretical data available at this time upon which to base the calculation of perforation size or pitches, but practice and actual experimentation lead to the conclusion that a critical length of perforation for over-all width of the film, as well as a critical height of the perforation can be determined with a sufficient degree of accuracy. The length of the perforation will be treated later in this paper when discussing the transverse shrinkage characteristics.

In regard to height of perforation, it is apparent that the greater the film bearing surface, *i. e.*, the greater the number of perforations for a given length of film, the smoother is the running of the film because of the lesser degree of adjustment, or slight backward and forward movement of the film, which may be caused by differences in pitch between film and sprocket.

It is also apparent that the driving strength of the film will be affected proportionally to the increase in the number of perforations in a given film length, partly because of the greater number of bearing surfaces thus provided.

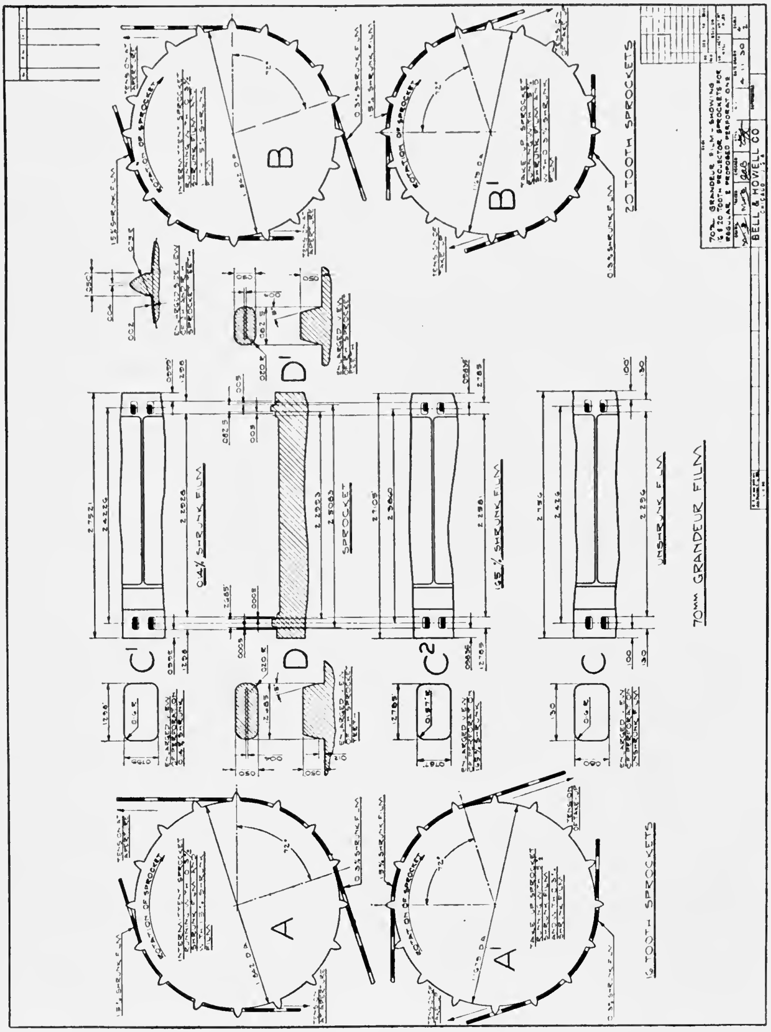

FIG. 1. Sprocket design for 70 mm. wide film.

On the other hand, consideration must be given to the inevitable weakening of the film material, or support, between perforations and a critical point can be practically determined where this weakening becomes excessive and where the stress imposed upon the film results in its breaking at the corners of the perforation.

The determination of the arc of contact of film and sprocket for a projection machine and other machines used for exhibition purposes is limited to a length such that it will permit the running of the film without tooth engagement and disengagement interference.

Fig. 1 may now be considered. At *A* an intermittent sprocket is drawn so as to answer the requirement of a 72 degree arc of contact for a perforation pitch of 0.234 in. as practiced at the present writing for film of a width of 70 mm. For economy of space, the sprocket drawn shows the existing condition for shrinkage of both 0.13 and 1.5 per cent.

Following Mr. Jones' formulas[2] and establishing the number of sprocket teeth at 16 (the accepted practice for 35 mm. film), we find that the base diameter of the sprocket (formula 7) should be 1.1842 in.

The circular pitch of the sprocket should be (formula 10 transposed) 0.2337 in.

The tooth thickness for a maximum shrinkage of 2.5 per cent (formula 29) should be 0.0556 in.

Although Mr. Jones' formula calls for a tooth thickness of 0.0556 in., this has been reduced to 0.050 in. as shown at *D*, Fig. 1, because in practice it is considered favorable to increase the latitude of film perforation clearance for a given length of the arc of contact and for a given maximum shrinkage.

A check on the above results as per formula 15 proves that the maximum shrinkage that can be accommodated by a sprocket of the above dimensional specifications is approximately 3 per cent—which is close to the imposed requirements.

All other factors remaining equal, it is, however, possible to increase the bearing surfaces with the object of improving the smoothness of running of the film and considerably relieving the stress to which it is subjected, by reducing the perforation pitch so that five sprocket teeth are included in the chosen arc of contact.

If the perforation pitch is reduced from 0.234 to 0.1872 in. and the same calculations are carried out, it will be found that the sprocket dimension will be as shown at *B*, Fig. 1.

Base diameter of the sprocket	1.1842 in.
Circular pitch of the sprocket	0.1870 in.
Tooth thickness for a maximum shrinkage of approximately 2.5 per cent	0.0500 in.

The increase in the number of sprocket teeth and consequent reduction in perforation pitch, as compared with the condition illustrated at *A*, offers a greater number of film bearing surfaces and is, therefore, more closely corresponding to the ideal condition previously expressed, while the film portion between perforations is of sufficient width to withstand the stress imposed upon the film and therefore offers greater protection against breakage.

The above expressed considerations and dimensions apply to an intermittent, as well as to a film feeding sprocket, both of which function as film driving elements.

A different condition is met when a take-up or hold-back sprocket is considered. The function of these sprockets is inverse. They hold back the film instead of driving it and are therefore *driven* instead of acting as *drivers*. Since only one of the teeth comprised in the arc of contact (except for the exceptional case of perfect mesh) can drive or be driven (as the case may be) in engagement with the film perforation, and since the *leaving* tooth is in both cases the only one in contact with the perforation, it results that the side paying off film is under tension, while the side paying in is loose in contrast to an intermittent sprocket for which the opposite condition exists.

The slightest interference of free engagement of the film perforation with the entering tooth, which may be caused by the looseness of the film at this end, will cause the film to take a longer path and be immediately crowded out of mesh.

It is evident that the remedy for this condition is that the hold-back sprocket teeth shall have a circular pitch slightly less than the pitch of the perforation of the maximum shrunk film.

The reversal of the function of the driven sprocket, as compared with that of the driver, calls for a reversal of its ability of accommodation. This can be secured by so reducing the base diameter of the sprocket that it will bring in perfect mesh the film when in its condition of maximum shrinkage. In other words, for a driven sprocket, the circular pitch of its teeth must be identical with the pitch of the shrunken film.

This condition is illustrated at A^1 and B^1, Fig. 1, where it is again shown that for the predetermined perforation pitch of 70 mm.

film, a 20 tooth take-up sprocket, B^1, presents considerable advantage over the 16 teeth illustrated at A^1, though both can accommodate film shrunk within the accepted limits without danger of interference.

The take-up sprocket dimension can therefore be established as follows:

Base diameter of sprocket	1.1679 in.
Circular pitch	0.1844 in.
Tooth thickness	0.0500 in.

The shape of the tooth to be within the involute curve generated on the base circle.

It remains now to calculate the transversal dimensions of the sprocket and sprocket teeth.

In reference to Fig. 1, it shall be assumed that the over-all width of the film is 70 mm. and that in consideration of the over-all width of picture record, sound record, spacings between them, and spacings between outer edges of perforation and edges of film, the transverse gauge from center to center of perforations is to be 2.426 in. for unshrunk film.

The width of the perforation is the first dimension which must be established.

It is quite evident that with the present knowledge of film behavior in regard to its resistance to stress, the conclusions which may be arrived at are based more upon practical experience than upon academic principles.

It may be opportune to mention here the advisability of undertaking a thorough scientific investigation in order to verify or contradict the theories advanced in this paper before definite conclusions are derived from them.

From this investigation, which would of necessity be rather laborious, the exact width of the perforation could be scientifically and therefore accurately derived for the film width which may be chosen as standard.

It is, however, quite within reason to consider: First, that it is advisable to secure film registration from the sound track side of the film surface. Second, that the width of the perforation must be calculated proportionally to the over-all width of the film so as to permit the accommodation of the shrunken film without reducing to a harmful extent the transverse width of the tooth, which engages the perforations at the side opposite to the sound record. Third, that an excessive width of perforation would tend to dangerously weaken the film.

The above considerations lead to the conclusion that a critical perforation width can be determined with sufficient accuracy to assure satisfactory film registration and shrinkage accommodation with a minimum of film wear.

With reference to film registration, the shape of the perforation plays an extremely important part. In consideration of the fact that a change in film dimensional standards demands alteration and rebuilding of all machinery used by the motion picture industry an improvement in the shape of film perforation can be considered without fear of encountering too many difficulties in its application.

Commercial reasons have imposed upon the industry the present practice of two different sizes and shapes of perforation, one known as the Bell & Howell Standard, for negative films; and the other as the rectangular, for positive films; the first having a height of 0.073 in. and the second a height of 0.078 in. for an equal width of 0.110 in.

Such reasons disappear with the creation of a new film standard width, and it seems reasonable to conclude that only one pitch size and shape of perforation should be determined for both negative and positive films.

This question has been discussed in papers previously presented to this Society and it has been conceded that the rectangular shape of perforation, with rounded corners, is the one most adaptable and that it presents the greatest opportunity of accurate film registration, especially inasmuch as film control can be established from the film perforation instead of from the film edge. This procedure compensates whatever possible errors may be encountered in the different processes of film manipulation, for it is possible to register the film entirely from the perforation in both transverse and longitudinal control.

Film control from the perforation also materially reduces the width of the surface to be registered and, by nearing the ideal condition of perfect registration, reduces to a minimum the necessary allowances for shrinkage accommodation.

At *C* in Fig. 1, the dimensions of 70 mm. unshrunk film are shown, as well as an enlarged view of the rectangular perforation and its dimensions as accepted in the present practice, 0.080 by 0.130 in.

At C^1 and C^2 are shown the dimensions that are assumed by the 70 mm. film for transverse shrinkage of 0.14 and 1.65 per cent.

It is to be noted that this range of transverse shrinkage has been chosen to correspond with the 0.13 to 1.5 per cent accepted range for the longitudinal shrinkage since experimentation proves that transverse shrinkage is approximately 10 per cent higher than the longitudinal.

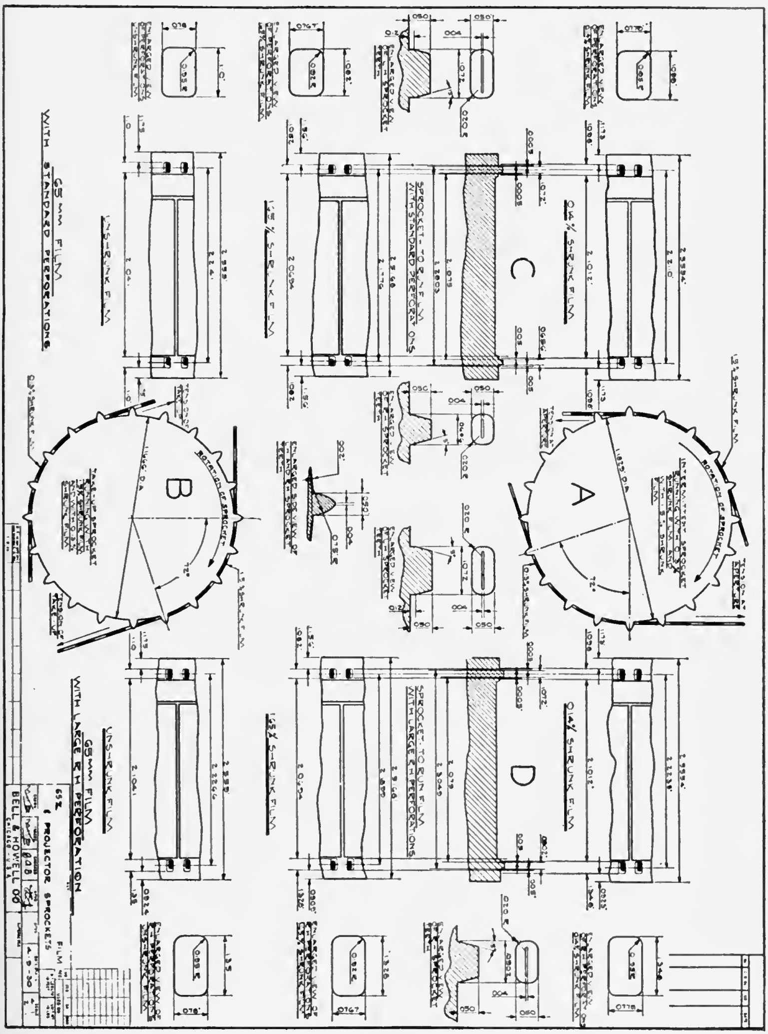

FIG. 2. Sprocket design for a 65 mm. wide film.

In consideration of the fact that film control should be secured at the sound track side of the film, the width of the left-hand sprocket tooth, shown at D, Fig. 1, has been determined so as to fill the perforation at its maximum shrinkage within tolerances of 0.0005 in. at each side of the tooth.

If the right-hand sprocket tooth is now considered (D^1, Fig. 1) it is found that in order properly to accommodate an over-all shrinkage of 1.65 per cent, its over-all width shall be reduced to 0.08215 in. bearing on the flat portion of the perforation face.

Experience proves that for a sprocket tooth, the mission of which is merely to guide the film, this ratio of bearing surface is amply sufficient and does not impose upon the face of the perforation such stress as would result either in breakage or in excessive wear of the perforation itself.

As a final consideration, the shape of the teeth must be determined. Since the corners of the perforation are rounded in order that they may present greater resistance to stress, the base of the sprocket tooth should be designed to follow this curve under all shrinkage conditions. The sides of the teeth should be parallel for a sufficient height to accommodate amply a maximum thickness of the film and then should be relieved by an angle of 15 degrees, as shown in Fig. 1, at D and D^1.

We shall now rapidly consider the present practice in perforation dimension for a film of a width of 65 mm.

Fig. 2 illustrates at A and B the dimensions derived from Mr. Jones' formulas for an intermittent and a take-up sprocket, respectively, for a perforation of a pitch of 0.187 in. and a height of 0.078 in.

Since the consideration expressed for the 70 mm. film applies to the shrinkage of the 65 mm., we shall only remark that the following dimensions permit the accommodation of a longitudinal shrinkage ranging from 0.13 to 2.5 per cent.

Number of teeth	20
Base diameter of intermittent sprocket	1.1829 in.
Base diameter of take-up sprocket	1.1666 in.
Circular pitch of intermittent sprocket	0.1867 in.
Circular pitch of take-up sprocket	0.1837 in.
Tooth thickness	0.0500 in.

There is, however, no analogy between the two film widths in regard to width of perforation, which for the examples illustrated at *C*, Fig. 2, has been kept equal to the width of the perforation used in 35 mm. standard film.

Following the assumptions previously expressed in regard to critical width of perforation and of the apparent necessity of increasing the surface of the perforation, which bears with the sprocket tooth proportionally to the increase in over-all width of the film, it seems logical to assume that the width of the perforation for 65 mm. film could be advantageously increased.

Furthermore, considering the advantages derived by controlling the film at the left-hand perforation, that is to say, at the sound track side of the film, it is found that in order to accommodate a transverse film shrinkage of 1.65 per cent for an over-all film width of 65 mm., the width of the right-hand sprocket tooth would be 0.0656 in. and its flat face would therefore bear only on less than the 37 per cent of the flat face of the perforation.

In order to increase this bearing surface, it has been proposed to enlarge the perforation width at the right-hand side from 0.110 to 0.135 in., which would permit an increase in the width of the right-hand sprocket tooth to 0.0902 in., as shown in the section *D* of Fig. 2 thereby securing a bearing surface somewhat greater than 53 per cent of the width of the flat portion of the perforation.

Such increase in perforation width would indeed apportion amply sufficient bearing surface, but the unsymmetrical condition thus created would have the disadvantage of weakening the film at one side only, thereby unbalancing its resistance to stress. Furthermore, in actual practice, it would necessitate the use of sprockets having narrow teeth on both sides in order to avoid the constant danger of mutilating the perforations in the event of accidental or desired reversal of the film on the sprocket.

The foregoing considerations have been expressed taking into account only the film dimensions proper, irrespective of the nature of the photographic images impressed upon it.

The experience acquired in the past two years of sound picture production and presentation has lead the way to some conclusions which not only permit the improvement of the present technic, but also foresee future developments.

It is, for example, of major importance that the sound record portion of the film should be properly supported and its running should be controlled with a great degree of accuracy.

The transverse control is secured by the size and shape of the perforation nearest to it and by appropriate side tension while the smoothness of running is, as previously seen, insured by proper sprocket design.

There remains the necessity of controlling the film position in the focal plane of the sound reproducing optical system. It is quite evident that a mechanical support of the sound portion of the film is most desirable and that this support, to be effective, must offer a bearing surface of a certain magnitude. It is also not less evident than the support of the picture area of wide film demands more consideration than the smaller area of the 35 mm. standard in practice today.

The spacings between edges of film and perforations, between perforations and sound, or perforations and picture record, and between sound and picture records, assume considerable importance, since it can be said that they play a triple role:

First. They must afford, as previously stated, sufficient film support.

Second. They must eliminate the possibility of encroachment of picture record on sound record, which may result from film shrinkage.

Third. They must eliminate the possibility of interference due to development streaks which may be caused by the perforations during the processing of the film.

Fig. 3 shows the dimensional specifications proposed for films of an over-all width of 70 and 65 mm.

Starting from the control side of the film and following an imaginary transverse axis, we notice that the space between the film edge and perforation is 0.100 in.

The width of the perforation is, as previously determined, 0.130 in. It is suggested that the inner edge of this perforation be used as a marginal guide for transverse registration of the film.

Beside the perforation, a spacing of 0.083 in. is provided to eliminate the encroachment of development markings upon the sound record or of any burring, and to prevent interference with the sound record of slight cracking of the perforation.

The film portion from the edge to this spacing is actually supported at the aperture plate, a section of which is shown directly under the drawing of the film.

Next, a light shield 0.020 in. wide is suggested, the mission of which is to avoid the possibility of light encroachments upon the

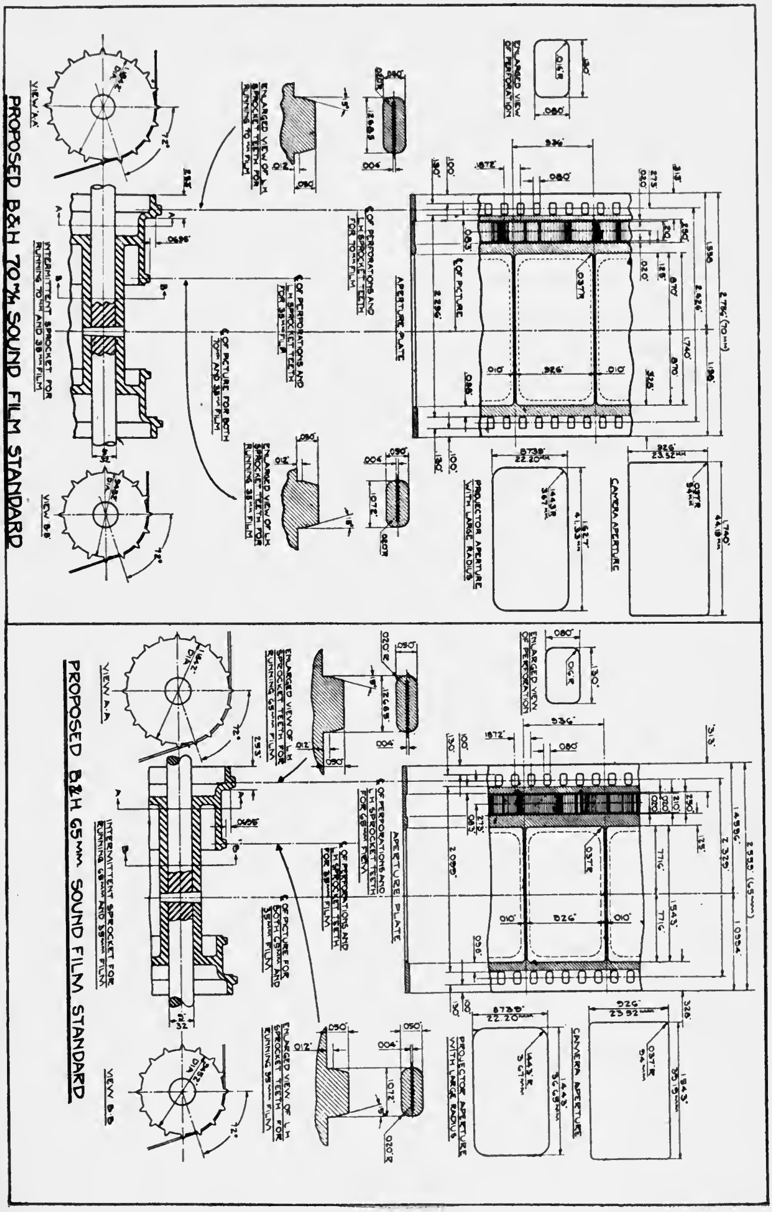

FIG. 3. Proposed dimensions for a 70 mm. and a 65 mm. film and their sound records, picture records, and spacings, calculated to produce good control and adequate protection of picture and sound record.

sound record which might be caused by either a swaying transverse motion of the film or by excessive shrinkage.

The sound record has a width of 0.210 in. This dimension has been determined by increasing the standardized width of the sound record for the 35 mm. film proportionally with the increase in over-all width of the film.

It may be opportune to note here that the width of the sound record can easily be increased, if found necessary, by reducing the width of the spacing between sound and picture records.

The aperture plate is relieved at its portion corresponding to the sound record to permit free running and eliminate possible accumulation of dirt and consequent scratches.

After the sound record another light shield is provided 0.020 in. in width, followed by a spacing 0.125 in. wide, which primarily allows means of providing a sufficiently great supporting surface at the aperture plate for both sound and picture areas. The mission of this spacing is also to eliminate the possibility of encroachment of the picture area upon the sound track in case of maximum shrinkage of the film. The distance between the edge of the film and the second light shield is 0.563 in.

Let us suppose the picture record to be adjacent to the light shield and the side registration to be controlled by the edge of the film. If a shrinkage of 3 per cent is assumed, the edge of the picture record would be brought 0.017 in. nearer the scanning slit or at such dangerous proximity to it that a side motion 0.003 in. in magnitude or any shrinkage in excess of 3 per cent would cause serious interference in the reproduction of the sound record.

Following the spacing is the picture area itself, the width of which is, for the 70 mm. film, 1.740 in. or 44.19 mm. for the camera, and 1.627 in. or 41.33 mm. for the projector aperture.

It will be noted that the height of the apertures for the same film is 0.926 in. or 23.52 mm. for the camera, and 0.8739 in. or 22.20 mm. for the projector, which appears to be a very pleasing proportion especially if the corners of the projector aperture are rounded as suggested with a radius of 3.67 mm. The ratio between height and width of the aperture is 1.87.

With reference to the 65 mm. film, the ratio between height and width of the projector aperture is altered from 1.87 to 1.65.

After the picture record there are found, first, another spacing 0.098 in. in width, then the perforation, 0.130 in. wide, and finally a spacing of 0.100 in. between perforation and edge of film which provides an over-all surface 0.328 in. wide fully supported at the aperture plate.

It may be opportune to remark that the bearing surface at this end of the film is reduced from 0.328 to 0.282 in. for a shrinkage of 1.65 per cent.

The three bearing surfaces created by providing the suggested spacings are in the estimation of the authors essential for films of the widths which have been considered.

The spacings have been calculated to afford protection to both the picture and the sound record, as well as to afford the best possible mechanical control consistent with resistance to wear and stability.

It will be most opportune at this time to mention that from the engineering standpoint, we always consider the 65 mm. dimension preferable to the 70 mm., inasmuch as it will offer some advantages both in the matter of optical possibilities and more favorable conditions for better mechanical control.

Screen size proportions have been discussed at length, and although it is apparent that there is a strong current in favor of a proportion of two to one, we believe that serious consideration should be given to this matter and the decision taken should be dictated by both artistic and technical considerations, and that the matter of proper film support and control should be accounted for, due to their importance with consideration for the life of the film.

At the bottom of the figures, two conventional sprockets and their tooth dimensions have been drawn, indicating the possibility of sprocket design, involving interchangeability of the 70 mm. or 65 mm. wide film with film of the 35 mm. standard width.

The considerations of which this paper has been made the subject are presented to this body with the object of bringing forth arguments based upon the practice and the theory of motion picture film control and with an earnest desire on the part of the authors to contribute to the establishment of wide film standards.

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CONSIDERATIONS IN THE DESIGN AND TESTING OF MOTION PICTURE SCREENS FOR SOUND PICTURE WORK

H. F. HOPKINS*

In the design and selection of a suitable screen for use in sound picture systems, it will generally be recognized that the problem may be treated under two general headings, namely, that relating to the optical properties and that relating to the acoustic properties.

From the point of view of the optical requirements, the problem is varied, depending upon the illumination available at the screen, the reflection and diffusion effects taking place at the screen, and the general effect of these upon the audience. These problems have been under investigation ever since the advent of the moving picture and a considerable amount of valuable data has been collected. Two papers bearing on this problem have been presented before this Society, one by Messrs. L. A. Jones and M. F. Fillius[1] and the other by Messrs. L. A. Jones and C. Tuttle.[2] Other workers in this field have applied themselves to this problem over a considerable period of time but to the best of our knowledge have not published their results. In spite of the considerable amount of work done, the diversity of the problem and the ever-changing conditions in the theater leave much to be discussed and interpreted by workers of the future.

The introduction of the sound picture is one of the changes in the theater that has resulted in a considerable change in the motion picture screen. In its pioneer stages, the so-called "sound picture" was utilized generally only as a means for providing synchronized musical accompaniment for the picture, although in some cases attendant sound effects were incorporated in the recording along with the music. The general idea at that time was to place the loud speakers so as to obtain as nearly as possible the impression that the music was being provided by an actual orchestra. In consequence, the loud speakers were ordinarily placed in the orchestra

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pit and the effects thus obtained were generally considered adequate. The ultimate goal of the synchronized sound picture, however, was the association of realistic dialog with the picture, the possibilities of which were immediately recognized. With the development of the art to a point where the recording of associated dialog was successfully accomplished, it became apparent that a more suitable location for the loud speakers must be found. If realism is to be attained, the character on the screen must appear to be the sound source. A suggested method for approximating this illusion was to place the loud speakers on the stage alongside of the screen, but it would appear that a more desirable place would be immediately behind the picture. This, of course, imposes as a requirement a screen which will efficiently transmit acoustic power as well as one which is suitable as a light reflector. In the Bell Telephone Laboratories considerations of the problem of obtaining a suitable screen have been limited largely to studies of the acoustic effects produced by the screen when used in the manner suggested, and it is the purpose of this paper to discuss these effects.

In regard to the acoustic properties of a screen interposed between a sound source and an observer it is to be expected that sound may be transmitted in various ways. The screen may be made to vibrate as a diaphragm under the driving influence of the sound emanating from the source and as a result of this vibration produce new sound waves that ultimately reach the observer. As a second possible manner, the original sounds may be transmitted through air passages in the screen material. A third possibility would be by wave propagation in the screen material as a conducting medium. Because of certain practical limitations to the permissible thickness of a screen, however, and because of the physical properties of the materials that might be used in its construction, the power so transmitted would be small in comparison with that transmitted by either of the other two methods, and therefore no further consideration need be given this effect. In the following discussion the sound transmitted will be considered to result from either of the first two methods or from a combination of the two.

A sound picture screen as a vibrating diaphragm may be expected to set up sound waves differing from those of the source in a number of respects. From a knowledge of the permissible tension to which a screen may be stretched, and of the density of the material used, it would be expected that the natural frequency of the screen as a whole would be low. At this natural frequency, the screen may be an efficient transducer, but for higher frequencies where the mass reaction becomes large, the greater portion of the driving force would be consumed in accelerating the screen and but little would be available for moving the air load. This natural frequency, however, is ordinarily below the frequency band of interest in sound picture systems and therefore, over this band, the transmission efficiency would be greatest at the lowest frequency and would decrease as the frequency increases. Furthermore, under the conditions in which we are interested, the screen is far from a simple vibrating system and, therefore, irregularities will occur in the transmission characteristic, although the magnitude of these irregu-

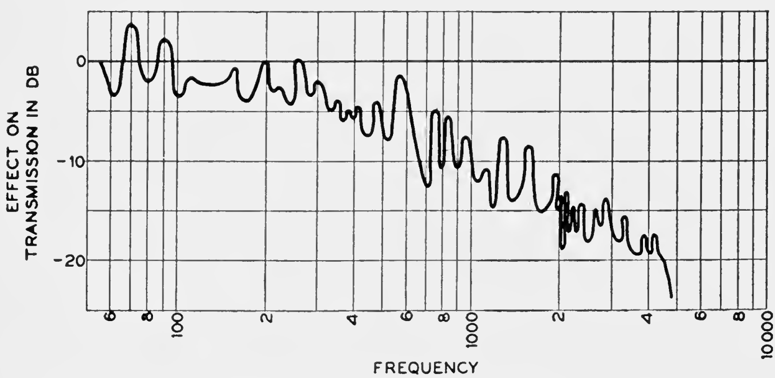

FIG. 1. Effect resulting from a screen which acts as a diaphragm.

larities may be small in comparison with the total effect. Other considerations in connection with diaphragm action are the alteration of the sound field due to a difference between the directive effects of the sound source and of the screen, and the possibility of reduction in the loudness effect due to frictional dissipation.

Fig. 1 shows the effect of a screen in which the transmitted sound power results largely from diaphragm action. The ordinates of the curve indicate the effect of the screen on the sound pressure at the position of an observer for various frequencies. It is evident that the transmission loss increases with increasing frequency due to the mass reaction effect. The irregularities discussed above are also apparent.

In regard to the transmission of sound through the screen by means of air passages in the material, a device of this nature if properly designed may be expected to provide rather satisfactory results. In such a device, several features are of importance. The aggregate area represented by the openings in the screen must be of such magnitude as to provide a proper air load for the radiation of sound into the theater, if efficient transmission is to be obtained. Also since the volume of the air in the individual passages presents a mass reaction to the flow of sound energy, proper dimensioning of the holes is of great importance. The ratio of the length of the passages, represented by the thickness of the screen material, to the area of a single opening should be small. Furthermore, if this requirement is met, the absorption of sound in transit through the screen will be reduced to a minimum.

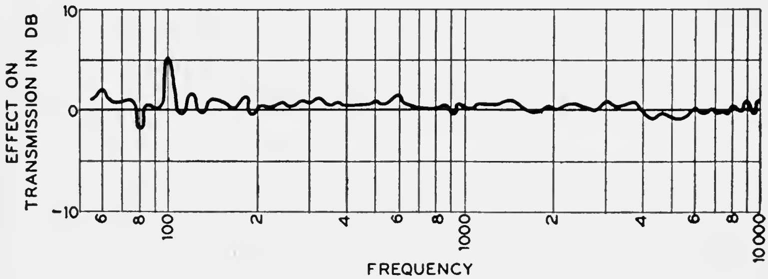

FIG. 2. Effect resulting from a screen which transmits sound freely through open areas.

Fig. 2 shows the effect of a screen in which the sound power in the theater is largely the result of transmission through openings in the screen. In this particular case, the aggregate area of the passages is about 44 per cent of the screen area. It will be observed that this device offers practically no attenuation to the transmission of sound throughout the frequency range of interest and that the irregularities in the transmission characteristic have been reduced to a negligible magnitude, except at the lowest frequencies, where the results are perhaps less reliable.

In regard to the above screen, it is not desirable from the optical standpoint to provide too great an area for the sound passages. The tendency has been therefore to provide rather small, widely spaced openings, as a result of which, sound transmission might be expected to take place by a combination of diaphragm action and air passage conduction. Such a screen might be expected to provide results intermediate between those of Figs. 1 and 2 in regard to both transmission efficiency and uniformity of response. Fig. 3 shows the transmission characteristic of a screen of this type. This screen is similar in design to that of Fig. 1, except for the sound passages. A comparison of the two curves (Fig. 1 and Fig. 3) shows that the efficiencies at a frequency of 100 cycles are approximately equal. At a frequency of 2000 cycles, however, the first screen (Fig. 1) transmits only about 4 per cent of the total sound power, whereas the other screen (Fig. 3) transmits about 80 per cent. Evidently, the transmission indicated in Fig. 3 for frequencies above 2000 cycles is due almost entirely to the effect of the sound passages. The drooping characteristic in this range must therefore be due to the mass reaction of the air in the passages rather than to that of

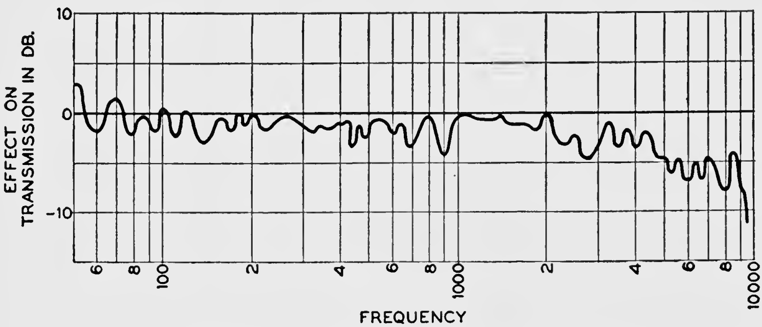

Fig. 3. Effect of a screen which combines diaphragm action with free transmission.

the diaphragm. In Fig. 3 the aggregate area of the openings is about 4 per cent of the total screen area and consists of circular holes about 0.040 in. in diameter. The screen thickness is 0.030 in. It would appear from these dimensions that the effective mass of the air in the sound passages would explain the drooping effect observed. Also the aggregate area of the openings is of such magnitude as to reduce the efficiency at all frequencies. In this particular case it would appear desirable to increase the aggregate area of the openings and to decrease the effective mass of the air in the passages. The latter effect can be accomplished by using a thinner screen. Fig. 4 shows the transmission characteristic of a number of screens of various degrees of perfection as judged from an acoustic standpoint. Curve *A*, as in Fig. 1, is representative of a screen in which no air passages are provided. Curve *B*, as in Fig. 3, is the transmission characteristic of a screen similar to that in *A* except that it has openings presenting an aggregate area of about 4 per cent of

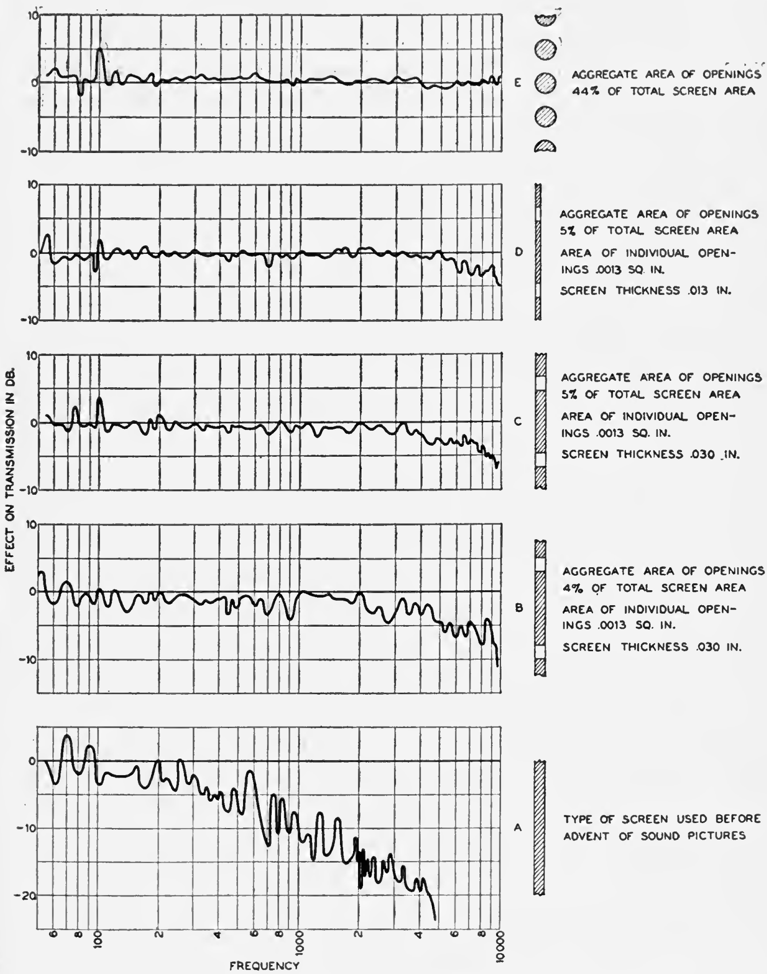

FIG. 4. Transmission characteristics of several types of screens.

the total screen area. Curve *C* indicates the results obtained with a screen similar to that of *B* except that the aggregate area of the openings is increased 25 per cent. It would appear that the increase in the combined area of the holes increases the air load sufficiently to give a noticeable improvement in efficiency throughout the whole frequency range although the droop at the higher frequencies, due to the air mass, is still in evidence. Curve *D* shows the transmission characteristic of a screen in which the size of the holes and the percentage of the open area are the same as in case *C*. In comparison with the other characteristics shown the improvement in this case has been effected by reducing the thickness of the screen and hence the mass reaction of the air in the holes. It will be noticed that the irregularities have also been reduced. Curve *E* is the same characteristic as shown in Fig. 2 and is given here only as a matter of comparison. The open area of the screen represented by this curve is about 44 per cent of the total area and the ratio of the length to the area of the air passages is considerably reduced in comparison with that for the screen represented in *D*. From the standpoint of acoustic transmission this screen would seem to be almost ideal. In view of the characteristics shown in *D*, however, it would appear that good acoustic effects may be obtained with screens in which the area of the openings is considerably less than 44 per cent, thus increasing the possibilities of improved optical performance.

Thus far the screens which have been discussed are devices in which the air passages, if present, are punched or otherwise purposely manufactured into the screen. A great many commercial screens are made of woven material in which the mesh of the weave is depended upon to provide the air passages. In general the individual openings thus provided are small and irregular as to shape and length. Of course the woven material may be very light, approaching netting in character, but screens constructed of such materials are usually less satisfactory optically. In view of the nature and area of the passages provided in certain types of woven screens, it is to be expected from the above discussion that unsatisfactory acoustic effects may result from their use. Fig. 5 shows the transmission characteristics of three different woven screens. In this figure Curve *C* represents the effect of a screen of light netting. The acoustic properties, it will be noticed, are excellent but the screen is probably quite impractical, both optically and mechanically. Curve *B* shows the characteristic of a woven screen of a rather coarse, heavy material. Considerable loss is to be noticed throughout the frequency range becoming greater at higher frequencies. Curve *A* represents the performance of a still heavier material. The air load is apparently too low for efficient transmission and considerable loss throughout the frequency range is in evidence.

In reference to the above discussion and the data presented, it appears that the results obtained are consistent with recognized acoustic theory, that the satisfactory design of a screen to be interposed between a sound source and an observer presents no impracticable difficulties, and that it is entirely feasible to construct a screen which is suitable both acoustically and optically.

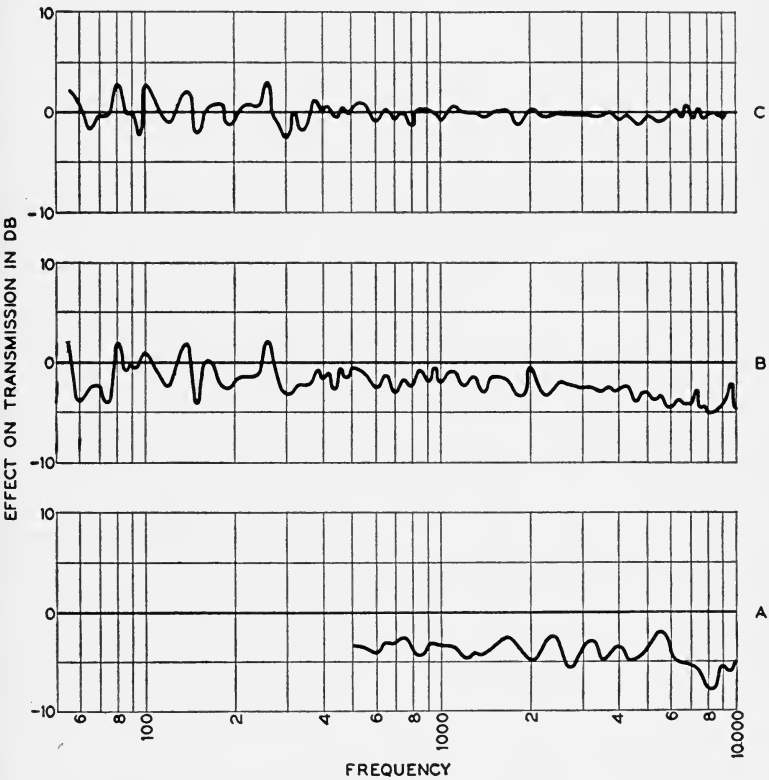

FIG. 5. Transmission characteristics of three different woven screens.

In the above discussion, the transmission data presented were obtained in a manner that may be of interest to other workers in this field. The method used is only one of a number that might be devised, but the results obtained correlate satisfactorily with data obtained by listening tests in theaters, and are therefore felt to be quite reliable. The scheme consists essentially of a determination of the difference in response of a loud speaker, or other sound source, with and without the screen. The response was measured in the manner described by L. G. Bostwick in the *Bell System Technical Journal,* Vol. 8, January, 1929.

In such a test it is desirable that the screen be mounted in the same relation to the sound source that it occupies when used in the theater and in our work we have stretched it across the mouth of one of our theater type loud speakers. In actual use in the theater the screen is often spaced a few inches away from the mouth of the horn and in such cases the horn may be "boxed in" to the screen by means of sound absorbing material. We have made tests to determine the effect of spacing the screen at such a distance with and without the "boxing" and also to determine the effect of rooms of different acoustic properties in which the tests might be made. The difference in the indicated performances of a given screen for the various conditions was found to be rather small.

Another consideration in regard to the method of test is that in view of the nature of the sound passages of the more satisfactory screens it might be expected that some dispersion of the sound might result, an effect quite desirable in view of the directional effect of all types of commercial loud speakers generally available. The dispersion of a few of the screens submitted for test has been measured and in some cases was found to be an appreciable factor. In so far as dispersion reduces the sound power in the more concentrated beam of the source, it is to be expected that tests made on the sound axis would show the greatest over-all effect of the screen.

In view of these effects and in the interests of uniformity, the data presented in this paper were all obtained in a relatively small, heavily damped room. The screen was stretched directly across the mouth of the loud speaker and the measurements were made on the sound axis.

REFERENCES

[1] JONES, LOYD A., AND FILLIUS, MILTON F.: "Reflection Characteristics of Projection Screens," *Trans. Soc. Mot. Pict. Eng.*, No. 11 (1920), p. 59.

[2] JONES, LOYD A., AND TUTTLE, CLIFTON: "Reflection Characteristics of Projection Screens," *Trans. Soc. Mot. Pict. Eng.* X (1928), No. 28, p. 183.

DISCUSSION

MR. WEINBERGER: Is it certain that the loss found is due entirely to the screen and not partly to the reaction of the screen on the loud speaker? Are the losses due to transmission through the screen and partly to a loss of radiation from the speaker itself because of reflection from the cloth stretched across its mouth?

MR. HOPKINS: The results which have been shown were obtained under conditions representative of actual theater conditions with respect to the relative location of the screen and loud speaker, and therefore any effects observed should be charged against the screen.

MR. WEINBERGER: It should be charged to the screen in that particular type of loud speaker, but I am interested in a measure of the screen applicable to any loud speaker and independent of the action of the screen on the source. We have worked on this in RCA Photophone and used a loud speaker back of the screen, which was a rather small radiator and placed at some distance from the screen so that we were certain there was no reaction from the screen on the radiator. I am inclined to be afraid of any measurements with the screen across the mouth of such a large horn unless some check measurements have been made proving it transmission loss only.

MR. HOPKINS: Of course some reaction of the screen on the loud speaker source may occur, but with relatively long horns, and with a relatively high mechanical impedance looking back into the loud speaker unit as is the case for the types used in these tests, this reaction might be expected to have a minimum effect. With a shorter horn of slower rate of taper, and with a lower mechanical impedance this effect might be expected to be more pronounced. In any case, the results are more significant if they show the over-all effect of the screen on the sound at the observer. The reaction on the source, however, appears to be negligible in comparison with the total effect.

MR. FALGE: I would like to have Mr. Hopkins identify the second sample of woven material in a more detailed manner; was the sample representative of screens on the market today and was it treated in any manner?

MR. HOPKINS: The characteristics shown are representative of many screens being manufactured at present. No loading was encountered on any of the screens considered, except that when necessary they were impregnated with flame-proofing material.

MR. KELLOGG: I notice there are a lot of small waves in the curves of transmission shown. Isn't it likely that this was due to the reaction of the loud speaker? It is difficult to believe that a piece of material would have rapid changes in sound transmission of the order of 4 db. for a frequency change of only 10 or 20 per cent. It looks plausible that the point raised by Mr. Weinberger might be the explanation of these small irregularities.

MR. WOLF: I should like to mention a matter discussed at some length by the Projection Committee, that is, the deterioration of screen surfaces which doesn't effect the acoustic properties of the screen as it does the optical properties. At the present time there is no practical method of cleaning screens. A method should be devised for making optical measurements on screens every three or six months.

MR. E. D. COOK: In thinking over the curves shown, it does seem as if the curves indicate that there was a reaction on the source. I notice that the irregularities had more or less pronounced separation throughout the length of the curves. If it were a matter of the screen alone, it would seem that they should come nearer together at the high frequency end.

MR. BLATTNER: I believe there is good reason for believing that there would be some reflection effects, which would show up but, as Mr. Hopkins shows in his data, they are negligible in comparison to other effects. They have been observed when using two speakers of radically different design, and therefore I think these are chargeable against the screen.

MR. RAVEN: I should like to ask Mr. Hopkins whether any tests were made to determine the variation in screen response when the screen was stretched very taut or was limp. I should also like to ask whether any investigation was made as to the effect of different filling matter—the pigments used in filling the screen to make it opaque to light. I have in mind a filler heavily charged with some hard pigment in comparison to some filler that was rather soft and not so resistant to sound.

MR. HOPKINS: We have not made any such tests. We are interested only in testing commercial screens submitted for approval. I might say that we measured the screen under several conditions. We stretched it over a large frame and also across the mouths of the horns always at the same tension so that it would have widely different vibration characteristics, and the results were pretty nearly identical.

MR. RAVEN: I take it that your conclusion is that whether the screen is very taut or hangs limp as a drop hangs, there is no great difference in effect.

MR. HOPKINS: That is, where the area of the openings is sufficient to give good transmission.

MR. RAVEN: Where the openings were not so pronounced, stretching tended to increase the efficiency?

MR. HOPKINS: Yes, so far as diaphragm action is concerned.

MR. PARKINSON: The speaker has mentioned transmission as effected by total area of perforation. Did he learn anything about the effect of different spacing of the perforation?

MR. HOPKINS: The size of the perforations were all the same; the difference in total area was changed by variation of the spacing of the holes.

MR. PARKINSON: You don't know whether the same area of perforation in different sized openings gave the same effect?

MR. HOPKINS: It is desirable to keep the ratio of the thickness of screen to the area of an opening as small as possible. It would be better to make the openings large rather than small.

MR. ROSS: Referring to Screen No. 2, what is the natural frequency of the screen? At 50 cycles, the curve showed it to be decidedly lower in efficiency, and at 100 there was a pronounced increase. Possibly the harmonic periods of the screen have a bearing on its transmission.

MR. HOPKINS: We have no data as to natural period of this screen. Because of the construction of the screen, the amount of diaphragm action might be expected to be small and therefore the vibrational characteristics negligible.

MR. JENKINS: I want to ask Mr. Hopkins about his procedure. Did you take a known speaker or did you measure the same speaker with and without the screen and take the difference?

MR. HOPKINS: The response measurements of the loud speaker with and without the screen were made successively as mentioned. We did not depend on the calibration of the loud speaker.

MR. BRAUN: I wonder if you made any tests which would disclose the amount of sound reflected from various screen surfaces in use today.

MR. HOPKINS: We have not been interested in the screens from that standpoint but only in the effect of the screen on the sound at the position of an observer.

MR. SHEA: We have been interested in the acoustical characteristics of screens to make sure that adequate sound transmission might be obtained without the sacrifice of sound characteristics. Those described are of manufactured screens as submitted and the information published was the results of tests rather than an attempt to design a screen. The method of test used appears to show the difference in sound transmission to the observer in the theater, and that is what the exhibitor is interested in. Since the author has shown that the loss due to the presence of the screen may be made small, in many cases less than 1 db., small variations are of secondary importance. Of course, the method is a difference method and the irregularities present in most acoustical room tests would show up here. If anyone is concerned much with them, it may be due to the fact that he has not noticed that the scale of losses is such that the variations are shown up rather markedly as compared to scales normally used for loud speaker characteristics. The loud speaker characteristics usually presented show more marked variations than do the screens described here.

RECENT AND FUTURE ECONOMIC CHANGES IN THE MOTION PICTURE FIELD

FRANKLIN S. IRBY*

"There are," said Mark Twain, "three sorts of prevarication—plain lies, damn lies, and statistics."

In the past, engineers have not been as vitally interested in the statistics and economics of their particular industries as they are beginning to be at the present. It cannot be said, however, that this interest has reached a high point as yet, but it is felt that in addition to the many technical subjects discussed before this Convention a pause to glance at the economic changes in the motion picture picture industry would be appropriate. After all, the economic changes in the industry affect one's individual welfare, and a review of the recent changes, as well as some thought on the future, may help to form a better picture of one's personal position.

Stimulated by the increasing drawing power of the talking picture, the motion picture industry experienced in 1929 the best year of its history. The wiring of houses for sound pictures progressed rapidly here and abroad, and at the close of 1929, there were approximately 9000 theaters equipped for such pictures, out of a total of 22,600 in the United States. There were about 2000 sound installations in Europe, out of a total of 27,000 theaters.

The data shown in Fig. 1 give some of the comparative facts on sound picture installation. These data are based on the best information available on January 1, 1930. Since this date, sound installations have progressed at a high rate, as is generally known.

It is estimated that at least 5500 additional theaters in the United States will be equipped for sound during 1930. This will mean that 75 per cent of all picture houses in this country will have sound apparatus by the end of this year. The total installations in Europe will probably reach 5000 by the end of 1930, bringing the total installations throughout the world to 22,000 or about 40 per cent

* McGraw-Hill Publishing Company, New York City. (Read before the Society at Washington.)

of the theaters built. This record-breaking growth will be considerably slackened at the end of this period, though it is expected that installations will continue until all suitable theaters have been equipped. Just what will be the final percentage of sound installations will depend on language barriers and limiting size of theaters in which sound equipment will pay. Satisfactory solutions will

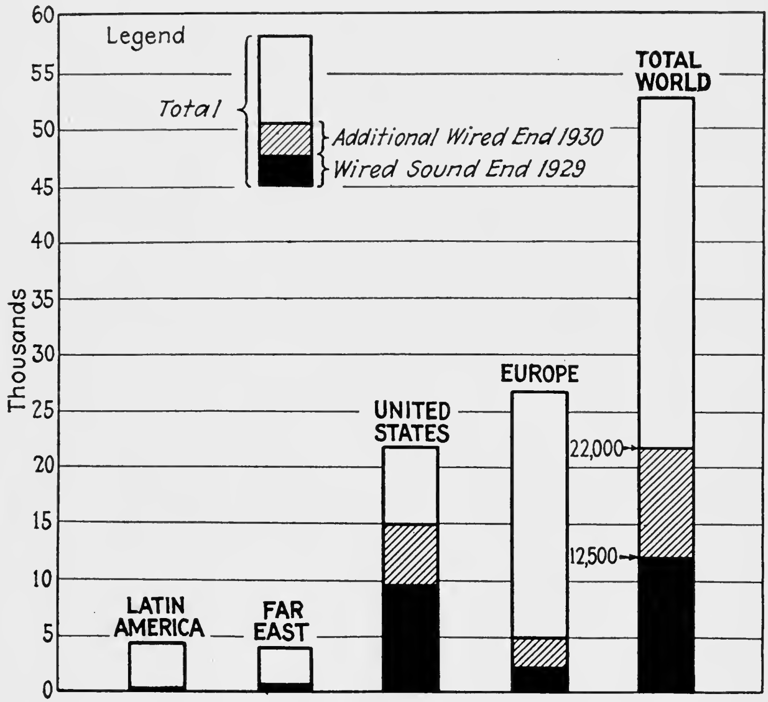

FIG. 1. Theaters wired for sound *vs.* total number of theaters.

ultimately hurdle both these present barriers, and at no distant date we may expect a sound equipped theater or no theater at all.

RISE IN THEATER ATTENDANCE

It may be of interest to note the rise in attendance at motion picture theaters during the past eight years. This is shown graphically in Fig. 2. The first sound equipments were installed in the latter part of 1926; however, no great public interest was aroused until the introduction of the talking picture, *The Jazz Singer*, in

October, 1927. The immediate success of this sound picture was the turning point from silent to audible pictures. The phenomenal rise in the attendance curve is most marked from this time up to the present and many indications point to even higher levels. It is conservatively estimated that the total average weekly attendance

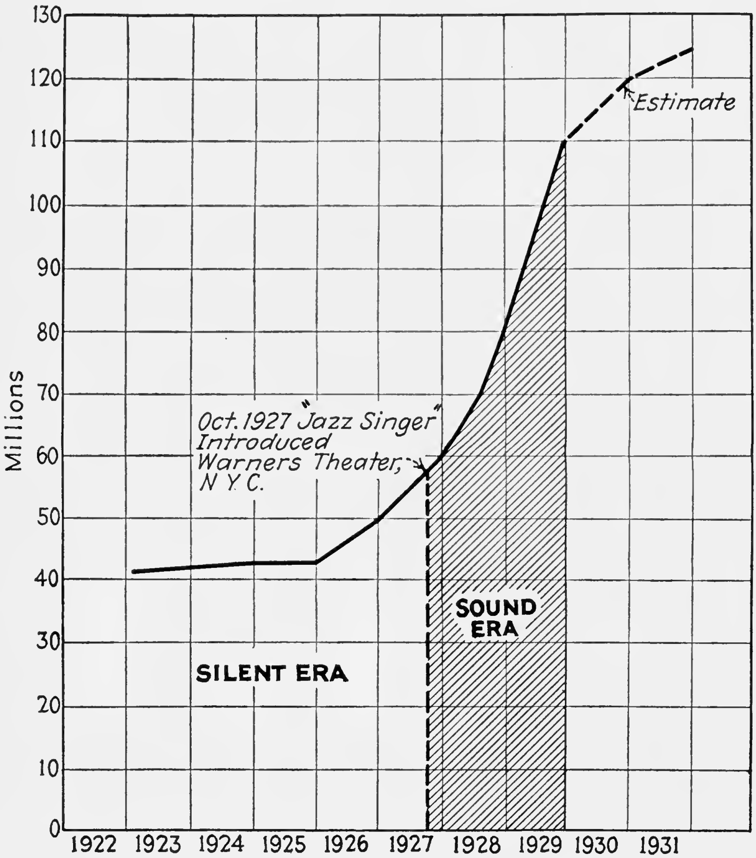

FIG. 2. Average weekly attendance at motion picture theaters.

will reach 125,000,000 by the end of 1931. This is based on the increased number of theaters that will be equipped, and the better quality and wider scope of sound pictures. With the present attendance of 115,000,000 paid admissions per week, it means that practically the entire population of the United States attends the picture theater once every seven days. It is an accepted fact that motion pictures can no longer be considered a luxury, but are a necessary form of recreation for the masses.

The average admission price in the key cities is given as 55 cents, while the average for all theaters is approximately 35 cents. Using an average admission price of only 30 cents and 100,000,000 as the average weekly attendance, it is estimated that the total annual paid admissions to American theaters has reached the sum of $1,560,-000,000. Of this amount $500,000,000 can be attributed to the introduction of sound pictures.

In contrast with such stupendous figures even for our present times, let us consider the early development of the railroads. The Baltimore & Ohio Railroad was organized on July 4, 1828, with a capitalization of $5,000,000. During the first 50 years of railroad development it is estimated that only $400,000,000 was expended on construction. Compare this modest sum with the estimated paid admissions of $500,000,000 to our movie theaters for the first four months of 1930! Times have certainly changed.

In 1907, there were 5000 theaters in the United States; at the beginning of 1930 there were 22,624, representing an average growth of about 740 theaters per year. This average has now decreased to about 500 new theaters annually. It should be noted, however, that the type and size of the new theaters are far superior to the earlier theaters. The total investment in the motion picture industry has increased year by year until today it is about $2,500,000,-000 in the United States. In Europe, the total investment in this industry is estimated at $1,000,000,000. Motion pictures, while not classified as a manufacturing industry, may be considered as such from the point of purchase by the public of entertainment as a commodity. Considering this industry in the latter classification it now ranks eighth of all manufacturing industries in this country.

THEATER CHAINS IN THE UNITED STATES

The earlier theaters in this country were individually owned units. It was not long, however, before ownership or control of more than single units appeared. This was a natural step, in view of chain organizations formed in many other fields. From 1925 to 1930, this growth has been particularly rapid. The introduction of sound pictures has played an important role in advancing these consolidations. Referring to Fig. 3, it will be seen that of the total theaters in this country, 5805 were operated under chain ownership or control, as of January, 1930. There were actually 329 theater chains in existence at that time. These chain-controlled units may be classified under the following groups:

12 chains control 50 or more theaters, each
15 chains control 25 to 50 theaters
135 chains control 6 to 25 theaters
167 chains control 6 or less theaters.

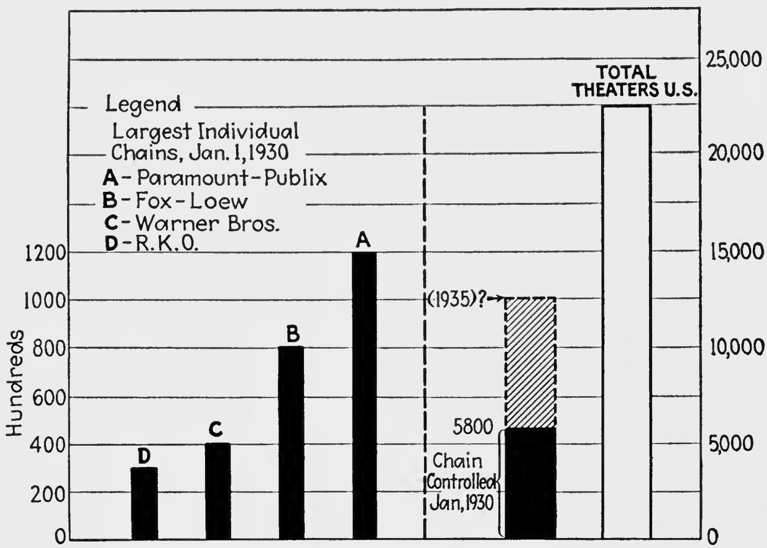

FIG. 3. Chain controlled theaters in the United States (January, 1930).

Of the larger chains there are several which are outstanding. They are shown to the left in Fig. 3, the number of theaters controlled indicated in hundreds. It should be noted that of all theaters now built, only about 25 per cent are chain controlled, but they represent the key theaters throughout the country, and their revenue represents approximately 75 per cent of the total. It is expected that chain growth will continue at a rapid pace, and by 1935 chains large and small will control over 50 per cent of the total theaters in the country.

Economic reasons for the growth of theater chains are many. First, they have introduced better theaters, better management, and better planned performances. Second, by representing diversified investments in various sections of a single city, as well as by states, they have provided greater stability and less risk to the investing public. By enabling the building of elaborate and beautiful theaters, chains have done much to increase the public's theater-mindedness. There are other important reasons for this fast chain growth, and expectations for future growth. Huge sums have been invested by the producing companies in studios and equipment. This is particularly true with the advent of sound recording apparatus. It is seen, therefore, that to protect the future outlet for their pictures, an assured means of distribution under their personal control is necessary. The above reasons, as well as the competition for future production outlets, will be the guiding influence in chain expansion.

For the motion picture engineer, these concentrations should create a greater demand for his service. The larger chain units will undoubtedly build up their own special research and technical staffs to handle the increased complexity of mechanical and electrical equipment. Such staffs are already in existence for several groups, as is well known.

FOREIGN CHAIN CONTROLLED THEATERS

Of the 27,000 theaters in Europe, relatively few are under any chain control. However, there are some well-organized units in a few of the principal countries. In Great Britain, Gaumont controls 300 theaters; Provincial Cinema controls 150; Associated British controls 110; and United Pictures 50. There are a great many other chains that control from 6 to 12 theaters; theaters so controlled represent, as a rule, the better class houses in key locations.

The principal theater chains of France are: Pathé-Nathan controlling 60 theaters; Aubert-Franco-Film controlling 40, and many smaller chains of 8 theaters or less. Of the German chains, U. F. A. controls 80 theaters throughout Germany, and Emelka controls about 50 theaters. In Italy, Pitaluga has a practical monopoly of the most outstanding theaters. In Australia, Hoyts Theaters, Ltd., and Union Theaters, Ltd., control 250 theaters together.

It is worth noting that very recently we have seen American capital entering foreign theater control with the acquisition of the Gaumont chain in England by William Fox, this control now being under the Clarke syndicate. Also, within the past two weeks we have seen a substantial interest acquired in the Kuchenmeister group in Germany by Warner Brothers. This group includes Sprekfilm of Amsterdam, Tobis of Berlin, Associated Sound Film Industries, Ltd., of London, and Compagnie Française Tobis of Paris. The patents and license involved are those controlled by both the Kuchenmeister-Tobis and Klangfilm groups. The latter companies occupy an important position in recording and reproduction of sound pictures in Germany and Switzerland as well as in other European countries. A direct interest in the patents and licenses of the companies involved is thus obtained by Warner Brothers.

Foreign chains, up to the present, have been greatly handicapped due to the lack of capital. The European mind has not fully grasped the significance of building well designed and attractively decorated theaters, as a means of creating a greater public desire for theater recreation. Given an opportunity, American capital will introduce the most modern of houses and with better showmanship increase the theater attendance and profit.

In continental Europe, there are serious problems still to be solved before such a step will be feasible. One is the sluggish attitude toward doing things differently from the way they have always been done and, secondly, the great fear of having this field taken out of their hands. This is understandable, but after all, the masses abroad would actually appreciate good entertainment as they do here. It would appear practical that a few modern, well managed theaters placed in key positions would be a successful stepping stone toward the modernization of the European theater industry.

SOUND PICTURES AND FOREIGN MARKETS

The enormous increase in the average weekly attendance in American theaters following the introduction of sound has already been shown. The same is true, although to a lesser degree, for the theaters in Europe which have been equipped with sound apparatus. With theaters throughout the world wired for sound, there are important problems of language to be considered to produce the proper pictures for our foreign markets. American pictures are now shown in 70 countries with subtitles translated into 37 foreign languages.

Heretofore the silent picture was universal in its appeal. The print, destined for foreign countries, needed only the translation of subtitles in the native language. This, of course, is impossible with sound films and, therefore, new solutions have been advanced.

A "double-shooting process" has been used to some extent, in which two separate groups of players are used with one story and the same group of settings. Another solution, which has been used effectively in the case of sound-on-film, is to insert a section of film in the feature at certain intervals on which there has been recorded sound in the foreign language which describes the picture plot in the same way as a master of ceremonies is sometimes used. Another method has been to print the subtitles on the picture at requisite intervals, and continuing to use the sound reproduction as recorded in English. All of these systems have certain drawbacks, and may be considered

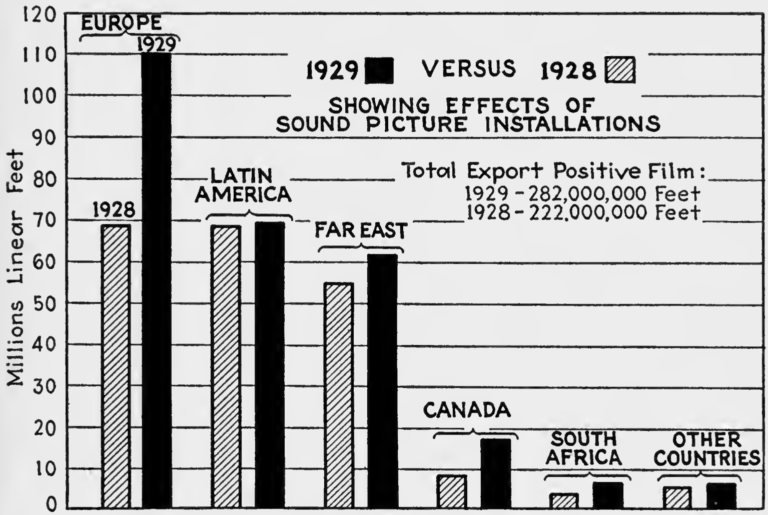

FIG. 4. American film exports.

only as temporary expedients. However, where the particular foreign market warrants, the use of foreign players in the double-shooting process seems a way out for economical production to a limited extent.

Despite this apparent handicap of language, it is interesting to note that United States film exports increased 60,000,000 linear feet in 1929 over 1928. The total American film exported in 1929 was 282,000,000 feet of which about 8,000,000 feet was negative film. This compares with approximately 1,000,000,000 feet of positive film produced in the United States in 1929. It can be seen that our foreign markets in the past have been important, and every effort will undoubtedly be made to continue them in the future. In Fig. 4 are shown some comparative data on American film exports for 1928 and 1929. The increase in exports for Europe is accounted for by the larger number of theaters wired and the demand for talking pictures in Great Britain. A 100 per cent increase for Canada is also indicated.

A UNIVERSAL LANGUAGE

It is estimated that 85 per cent of the motion pictures shown throughout the world at present are produced in the United States. Of the remaining 15 per cent Germany has 8 per cent of the showing, England and France about 2 per cent each, while the remaining 3 per cent is accounted for by all other film producing countries. It should be pointed out, however, that the popularity of sound dialog films in continental Europe and other countries in which English is not the national language is already beginning to wane, while in Great Britain, Australia, and New Zealand they are growing more popular. It is obvious that either these countries will have to be supplied with the proper type of silent films and a limited number of sound films, of the musical type, or else sound films in their respective national languages.

Radio broadcasting, though making rapid strides in national development during the past eight years, has remained nationalistic in character. While international broadcasts are becoming more common, without the audience's vision of the scene and corresponding action it is felt a universal language will hardly be introduced through this medium. On the other hand, it is not too improbable to predict that Anglicizing speech throughout the world in decades to come can be accomplished by means of the sound films. It is improbable, however, to predict this in the near future.

The universal appeal of American films in the past has been due to their improved technic and production as a whole as compared to foreign productions. It can reasonably be stated that such will hold true in the future with sound recording. Therefore, we have every opportunity to maintain these foreign markets by making foreign language sound pictures in this country, or controlling the making of them abroad, within our own equipped and directed studios. A development of the latter will also tie in, perhaps, with the development of American chains in foreign countries, as previously mentioned.

WIDE FILM DEVELOPMENTS

After two years of most hectic and revolutionary development, the motion picture industry might well pause for breath, but this appears improbable. New technical developments that may be as far reaching as the introduction of sound are crowding upon the scene, and producers must embrace them or be left behind in the race for supremacy. The major developments in the offing are: the growing use of color and the introduction of wide film. My comments will be restricted to the introduction of wide film.

One of the first important economic problems should be settled at an early date—that is, a standard width for the new wide film. Whether this film should be 70 mm., 65 mm., or 56 mm., will be left for the discussion of others. However, it is apparent that a standard width and other essential dimensions should be agreed on to preserve the great advantage of interchangeability of films.

Our motion picture industry owes its success, in the past, to the universally adopted 35 mm. film, which allowed pictures made in Hollywood to be shown throughout the world. It should be apparent that to require different projection heads and other equipment to handle widths of film, other than the present 35 mm. film and one standard wide film would not be practical. The introduction of the new equipment in this country will probably be slow, and at the same time expensive. The same will be true for foreign installations, and unless a standard width is agreed upon, serious obstacles will arise in the future.

EDUCATIONAL SOUND FILMS

The evolution which has taken place from silent to sound pictures has opened new doors for the use of films as a means of education. Great opportunities lie ahead of the industry for intensive development in this field. Every high school auditorium in this country should eventually be equipped with sound projectors.

In the past, the use of silent films for instruction purposes has had a limited application. The advent of successful sound pictures is as yet so new that producing companies have not had time to consider the development of this field. In fact, such companies have considered educational films outside the realm of their activities.

Up to the present, at least, the high cost of sound recording equipment and the lack of subsidies from the states' and federal educational departments have prevented a greater use of sound films for this purpose. Quantity production of educational films would lessen considerably the costs involved. Some means for equitably distributing such costs should be found. Why not seek the aid of the individual states and other responsible bodies for such a worthy cause? The universal adoption of sound films for educational purposes would make it possible to present the finest teachers of the country to many audiences. Perhaps the students of tomorrow

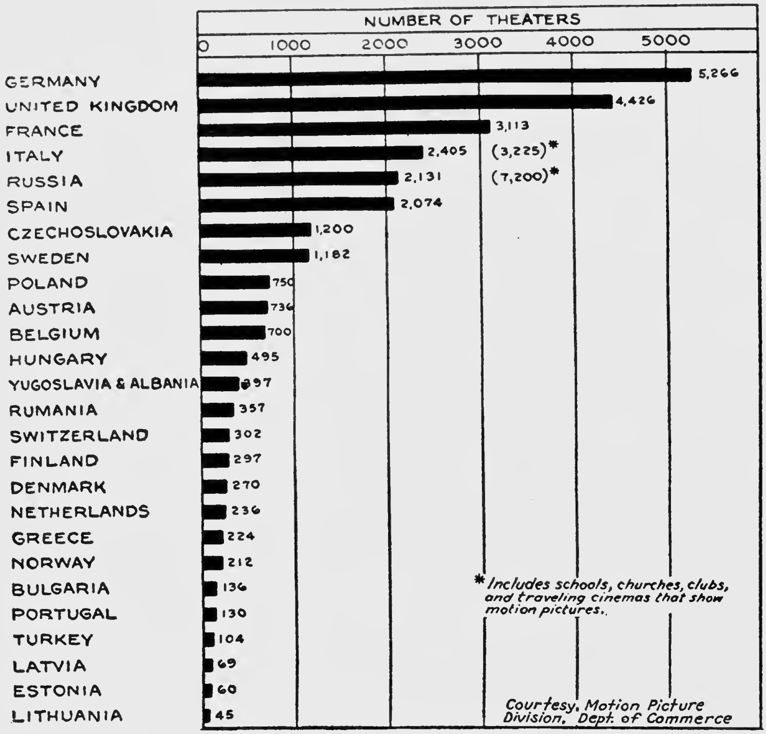

FIG. 5. Motion picture theaters in Europe (1929).

will see and hear of the places on the geographical horizon which today are confined to the pages of a book.

The twentieth century has ushered in many outstanding scientific accomplishments, the airplane, the radio, the telephone, and many others, but none have contributed more to the happiness of the human race than motion pictures. They have brought vision, romance, and laughter to make life more interesting. Today with sound pictures, even those millions throughout the world who cannot

The Motion Picture Industry Abroad

	Number of Theaters	Number Theaters Wired for Sound at End of 1929	Number Theaters Built in 1929	Number Sound Studios at End of 1929	Number Sound Pictures Produced in 1929	Total Silent and Sound Pictures Produced in 1929
Germany	5,266	223	123	2	90	282
Great Britain	4,426	980	171	10	16	50
France	3,113	166	20	5	4	52
Italy	2,405	51	1	1	0	4
Russia	2,131	*	*	..	*	*
Spain	2,074	25	10	..	3	20
Czechoslovakia	1,200	15	50	..	0	{ 19 Features 383 Newsreel
Sweden	1,182	45	7	..	0	*
Poland	750	8	0	..	0	12
Austria	736	23	0	..	0	{ 19 Features 160 Shorts
Belgium	700	24	10	1	1	5
Hungary	495	19	0	..	0	4
Jugoslavia	397	13	0	..	0	Newsreel
Rumania	357	4	4	..	0	4
Switzerland	302	25	10	..	0	2
Finland	297	4	5	..	0	30 Educa'nal
Denmark	270	20	0	1	2	4
Holland	236	57	7	..	0	2
Greece	224	6	0	..	0	*
Norway	212	8	1	..	0	3
Bulgaria	136	0	1	..	0	0
Portugal	130	0	6	..	0	{ 3 Feature 235 Newsreel
Turkey	104	2	4	..	0	0
Latvia	69	2	0	..	0	2
Esthonia	60	1	2	..	0	4
Lithuania	45	1	1	..	0	0
Totals	27,313	1,722	433	..	116	1,299
Latin America	4,402	300	*	..	0	Negligible
Far East	4,000	400	Est. 40	..	0	5
United States	22,624	9,000	500	..	{ 800 1,000 150 *	856 Features 1,104 Shorts 174 Serials *Newsreels

* Figures not obtained.

read will have the books of knowledge opened to their ears. Today the motion picture industry stands at the threshold of new adventures. The psychological aspects of the upheaval that has just transformed this great industry have not yet been fully realized. We can expect greater realism, greater stability, greater accomplishments, and greater prosperity for the future.

THE MEASUREMENT OF DENSITY IN VARIABLE DENSITY SOUND FILM*

CLIFTON TUTTLE AND J. W. McFARLANE

The dependence of the optical density of developed photographic materials upon the method of its measurement was first demonstrated by Callier.[1] He discussed the effect of light scattering by the photographic image and presented data which seemed to justify the empirical relation:

$$D_{\parallel} = QD_{\#}$$

where $D_{\parallel}$ (specular density) is the value obtained with the developed image in a specular beam, $D_{\#}$ (diffuse density) the value obtained with diffuse illumination, and Q a constant factor greater than unity.

This form of relation holds with practical accuracy for many materials though it has since been shown by Bloch and Renwick[2] and by one of us[3] that an exponential relation fits the facts better over an extended density range for the data of Callier and for other data on a variety of materials. A theoretical relation involving optical constants of the grain clumps proposed by Silberstein and one of us,[4] finds excellent experimental justification, and if enough information regarding the optical characteristics of the developed image was available this relation could be applied to the solution of any practical problem.

DENSITY MEASUREMENTS IN RELATION TO SOUND PICTURES

In the theory of sound reproduction with the variable density method as outlined by MacKenzie,[5] Jones and Sandvik,[6] and others[7] the measurement of sound track density plays an important part, for it is from these measurements that the values of negative gamma, positive gamma, and the resultant or over-all gamma are determined.

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* Communication No. 435 from the Kodak Research Laboratories. (Read before the Society at Washington.)

The value of density which is effective in the reproduction of the sound track is neither "diffuse" nor "specular" in the sense that these two terms have been used in the literature. So far as we are aware, there are no published data correlating "sound-reproducer" density

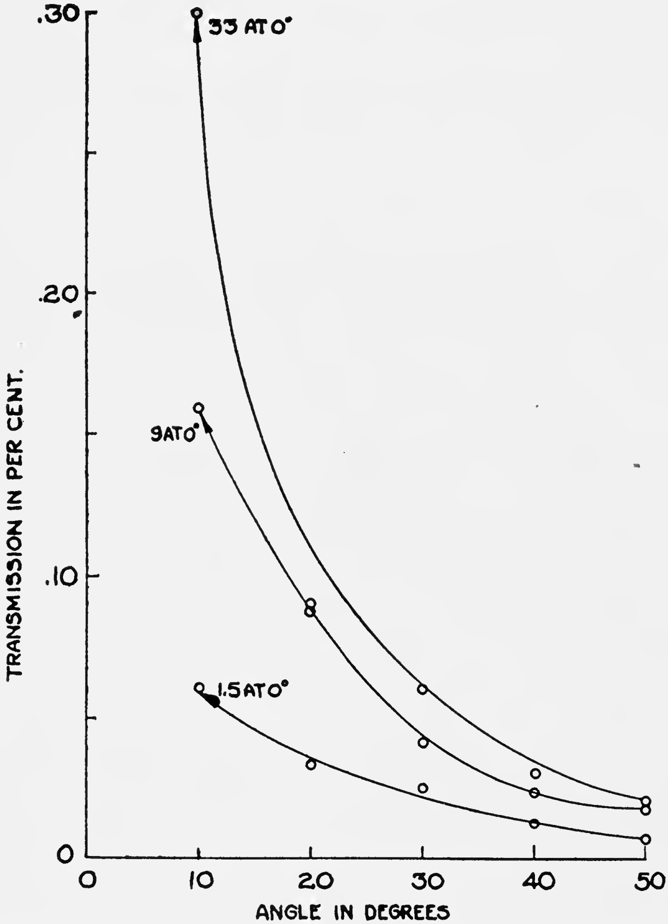

FIG. 1. Distribution of light scattered by positive film of different densities (expressed as per cent of normally incident light).

with either of the aforementioned values. It may be of interest, therefore, to consider briefly the matter of density measurement in its relation to sound picture projection.

ANGULAR DISTRIBUTION OF INTENSITY FROM POSITIVE FILM ILLUMINATED BY PARALLEL LIGHT

Because of the fact that the photographic image is a nonhomogeneous material formed by clumps of metallic silver grains embedded in a matrix of gelatin, the light which is transmitted by the image is scattered by reflection and diffraction. Fig. 1 shows distribution curves for images developed on motion picture positive film. To obtain these curves, the sample was illuminated by approximately parallel light and the intensity distribution was read with a photometer mounted on a spectrometer arm so that it could be rotated about an axis passing through the image. The normally transmitted intensity is so much greater than the intensity a few degrees

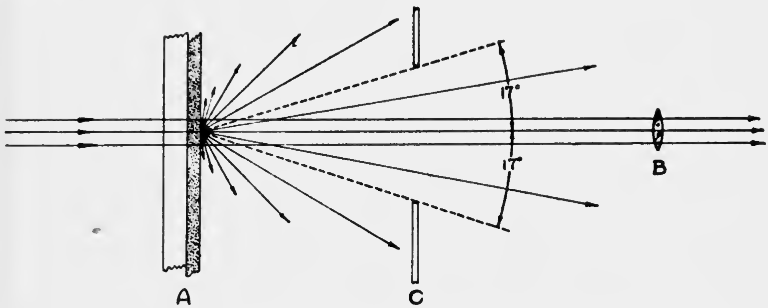

FIG. 2. Diagrammatic representation of light scattering by photographic density.

away from the normal that it is practical to show only a section of these curves in the graph.

At first glance, distribution curves, such as are illustrated in Fig. 1, may be misleading. The relative intensities even at angles close to the normal are so small compared to the intensity of the specularly transmitted beam that one might feel justified in neglecting their effect. These curves are only cross section views of the distribution, and to get an accurate conception of the total amount of light scattered away from the normal, the intensity values given by the ordinates in Fig. 1 must be multiplied by an area factor which varies with the sine of the angle from the normal.

The following relation may be used to determine the total transmission from the angular distribution curves:

$$T_{\text{TOTAL}} = 2\pi \sum_{0°}^{90°} T_{\Theta} \sin \Theta \; \Delta\Theta$$

in which T_θ is the average value of the ordinate over the increment, $\Delta\theta$. The same relation may, of course, be used to determine the effective value of transmission between limits fixed by the solid angle subtended at the measured sample by the window of the receiving element.

The significance of light scattering by the photographic deposit in the problem of density measurement may be made clear by reference to Fig. 2.

In this figure, parallel light, represented by arrows at the left, is incident upon the photographic density, A. The transmitted light is indicated vectorially by the arrows at the right of the figure. If a printing material is placed in contact with the illuminated sample, all of the transmitted light, regardless of direction,[8] is effective in exposing the positive material. A measurement of density, to be significant for contact printing, must therefore be based upon the total transmission, that is, it must include an angle of 90 degrees each way from the normal in Fig. 2. This value, which is spoken of as "diffuse density," is the value given by most of the commonly used densitometers.*

If the photographic deposit, A, is included in an optical system and is imaged by a lens (B, Fig. 2) which subtends a relatively small solid angle at A, most of the scattered light is lost and should not be included in a measurement of the transmission (or density) if a projection print is to be made of the image. Under these circumstances the specular value of density ($D\|$) is nearer to the correct value.

In sound reproduction, with the sample illuminated by light from an optical system and with the transmitted intensity collected by the window of a photo-cell (represented diagrammatically by C in Fig. 2) a value intermediate between the diffuse and specular densities is effective.

DENSITY MEASUREMENT UNDER PRACTICAL CONDITIONS

Several factors may influence the value of density as measured by the photo-cell in the reproduction system. The degree of collimation of the incident beam of light, the uniformity of the sensitive surface of the photo-cell, the quality of the incident radiation,

* The integrating densitometer,[3] in which the sample to be measured is placed over the window of an integrating sphere, and the most common type of densitometer, in which the sample is placed in contact with a diffusing opal glass, both give values of diffuse density in agreement with each other.

the spectral sensitivity of the photo-cell, and probably numerous other considerations may have some influence.

Under conditions which exist in practice, we believe these factors to be of small importance in comparison to the effect of altering the angle of the cone of transmitted light which is collected by the photo-cell. It is nevertheless desirable to state as specifically as possible the conditions under which we have made our measurements.

Fig. 3 illustrates the optical system which was used to illuminate the sample with a slit image. This system was built up from standard parts and it duplicates the system which is actually used in many theater installations. Most of the important dimensions are given in the figure. Both lenses, *B* and *D*, are of 10.5 mm. diameter and the solid angle subtended by the objective lens at the density, *E*, is 31 degrees.

A potassium photo-cell with a window 25 mm. in diameter was

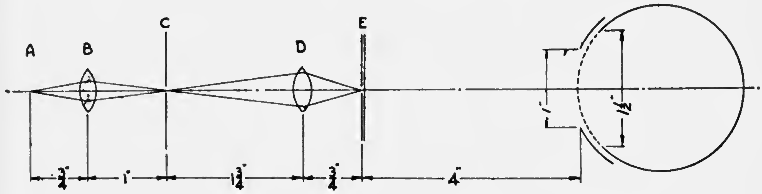

FIG. 3. Optical system used in density measurements.

placed at various distances from the measured sample, thus altering the solid angle of the cone of light which was collected. Photo-current was measured with a Leeds and Northrup H. S. galvanometer calibrated with the cell over the intensity range actually employed.

A series of densities developed on Eastman positive film in M.P. 16 to a diffuse gamma of 2.0 was measured.

A typical set of data is shown graphically in Fig. 4 in which the measured values of density are plotted against $\log_{10}$ of the half angle subtended by the window of the photo-cell at the sample. The lowest values of density, $D_{\#}$, were obtained with the Capstaff-Purdy densitometer and are shown plotted at the abscissa = $\log_{10}$ 90° = 1.95.

In most of the reproducers used in theaters, the angle subtended by the photo-cell window at the film is about 35° ($\log_{10}$ half angle = 1.54). The comparison between the value of diffuse density and the density actually measured by the photo-cell in the projector is given in Table I. For the lower densities the factorial difference between the two values is greater, which fact checks the previously reported data on positive film.[3] For practical purposes perhaps the Callier[1] type of relation:

$$D_R = 1.3D\#$$

in which D_R is the effective reproducer density, will hold with sufficient accuracy.

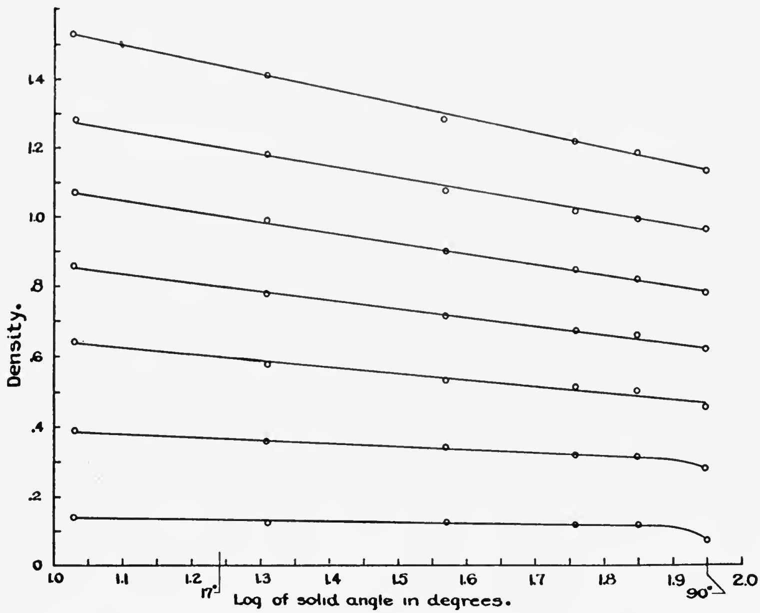

FIG. 4. Density of positive film image as measured by a photo-cell whose window subtends various solid angles at the measured sample. (Log_{10} of one-half of the solid angle is plotted.)

TABLE I

Relation between Diffuse Density and Reproducer Density for Positive Film

D_R	$D\#$	D_R/D
0.135	0.07	1.93
.37	.28	1.32
.60	.45	1.33
.80	.62	1.25
1.01	.78	1.29
1.20	.97	1.24
1.44	1.14	1.26

CONCLUSION

We shall not attempt to discuss the significance of these data in any detail, but wish only to point out one or two matters of interest.

A factorial difference in density determination results in a factorial difference in gamma. If the reproducer measures a gamma value 1.3 times higher than that determined by sensitometric methods employing diffuse densitometry, an audible harmonic may be introduced.

Some other factor, such as reciprocity failure which makes the sensitometrically determined gamma higher than the negative sound track gamma, may partially or completely compensate for the effect of higher sound projection gamma.

A second effect resulting from higher projection gamma is a change in the shape of the toe of the H & D characteristic. The toe of the characteristic curve which is effective in the semi-specular reproducer system will be shorter than that of the curve determined by the diffuse densitometer.

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SOUND-PROOFING AND ACOUSTIC TREATMENT OF RKO STAGES

A. S. RINGEL*

In the production of talking motion pictures, it is generally advisable to depart as little as possible from the technic that has proved so successful in making silent films. We are interested in obtaining moving "talkies" and not the "talkie stills," which were only too evident in some of the earlier efforts. This effect may be secured partly by the use of sound pick-up devices, which permit an actor to move about the set at will, and partly by having stages and sets of little or no reverberation.

J. P. Maxfield[1] has shown that reverberation is an important factor in helping to create the illusion of depth or perspective in sound. But it must be borne in mind that this, if desired, should be obtained by proper microphone placing and construction of the set itself. There should be none from the rest of the stage. When we consider the still relatively poor reproduction of sound in many theaters, principally as a result of reverberation, it seems that the finer artistic effects thus theoretically obtainable are completely overshadowed by the lack of intelligibility resulting from the addition of the reverberations in both recorded and reproduced sound.

A number of other factors must be considered in the construction of stages for filming talking motion pictures. These include size and number, sound-proofing, provisions for recording, monitoring equipment, ventilating and cooling systems, power outlets, and, of course, the relative costs of various materials to be employed.

Some of these problems have been considered by Humphrey[2] in a recent issue of the *Transactions* in which typical E.R.P.I. sound recording installations are described. At the RKO Studios, RCA Photophone recording equipment is employed, which, because of its simplicity and compactness, does not necessitate erection

* RCA Victor Co., Inc., Camden, N. J. (Read before the Society at Washington.)

of separate elaborate recording buildings. In fact, in most cases, the entire recording, mixing, and monitoring equipment is mounted upon a small cart, about three feet wide by five feet long, which is wheeled into a knock-down booth on the stage. This booth generally consists of double walls of Celotex or Insulite, is about 9 ft. square, and can be erected in five or ten minutes. The small crew of three required to man an RCA Photophone recording outfit is also relatively insignificant in comparison with the usual small army of stage hands, assistant directors, cameramen, actors, and what not.

The reproduction of the monitoring loud speaker in these small booths is given a sufficiently close approximation to the effect of theater reverberation by suitably attenuating high frequency response. Thus, the recordists will exercise greater care in placing microphones than when the monitoring speaker is too optimistic in output.

The problem on the RKO lot was first the conversion of some of the old "silent" stages, then the erection of newer ones in response to the requirements and demands of increased production. It was tacitly understood that the former were to be more or less experimental so far as size, sound-proofing, and acoustic treatment were concerned, and to be used as a guide in the design of later ones. Thus, some variations in soundproofing and acoustic treatment in initial construction were tolerated, and arrangements were made for shifting around part of the absorbing material to positions where it would be most effective.

NUMBER AND SIZE OF STAGES

The number of stages is, of course, determined by the production requirements. An average feature picture will take about three weeks in the filming and will use two stages almost continuously. While "shooting" is in progress on one, sets will be erected on the other. Thus, two will permit a production of some 12 or 15 pictures *per annum*, allowing reasonable intervals for retakes. The number of stages required for annual production program can thus be readily determined.

In the matter of size, the old silent stages on various lots range from about 70 by 100 ft. up to 150 by 300 ft. While the latter is unusually large, such dimensions are often required for long shots of elaborate sets. It is in this case that the silent pictures must make some concession to the sound technic Untreated, the reverberation times are likely to range from about 5 to 15 seconds. With a reasonable amount of acoustic treatment, the smaller, which have proved most popular, can be brought down to well within one second. The larger sizes cannot be considered economical, partly in view of the waste space, unused most of the time while a picture is being filmed, and partly because of the enormous quantity of absorbing material required to reduce the reverberation to a satisfactorily low level.

SOUND-PROOFING AND ACOUSTIC TREATMENT

Before proceeding further, it would not be amiss to distinguish between sound-proofing and acoustic treatment. By the former is meant those features of construction that would prevent the intrusion of sound originating from the outside. The latter is in the form of acoustic absorbing material which is distributed about the walls, ceiling, and floors so as to prevent reflection back and forth of sound which originates in the room itself. Of course, the absorbing material will in itself also tend to absorb sounds coming from the outside. In the matter of sound-proofing it is necessary only to reduce the intensity of intruding noises to a suitable level below that caused by "silenced" cameras, working in the open and protected by sound-proof hoods or housings.

OLD STAGES

The old stages were considered too large to be economical for sound picture production and it was decided to divide them into smaller sections. In advance of design and construction, consideration was given to likely interfering sounds from heavily traveled streets in the vicinity, from the carpenter shops just across the studio street, and from traffic on the studio street itself. In the presence of all these noises, it was decided to use double wall construction in this vicinity.

These stages had been built about 15 years ago and are typical. It will be sufficient to take one of those partitioned and describe its construction. (A number of other silent stages were treated in identical manner.) The over-all dimensions were about 80 by 175 by 40 ft. The clear height from floor to lowest member of the roof truss is 28 ft. The exterior wall consisted of the usual 1 in. cement plaster and metal lath over 1 in. wood sheathing, nailed across 2 by 6 in. wall studs, 16 in. on centers. The roof is sloping and consists of a composition roofing material over 1 in. wood sheathing over 2 by 6 in. joists, 20 in. on centers. The floor was of 1 in. planking on 2 by 6 in. joists, 16 in. on centers, on 6 by 8 in. beams set on joists, resting on concrete piers, 7 ft 11 in. on centers.

There were a number of doors and windows in the walls and nine dormer windows, about 4 ft. square, in the roof.

The outer walls were retained; all the openings in the sides were walled up with the exception of two doorways, 10 ft. 4 in. wide by

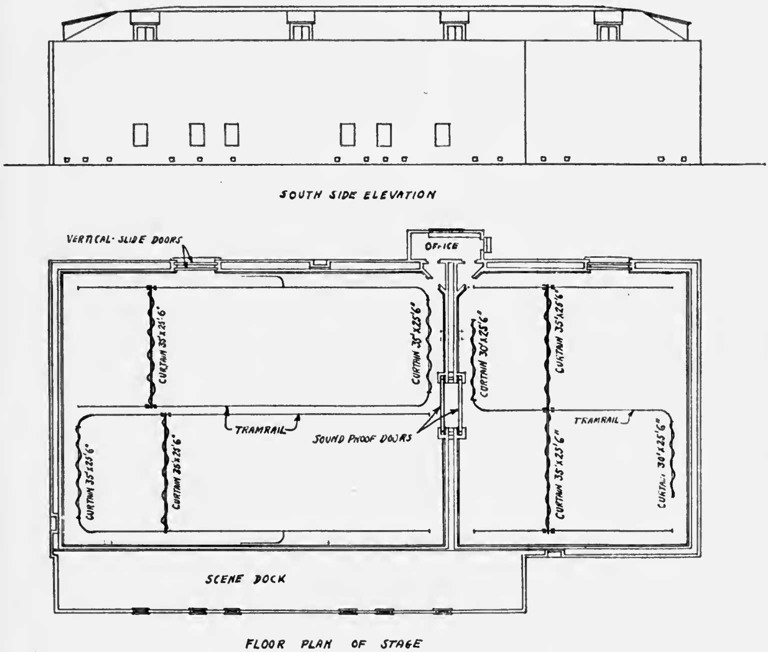

FIG. 1. Floor plan of stage—scale $^1/_{16}$ in. = 1 ft.

13 ft. 8 in. high, one for each of the partitioned stages. A scene dock on one side was not disturbed. A floor plan and elevation of the altered stage is shown in Fig. 1. One section is 75 by 107 ft. and the other 60 by 75 ft. on the interior. The inside walls are separated by an air space of 21 in. from the outer walls, to permit entrance of workmen, on all sides except where the scene dock is located, where the separation is some 16 ft.

Wall Treatment.—For sound-proofing, the inside face of the original exterior walls, including old door and window openings, was covered with a 15 lb. waterproof felt and $^1/_2$ in. Gyplap applied in 4 by 8 ft. sheets, nailed 6 in. on center at every stud. The vertical joints occurred only at the studding; both vertical and horizontal joints were filled in with a standard joint filler, and covered with a heavy sticker tape.

The existing flooring, joists, and girders, where adjoining the exterior walls, were cut free and supported on new underpinning. The inner walls were supported by 6 by 8 in. girders resting on new concrete piers, 7 ft. 11 in. on centers, and are entirely independent of the outer walls. The inner wall is of 2 by 4 by 16 in. on center studding, with the exterior covered as above with $^1/_2$ in. Gyplap, utilizing 4 ft. by 12 in. sheets laid vertically. The space between studs was filled in with mineral wool, consistently tamped and held in place by a covering of No. 40 cheesecloth, with $1^1/_2$ in. mesh No. 20 galvanized chicken wire over all. For a height of 12 ft. above the floor, additional protection to the wall was applied in the form of $^1/_2$ in. mesh galvanized iron wire screen. A 2 by 6 in. base strip, along the floor, and continuous 2 by 6 in. strips at heights 4, 8, and 12 ft. above the floor served as additional protection.

Mineral wool was selected as the absorbing material because of its relatively low cost, freedom from vermin, and fire resisting qualities, as well as the uniformly high coefficient of absorption over the frequency range.

The partitioning walls between the two sections of the stage were treated in a similar manner. A door opening, 12 ft. by 14 ft. 8 in., was left between stages, to facilitate transfer of equipment and sets and to enable the cameramen to obtain necessary long shots when desired.

Roof and Ceiling.—The roof trusses were rigidly connected to the outer walls and presented quite a problem. Both the roof structure and inner walls were considered too weak to support the load of an additional floating ceiling. Therefore, external sounds setting these in vibration are likely to be transmitted to the interior. It was also considered impossible to strengthen these members, unless at an expenditure of time and money equivalent to the cost of a new stage.

Since the idea of a floating ceiling was dispensed with, the following means were taken to make the roof structure more sound-proof and sound absorbent simultaneously. On all ceiling surfaces, $^1/_2$ in. Gyplap was nailed in 4 by 8 ft. sheets; the seams were not filled or taped. The sloping rafters, on two sides, were furred by 2 by 2 in. strips spaced 24 in. on centers, and then covered with Gyplap. Over the Gyplap were nailed furring strips $^3/_4$ by 2 in. set 16 in. on centers, and then a $^7/_{16}$ in. thick layer of Celotex in 4 by 8 ft. sheets. A similar furring of $^3/_4$ by 2 in. strips 16 in. on centers is laid over the Celotex and followed by a $1^1/_2$ in. thick rock wool quilting, encased

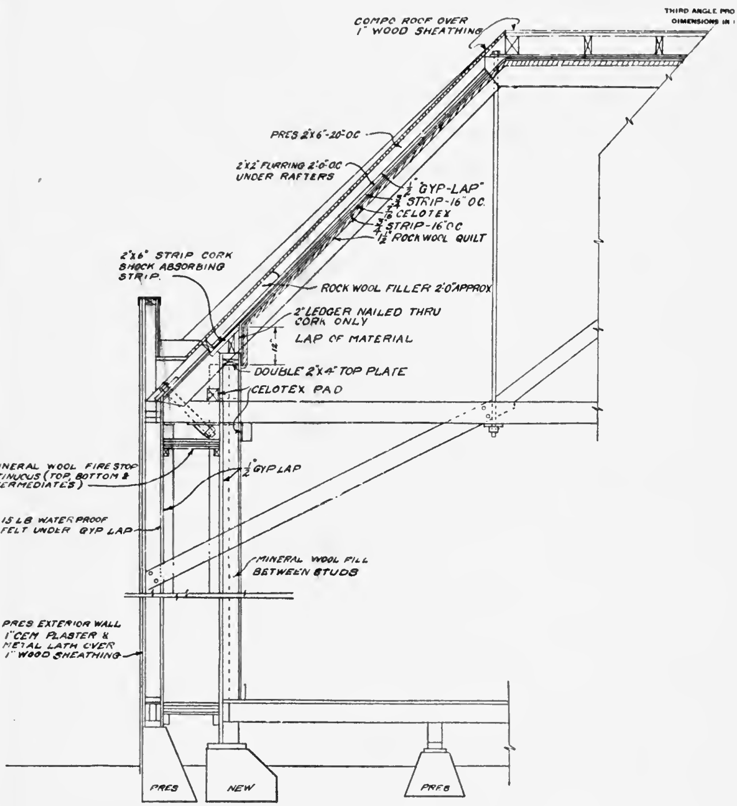

FIG. 2. Structural details of typical exterior wall and ceiling of sound proof construction.

in $1^1/_2$ in., No. 20 galvanized iron wire mesh, with No. 40 mesh muslin on one side under the mesh wire. This quilting is nailed over the furring strips, and No. 40 muslin is tightly stretched over it and nailed down with wood strips over the furring strips, so as to form panels 4 by 8 ft. over the entire ceiling.

The laminated structure, with air spaces, aids in the sound-proofing; the layers of Celotex and rock wool provide the acoustic damping. Additional support is provided for the weighted roof by resting it on the inner walls through a strip of cork 2 by 6 in., which acts as a shock absorber. These details, as well as those of the wall and roof construction, are shown in Fig. 2. Additional muslin is used over the rock wool quilt on the ceiling to prevent possible sifting down of fine particles of the absorbing material.

Floors.—It had at first been intended to strengthen the floor joists and nail another flooring over the old one, in order to prevent creaking and drumminess, as well as improve the sound-proofing. In the rush to get into production, however, sets were erected on the old floor. These, except in only a few cases, were quite free from such undesirable effects. It has been necessary at rare intervals to caution performers against stamping too hard, or to admonish stagehands off the scene. At times in dancing and cabaret scenes, a layer or two of 1 in. thick Celotex or Insulite underneath the floor of the set would be ample insurance against such unwelcome sounds. While the retention of this flooring is not altogether to be approved of, it has given surprisingly little trouble, in spite of its rather poor condition after the years of battering it had received.

There is no connection between the floor of one section and the other, nor is there any connection between it and the outer walls. Thus, hammering and other noises incidental to erection of sets are not transmitted or telegraphed from one stage to another.

Doors and Windows.—Even the most elaborate multi-wall structure will prove of no use if there are just a few cracks around doors and windows. A surprising amount of sound manages to leak through even a small opening and special care was taken to insure tight fitting joints, with sufficient overlap on doors and windows. Fig. 3 shows the details of construction of doors that communicate between the two sections of the stage and to the outside; also the side hinged doors covering the dormer windows.

The opening between stages is 12 ft. by 14 ft. 8 in. It is closed off by two vertically sliding doors of the laminated construction shown in Fig. 3. These are raised and lowered by hand, with the aid of counterweights. Each door consists of layers of No. 26 galvanized iron, $^7/_{16}$ in. Celotex, $2^1/_4$ in. air space, $^1/_2$ in. Gyplap, $^7/_{16}$ in. Celotex, $^3/_4$ in. air space, and $^7/_{16}$ in. Celotex facing the inside. Grooves at the bottom of each door contain 1 in. rubber tubing, and the door sill and jamb are grooved to hold rubber stops. When the doors are lowered, pressure is applied so as to force the door against the rubber, effectively closing off leaks.

Openings to the exterior are 10 ft. 4 in. by 13 ft. 9 in. and are also closed by two vertically sliding doors of the construction shown in Fig. 3. Levers are also employed to press the door against the rubber stops on the jamb.

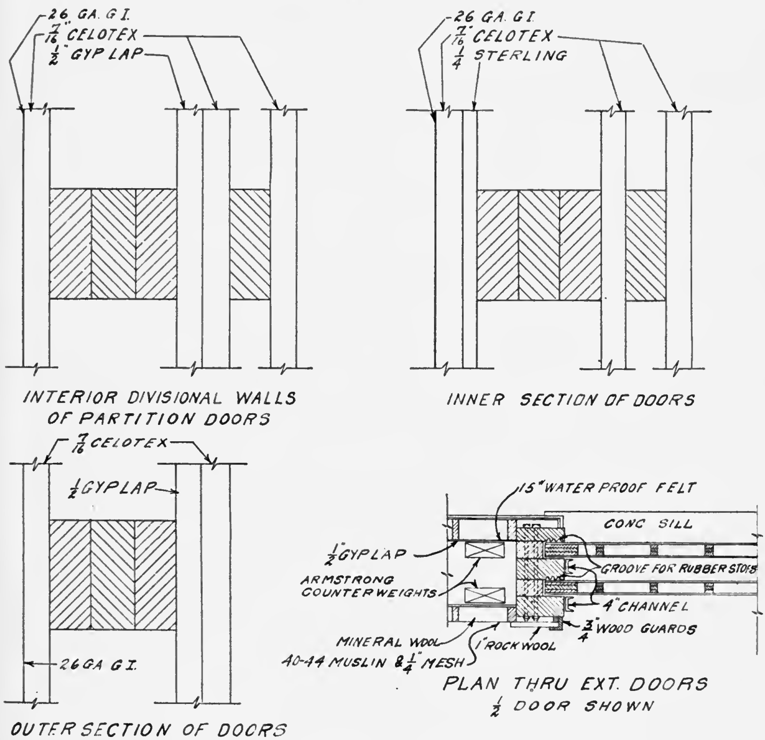

FIG. 3. Details of door and wall construction.

The dormer windows are covered by side hinged doors also shown in Fig. 3. There is ample overlap and little likelihood of sound leaking past them. During a "take" these are generally closed by means of a system of ropes and pulleys operated from the door, and all the other doors, communicating to the other section of the stage and to the exterior, are also shut.

Ventilation and Cooling.—No provisions were made for ventilation and cooling the old stages other than natural draft through the roof vents, which were well baffled. Usually, between "takes," doors and dormer windows are opened wide. This arrangement is satisfactory when working with moderate sized casts, but with large companies, especially when using the additional lighting required for color photography, the air conditions soon become uncomfortable. In the newer stages, a forced draft is resorted to. On rather noisy sets it is not unusual to proceed with doors and windows wide open.

Miscellaneous.—Inasmuch as the same roof and roof trusses were used to cover both sections of the stage, the sound-proofing of compressed air, gas, water, and electrical connections was considered relatively unimportant; particularly when we compare the relative areas that are capable of transferring the sound from one stage to another, or from the exterior to the inside. Such connections were made in the usual way by the contractors, and have not proved to be a source of trouble at all.

Additional Acoustic Treatment.—It is standard practice to erect a number of sets on a single stage, so that the director may shift from one scene to another with a minimum of delay. This procedure, unfortunately, conceals a not inconsiderable portion of the acoustic absorbing material on the walls and results in an increase in the reverberation time. Exposed reflecting surfaces are bound to cause noticeable echoes, too.

A number of vertically hanging curtains are provided for each of the partitioned sections and may be moved to any desired part of the stage by means of a system of tramrails and cranes, illustrated in Fig. 1. In the larger of the two divisional stages, four curtains of $^3/_4$ in. ozite are provided, each 35 ft. wide by 25 ft. high. These are covered on both sides with burlap, which is securely sewed to the vertical sides, top, and bottom, and a $^1/_2$ in. rope at the top is used to suspend the curtain from the tramrail crane. Those on the smaller stage are somewhat narrower. As seen from Fig. 1, they may be easily moved to various parts of the stage, where their absorption will be most effective.

The construction described has proved to be satisfactory in keeping out undesired external noises. Loud sounds from the backfiring of a heavy motor truck just outside the door have not disturbed recording at all. An exceptionally heavy rainfall did cause some trouble, but was not sufficiently serious to halt recording.

REVERBERATION TIME AND SOUND-PROOF CHARACTERISTICS

The calculated reverberation times of the partitioned stages with the stage empty and the sliding curtains close to the walls are shown in Figs. 4 and 5. The smaller ranges from about 0.5 to 1.0 second, and the larger is about 1.0 second. These were calculated on the basis of the old reverberation time formula of Sabine,[3]

$$T = \frac{0\ 05\ V}{Sa_a}$$

Upon completion, the stages quite apparently had a lower time than computed by the old formula.

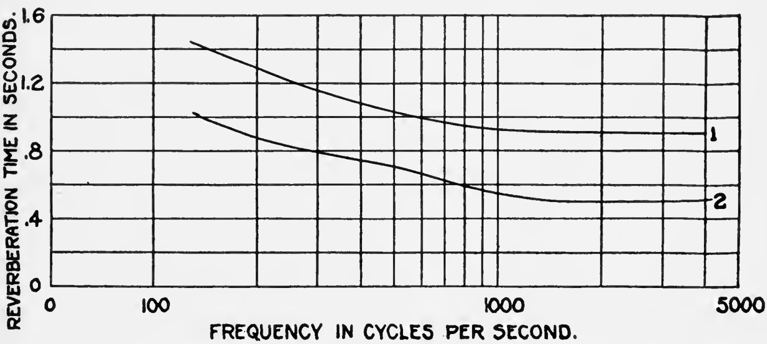

FIG. 4. Reverberation time of altered stage, 80′ × 110′ floor space. Rock wool fill between 2″ × 4″ studs, 16″ on centers. Curve 1: using Sabine formula, $T = 0.05V/Sa_a$. Curve 2: using Eyring formula, $T = 0.05V/ -S \log_e (1 - a_a)$.

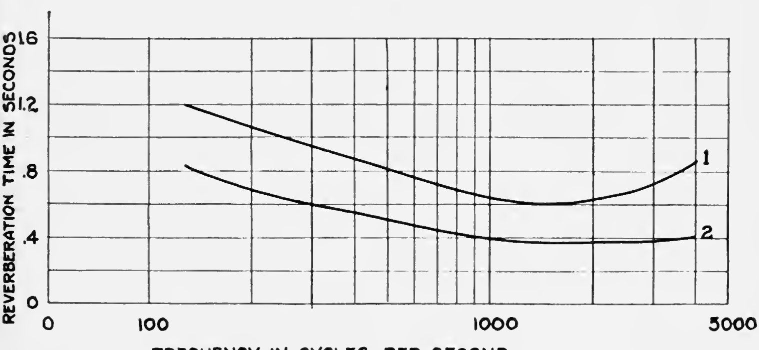

FIG. 5. Reverberation time of altered stage, 60′ × 80′ floor space. Rock wool fill between 2″ × 3″ studs, 16″ on centers. Curve 1: using Sabine formula, $T = 0.05V/Sa_a$. Curve 2: using Eyring formula, $T = 0.05V/ -S \log_e (1 - a_a)$.

A recent publication by C. F. Eyring[4] shows that the above equation is a special case of the more general equation

$$T = \frac{0.05\ V}{-\ S\ log_e\ (1 - a_a)}$$

and applies only to relatively "live" rooms, the latter applying to both "dead" and "live" spaces. Recalculated on the basis of the new formula, the reverberation times are considerably less than a second for most frequencies.

At any rate, we have had no trouble from insufficient acoustic damping on these stages. Any deficiencies in the sound pick-up in the past have been due to the directors being unacquainted with the limitations of the ordinary condenser microphone pick-up. Just as we cannot expect to photograph the features of an actor by focusing a camera on the back of his neck, so also we cannot expect to obtain the fine details of speech due to the high frequency components by locating a microphone behind him (unless, of course, suitable reflecting surfaces are provided). With experience, the studio staffs have learned of these difficulties and no longer expect results from impossible pick-up locations.

NEW STAGES

A new stage was erected on a relatively quiet location at one end of the studio street, and is 70 by 100 ft. in dimensions. This contained provisions for a combination viewing and scoring room, rehearsal space, offices, library, and the like, as well as the stage proper. This had at first been intended for production of silent pictures, but was later converted for talking pictures.

The external wall and roof is of the usual 1 in. Gunnite on 15 lb. waterproof felt, on 1 in. plank, on 2 by 4 in. studs, 16 in. on centers, supported on a concrete base running entirely around the stage. There is an air space separating the adjacent walls of the stage from the scoring room. Each of these walls is of 2 by 4 in. studding with $^1/_2$ in. Gyplap on the outside. The floor on the stage consists of 1 by 4 in. tongue and groove flooring, on 2 by 8 in. joists, 16 in. on centers. The joists are supported by 6 by 8 in. girders which rest on Celotex pads set on 6 by 6 in. posts set on 24 by 24 by 10 in. concrete bases in the ground, 8 ft. on centers. A single vertical sliding door of laminated construction and with rubber stops was provided.

Because of its quiet location, it was believed that this construction would be satisfactorily sound-proof to external noises and this has proved to be true.

For acoustic treatment, the stage was first lined with a layer of $^7/_8$ in. thick Celotex over the wall studs and ceiling joists. This gave fairly high reverberation times—of the order of 2 to 3 seconds. The time was excessive, unless modified by the introduction of additional hangings. As a result, tests made on a preliminary set were altogether unsatisfactory, and the Celotex was replaced with a filling of rock wool between the studs. The latter treatment produced reverberation times considerably less than a second over most of the frequency range and the stage has given no more trouble from this source. (See Fig. 6.)

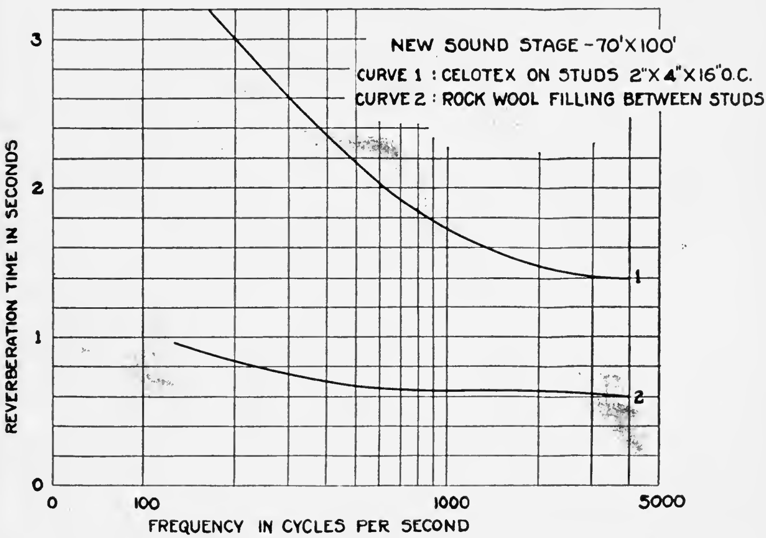

FIG. 6. Reverberation time of new sound stage—70′ x 100′.

Baffled vents at the roof and an exhaust fan system are provided for ventilation.

The experiences with the first stages were made use of in the latest to be erected. This consists of a building 150 ft. wide by 447 ft. long and is divided into four stages, each 108 by 145 ft. Exterior views are shown in Fig. 7. Three of these units have a clear ceiling height of 35 ft. from the floor line to the underside of the trusses.

and the fourth has a clearance of 45 ft. Runways and ventilating ducts are located in the trusses above this height.

The structural framework contains steel columns and trusses. The exterior walls and roof are of the typical 1 in. cement on 1 in. wood sheathing on 2 by 6 in. studs described previously, with $^1/_2$ in. Gyplap covering the inside of the studding. As before, the inner walls and floors are separated from outer walls and from those of the other divisional stages. The inner walls are of practically the same construction, except that 2 by 6 in. instead of 2 by 4 in. studs are employed and filled in with rock wool. This increase in absorption is required because of the greater size of the stages. The divisional walls between stages are practically the same as the inner walls. The floor is raised above the ground to allow for ventilation

FIG. 7. Exterior views of new RKO stages.

below, as in the older stages; and the finished floor is floated on a double thickness of Flaxlinum to deaden it. The acoustic treatment on ceilings, as before, consists of layers of Gyplap, air space, Insulite, air space, and 1 in. exposed mineral wool blanket. Bottoms of runways are covered with a 1 in. mineral wool blanket to avoid reflection.

Double doors between stages open horizontally and open very wide as may be seen from the photographs of the interior, Fig. 8. Thus, all the stages may be combined into a single huge room, if so desired. Double doors to the outside are located on both sides and are operated vertically by hydraulic lifts.

The stages are ventilated by an exhaust fan system, which changes the air completely every seven and a half minutes. Fresh air is

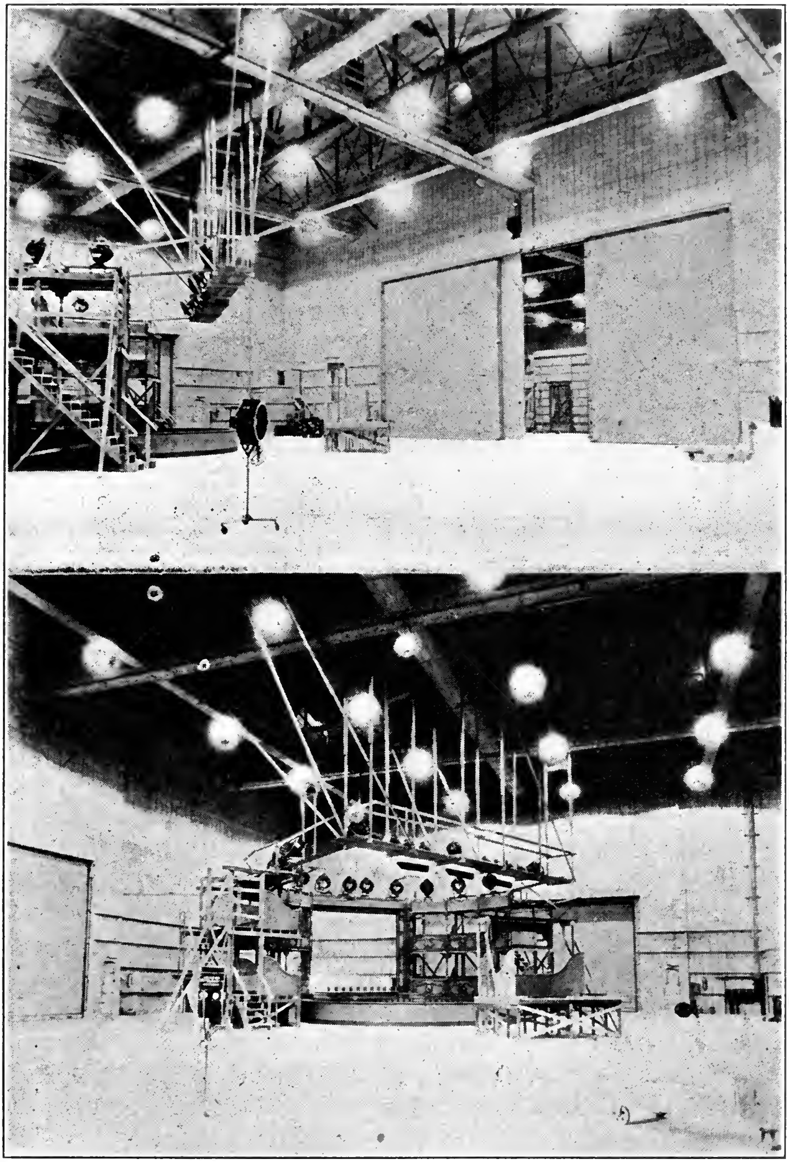

FIG. 8. Interior views of new RKO stages.

brought in under the floor through well baffled and sound-proofed ducts of Insulite, lined with a mineral wool blanket to reduce conduction of external noises. The heated, vitiated air is drawn out through similar ducts in the rafters. This construction enables the running of fans during "shooting" without any disturbance from the motors. An individual fan operates in a suction chamber for each stage. The reverberation times, as calculated from Eyring's revised formula, shown in Fig. 9, vary from 0.5 to 0.8 second.

VIEWING AND PROJECTION ROOMS

The old viewing and projection rooms were revised so as to be suitable for listening to talking pictures. A double floor, wall, and ceiling construction insulates the projection room from the viewing

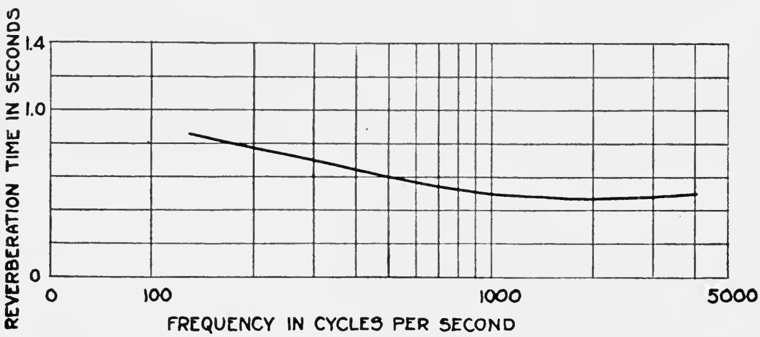

FIG. 9. New sound stage—108′ × 145′. Rock wool fill between 2″ × 6″ studs, 16″ on centers.

room. The walls of the projection room are of 2 by 4 in. studding, 16 in. on centers, with $^1/_2$ in. Gyplap on the outside and $^1/_2$ in. asbestos board on the inside. The adjacent wall of the viewing room is similar, except that $^7/_{16}$ in. Celotex covers the studding on the interior.

One of these rooms is 51 by 16 by 9 ft. high, the ceiling being somewhat arched. For acoustic treatment, the end walls were covered with a 1 in. blanket of mineral wool; the floor carpeted, upholstered seats installed, and hangings of Flaggtex placed on rear walls and side walls from the rear extending forward 20 ft. The treatment tends to prevent undesirable reflections along the length and the audience is located in a relatively dead region, acoustically, the advantages of which have been explained by Watson.[5] It was found that this treatment was not sufficiently satisfactory, and peculiar flutter echoes were obtained when clapping hands. Additional hangings on the arched ceiling eliminated these effects. The reverberation times of this room are shown in Fig. 10.

Two smaller rooms were also used. Originally, these had a flimsy partition between them that could permit cross-talk of sound. A new wall was installed between them, consisting of 2 by 4 by 16 in. on center studding, covered on both sides with $^1/_2$ in. Gyplap. A common projection room is used for both these viewing rooms and is insulated from them as described before. For acoustic treatment in these rooms, which are 7 by 20 by 8 ft. high, $^7/_{16}$ in.

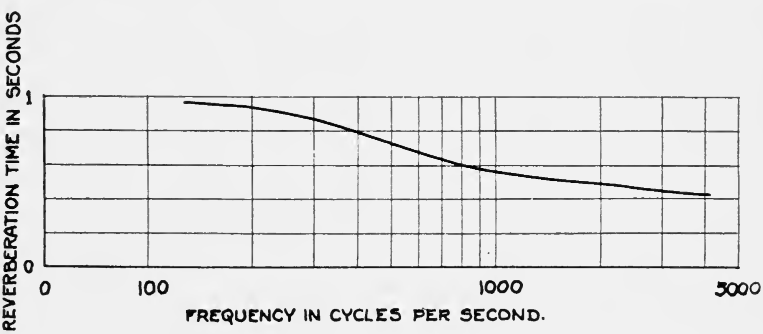

FIG. 10. Reverberation time of viewing room—51′ × 16′ × 9′.

Celotex on walls and ceiling over 1 in. furring was used. The reverberation times were well under 0.5 second.

SUMMARY

For sound-proofing motion picture stages, light double wall constructions are required in noisy city locations; on quiet spots, a single wall is satisfactory. Reverberation times of the order of 0.5 to 1.0 second are obtained by filling in wall studs with mineral wool and using layers of Celotex or Insulite with Balsam or mineral wool on the ceiling. Artificial ventilation is provided by use of a separate exhaust fan and well baffled ducts for each stage.

In conclusion, I wish to express my appreciation to Messrs. Dreher and Decker, who so kindly made available some of the constructional details of the newest stages, and Mr. Carrol Clarke, formerly of the RKO Art Department, for his coöperation on the alteration of the older stages.

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[3] SABINE, W. C.: "Collected Papers on Acoustics," *Harvard University Press.*

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[5] WATSON, F. R.: "Acoustics of Buildings," *John Wiley & Sons*, New York.

DISCUSSION

MR. MAXFIELD: I had the pleasure in Hollywood of visiting the stages described, and they are very excellent sound stages. As to his reference to my publication a few months ago, the stage should be as dead as possible and the reverberation should be built into the studio set. The fact that recorded reverberation adds itself to the reverberation in the auditorium delayed us several months. We found that certain of the producers complained and wanted to know why they couldn't understand so well when a length of film taken in a dead room was connected with another which had been exposed in a room in which the walls were treated. It is easy to have both dead and live records by changing the microphone position. If you record only the direct sound, you can get a sound track without reverberation, but with the microphone farther away you get a record with considerable reverberation. In answer to repeated questions from the producers as to why with reverberation the reproduction was harder to understand when it was pieced with a long shot, we believe another factor entered into it—the coördination between the ear and the eye. When the speaker is present, you listen naturally, and otherwise there is a lack of attention.

MR. RINGEL: I quite agree with Dr. Maxfield in that there should be no reverberation on the stages themselves. We should like to cut it down to zero. If, for artistic reasons, any is required, it should be obtained from the construction of the set itself and by proper microphone placing. But when we consider the still relatively poor reproduction of speech in most theaters, principally the result of reverberation, it seems undesirable to reduce the intelligibility still further by introducing reverberation in the recorded sound. The reproduction is much closer to the original when the microphone is located close to the speaker, where the direct sound is practically predominant.

At the present state of development of the art, I believe that this is a psychological problem rather than a scientific one. I concede that with perfect recording and reproducing equipment covering the entire spectrum of sound, and with no reverberation at the listener's ears, and with a pick-up of sound on the set equal to binaural listening, the effects obtained by the introduction of reverberation in recording will aid considerably in enhancing the illusion. Mr. Crabtree's statement referring to loud speakers, "They have a long way to go before perfection," applies also to all the other elements in recording and reproducing the sound. The artistic effects theoretically attainable on such a perfect system result in rather poor reproduction of sound with present-day recording and reproducing apparatus. This has been demonstrated by the relatively poor naturalness and intelligibility in the long shots of the film presented by Dr. Fletcher of the Bell Laboratories. Even in the close-ups, with the microphone near-by, Dr. Fletcher's "canned" voice was still far from resembling his true voice.

MR. WEINBERGER: I think RKO and RCA Photophone undertook a courageous experiment in the design of these stages. When we first worked in Hollywood there were only expensive concrete sound stages in use in other studios and RKO decided to try inexpensive light walled stages. They were perfectly satisfactory, and the industry owes them, I think, its gratitude for what they have done. I hope in the future that this design will be taken advantage of by the industry.

MR. EVANS: I do not know when the work you refer to was done. Warner's original sound stage used the light and inexpensive type of construction. I question, therefore, whether RKO was the first to use the lighter type of construction.

A MODIFIED FILM WAXING MACHINE*

J. I. CRABTREE AND C. E. IVES

In a previous communication[1] J. G. Jones described a machine for applying a thin line of paraffin wax along the edges of motion picture positive film to serve as a lubricant and facilitate the passage of newly processed or "green" film through the projector. The wax was applied by means of two thin steel disks which dipped partly in a pan of melted wax fitted with an electric heater, while the film was led over these disks emulsion side down.

When used for waxing sound film it was found that unless the temperature of the melted wax was maintained constant, on cooling too much wax was applied and this tended to offset on the sound track, thus causing extraneous noises.

In a subsequent communication[2] a more suitable method of applying the wax was described. This consisted in applying a cold solution of paraffin wax in carbon tetrachloride by means of an apparatus similar to the above. After application of the solution the solvent was evaporated by passing through a long tube through which a current of warm air was blown. By this method the quantity of wax applied is independent of the temperature and depends on the concentration of the solution and the peripheral speed of the application disks in relation to the rate of travel of the film. It is thus possible to consistently apply a thin wax coating of the necessary width which ensures that the sound track is not marred by extraneous lubricant.

Experiments were then made to adapt the Jones waxing machine for the use of the wax solution. The machine was so modified that after applying the wax solution the film traveled through a distance of about 12 feet before reaching the take-up, but with a 1 per cent solution of wax the solvent did not evaporate sufficiently to prevent spreading of the wax solution in the wound up roll. By impinging

* Communication No. 441 from the Kodak Research Laboratories. (Read before the Society at Washington.)

a current of hot air against the film it was possible to evaporate a sufficient quantity of the solvent, but it was desired to eliminate this auxiliary drying apparatus if possible.

Further tests indicated that by using a more concentrated wax solution (5 to 10 per cent) and by rotating the disks more slowly the auxiliary drying apparatus was not necessary. With a 10 per cent wax solution and a rate of travel of the film equal to 180 feet per minute, satisfactory applications were obtained with the peripheral speed of the disks equal to one-fifteenth that of the travel of the film.

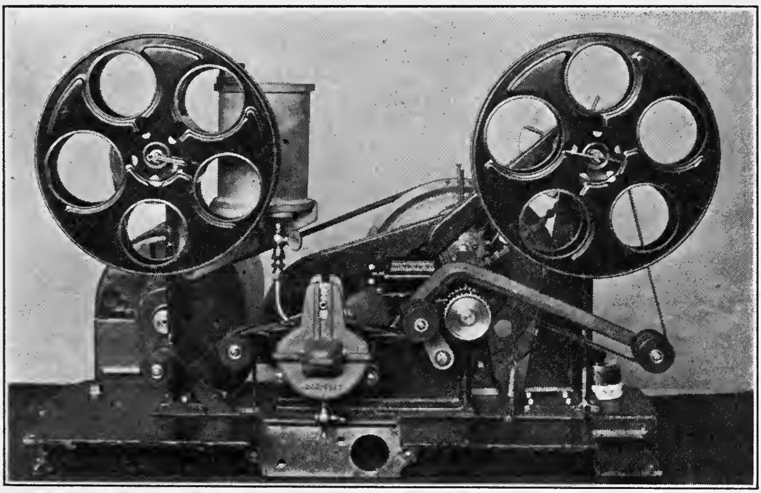

Fig. 1. Modified Jones wax applicator.

With this procedure the resulting wax coating was somewhat soft when wound in the roll owing to incomplete evaporation of the solvent, which caused a slight offsetting of the wax on the base side of the film. This is desirable, however, because both sides of the film require lubrication in the projector.

Conical cinching of the film would tend to make the wax coating wander onto the sound track, but in such an event the coating of wax is so thin that the extraneous noises thereby produced would be of negligible magnitude. Exhaustive ground noise tests with film waxed in the manner indicated have shown that in practice the waxing procedure does not introduce extraneous noise.

The Jones machine modified for the application of a wax solution instead of melted wax is shown in Fig. 1. The new parts required are (*a*) a feed sprocket, (*b*) new application disks (0.15 in. thick), (*c*) new wax pot, (*d*) tank for holding wax solution fitted with feed pipe, and (*e*) one reducing and reversing gear for driving the application disks. The old hood and electric heater are discarded and the machine rewired.

A close-up view of the application disks and wax pot is shown in Fig. 2. The pressure roller, *R*, serves to maintain good contact

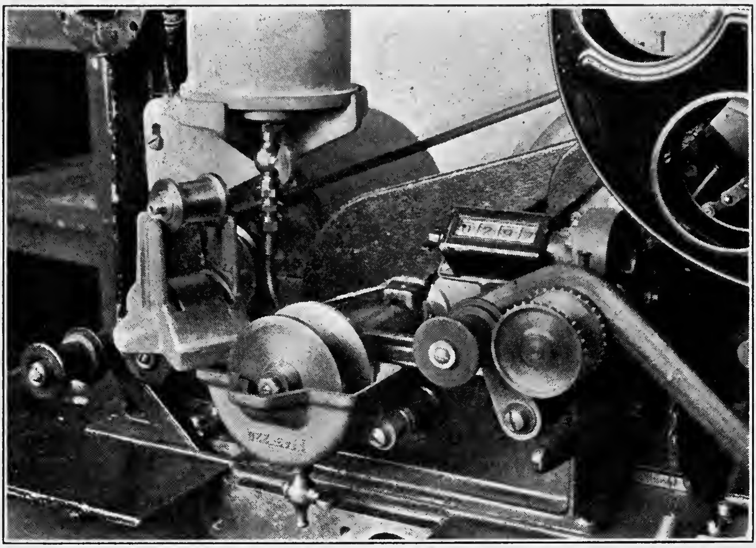

FIG. 2. Close-up view of application disks and wax pot.

between the blades and the film, while the window in the side of the tank affords a check on the volume of the liquid.

Under operating conditions the wax tank is fitted with a cover but even under these conditions considerable evaporation of the solvent takes place and it is necessary to keep a dilute replenishing solution in the reservoir which has a concentration equal to half that in the tank proper. For example, when using a 10 per cent solution of wax in the applicator tank, the reservoir tank should contain a 5 per cent solution.

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[2] CRABTREE, J. I., SANDVIK, O., AND IVES, C. E.: "The Surface Treatment of Sound Film," *J. Soc. Mot. Pict. Eng.*, **14** (March, 1930), p. 275.

DISCUSSION

MR. HUBBARD: It seems to me that the solution used to give the proper lubrication with the Dworsky machine might give the same lubrication as this modified Jones machine. The only objection to the wax solution all over the film is that it is subject to finger prints and marks in handling, and this would not apply so much to this type of machine. I should like to ask whether the parts for this can be obtained to apply to the present Jones waxing machine.

MR. IVES: Yes, the parts can be obtained, and it is only necessary to drill a few holes in the casting for the supply tank. It is better to use hard wax for application over the entire surface so that dirt doesn't become imbedded and increase ground noise, but any wax for surface coating is not satisfactory from the viewpoint of lubrication. Nothing is better than paraffin for lubricating.

MR. W. B. COOK: Do you use carbon tetrachloride, and if so, do you have difficulty with a solution of 5 or 10 per cent? Doesn't it tend to separate?

MR. IVES: If you chill a 10 per cent solution to 30°F. or 40°F. some of the wax will come out of solution.

MR. COOK: We found it did and we abandoned the wax and used oil. It served the purpose equally well or better.

MR. IVES: It is more likely to smear and after oil has been smeared on the sound track it accumulates dirt rapidly. Precipitation of the wax may have been due to moisture.

PRESIDENT CRABTREE: Drying the carbon tetrachloride with calcium chloride will eliminate the water.

THE PROCESSING OF VARIABLE DENSITY SOUND RECORDS

R. F. NICHOLSON*

Before consistent faithful reproduction can be accomplished with the variable density system of recording, it is necessary to determine the proper exposure range and development of both the negative and the print. Predetermined characteristics have proved a help in determining these factors.

A half dozen sensitometric strips were made, respectively, on various negative and positive emulsions. They were developed in the particular developer being investigated. The developments were so timed that the entire contrast range of the developer was completely covered. The density readings were made on a Martens densitometer using diffused light. The portions of the Hurter and Driffield characteristics, falling within the exposure range of the particular recording system, were replotted on linear coördinates with the diffuse transmissions as ordinates and the exposure as abscissas. In a system such as the Western Electric uses, the exposure range can be made to cover the entire characteristic. In most of the flashing lamp systems, however, there is a limit to the available light range.

Fig. 1 shows a characteristic of Eastman Panchromatic negative, Type II developed in M. Q. borax to a gamma of 0.78. The positive characteristic in quadrant III is of Eastman Cine positive developed in M.P. 16 to a gamma of 2.15. The respective contrasts of negative and print roughly approximate standard commercial developing. Within certain limits, the exposure of a point on the print in a contact printer is proportional to the diffuse transmission of the corresponding point on the negative. Therefore the ordinates of the negative characteristic and the abscissas of the print characteristic are linearly related and it is possible to graphically predetermine the over-all characteristic of print transmission *versus* negative

* 106 W. 56th St., New York, N. Y. (Read before the Society at Washington.)

exposure for any printer exposure, without actually making a print. The abscissa of a point on the over-all characteristic is equal to the abscissa of the corresponding point on the negative characteristic. The ordinate of this point is determined by projecting from quadrant I to IV, through quadrants II and III. The slopes of the straight lines in quadrant II vary inversely with the exposure of the printer light. By this method the over-all characteristic for any printer setting can be predetermined for all possible combinations of negative and positive characteristics. If 3.75 is the unmodulated negative

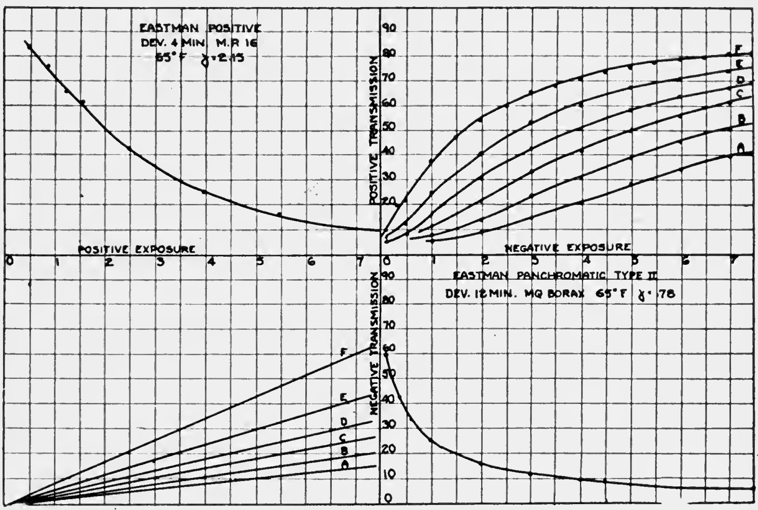

FIG. 1. Tone reproduction diagram for Type 2 Panchromatic negative developed to a gamma of 0.78.

exposure, the over-all characteristics obtained in Fig. 1 by varying the printer exposure, vary in unmodulated print transmission from 20 to 70 per cent. If we consider for the moment, that the negative exposure is directly proportional to the signal to be recorded and the print transmission is directly proportional to the reproduced signal, the proper processing for true reproduction can be determined from these characteristics. If extreme care were taken in their plotting they could be analyzed and the respective levels of the various harmonics determined. However with the following considerations sufficient information can be obtained by mere inspection. The closer the characteristic approaches a straight line, or a linear relation between negative exposure and print transmission, the less will be the film distortion. If the sound lamp intensity remains constant the volume of the reproduced signal is proportional to the range of modulation of print transmission, thus it will increase with the slope of the characteristic. The ground noise, due to accumulated particles of dirt on the positive, will increase with an increase in the unmodulated print transmission. However this is no inducement for lowering the print transmission as practically the same result could be accomplished by reducing the intensity of the sound lamp. The

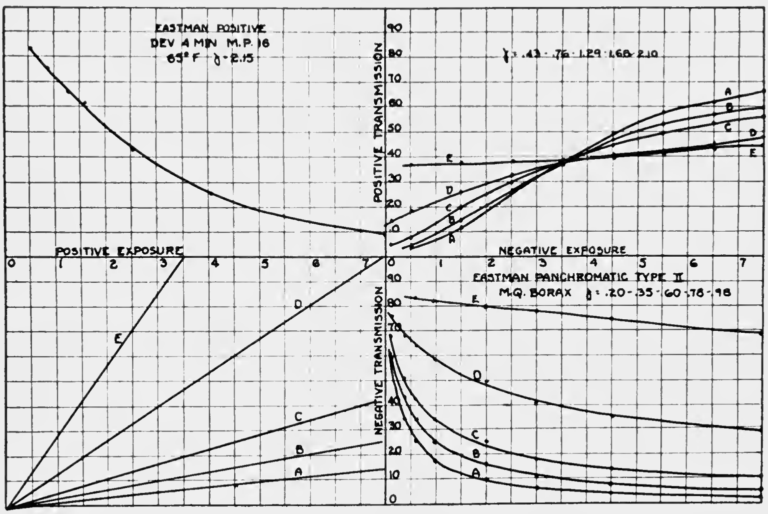

FIG. 2. Effect on the over-all characteristics of varying negative development.

noise level from this source would be independent of the unmodulated print transmission if the sound lamp intensity were adjusted to maintain a constant unmodulated exposure of the photo-cell.

Of these characteristics, *A* and *B* would reproduce most faithfully if the negative exposure range were from 2 to 7. With characteristic *F*, however, a signal of equal volume with only a small loss in quality could be obtained by modulating from 0.05 to 1.1. The recording level would be down 14 db. and the unmodulated exposure would be decreased 89 per cent. These are important reductions when portability is an essential factor in the design of the recording equipment.

The effect on the over-all characteristic of varying the negative development is shown in Fig. 2. The negative characteristics are of Eastman Panchromatic Type II, developed, respectively, 2, 4, 8, 12, and 20 minutes in M.Q. Borax. The corresponding gammas are 0.20, 0.35, 0.60, 0.78, and 0.98. The positive characteristic is the same as was shown in Fig. 1, Eastman Positive developed four minutes in M.P. 16 to a gamma of 2.15. In predetermining the over-all characteristics the printer lines are so drawn that the unmodulated print transmissions are all 40 per cent if we again consider

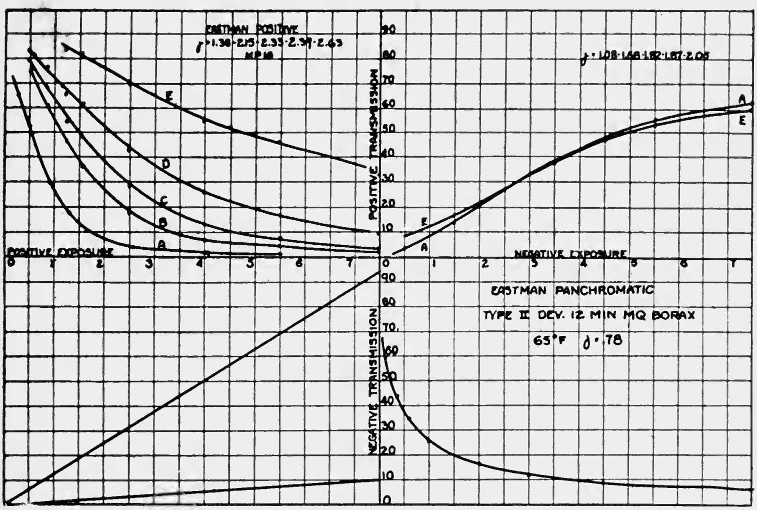

FIG. 3. Effect on over-all characteristic of varying positive development.

3.75 as the unmodulated negative exposure. Comparing the characteristics over an equal signal output or print transmission range, characteristic, *A*, with the maximum negative contrast, would probably produce the most faithful record. It possesses the added advantage of the least negative exposure range or recording level, reducing to a minimum the distortions due to overloading in the exposing system.

In Fig. 3 the effect is shown of varying the positive development with a constant negative development and unmodulated print transmission. The Eastman positive characteristics represent respective developments of 2, 4, 6, 8, and 12 minutes in M.P. 16 at

65°F. The corresponding gammas are 1.38, 2.15, 2.33, 2.39, and 2.63. The negative characteristic is the same as was used in Fig. 1, Eastman Panchromatic Type II developed twelve minutes in M.Q. Broax to a gamma of 0.78. As in Fig. 2, the printer lines are adjusted in each case to give an unmodulated print transmission of 40 per cent. The change in the shape of the over-all characteristics, due to the variation in the positive development, is so slight only the characteristics of the maximum and minimum development are shown. The remaining characteristics fall within the envelope

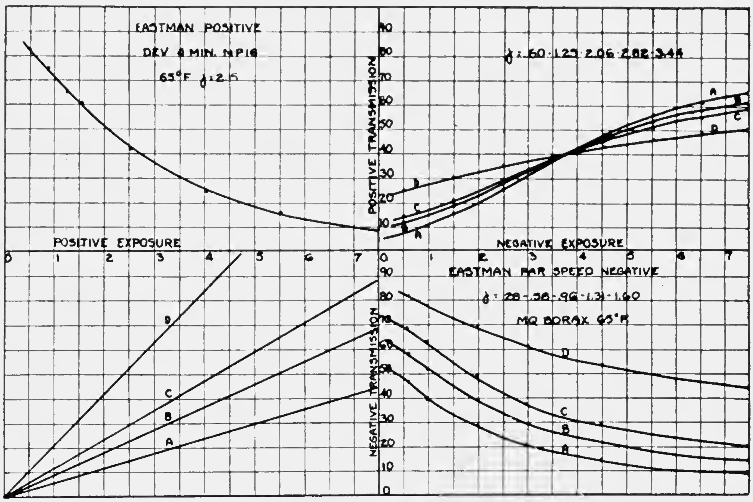

FIG. 4. Effect on over-all characteristic of varying negative development using Par Speed negative.

formed by these two curves. The mutual gamma varies from 1.0 to 2.0 with practically no apparent change in volume or quality.

In Fig. 4, the negative characteristics are of Eastman Par Speed negative developed 2, 4, 6, 10, and 15 minutes in M.Q. Borax to the corresponding gammas of 0.28, 0.58, 0.96, 1.31, and 1.60. As in Fig. 2, the Eastman Positive characteristic is used, developed 4 minutes in M.P. 16 to a gamma of 2.15. The results show an increase in slope with an increase in negative contrast, checking the results obtained in Fig. 2 with Eastman Panchromatic Type II.

These results tell nothing of the effects due to grain and resolving power but considerable knowledge is gained of the linear distortions and volume changes due to film processing. The results are not directly applicable to a sound recording system without some modifications. Usually there is some distortion in converting the amplified signal voltage into a modulated light intensity. Thus the negative exposure is not always directly proportional to the amplified signal; nor is the diffused transmission of the print a linear measure of the exposure of the photo-cell when the film is projected. It would seem that these transmissions would more closely approximate

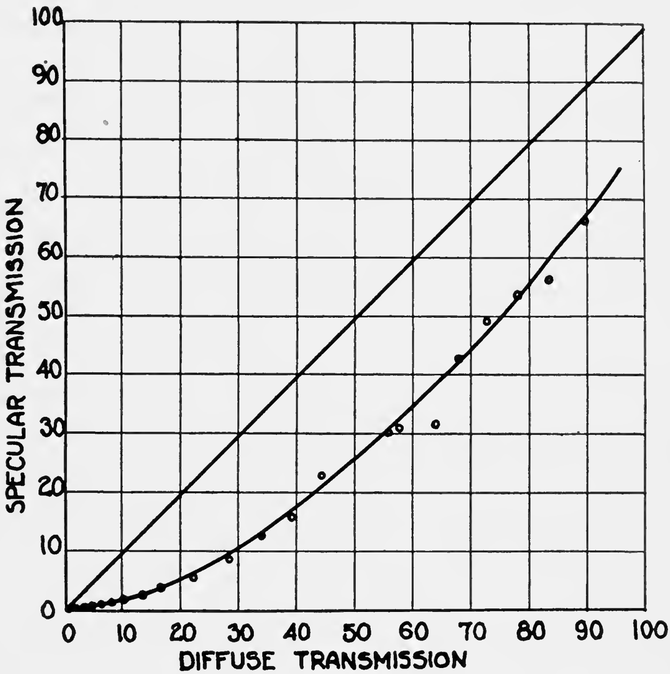

FIG. 5. Relation between diffuse and specular transmission.

the exposure of the photo-cell if they were actually read in the projector by inserting a micro-ammeter in the photo-cell circuit.

In Fig. 5 the relation between diffuse and specular transmission is shown. The transmissions as read in a projector fall approximately midway between the two, showing that the light is neither wholly diffused nor absolutely parallel.

DISCUSSION

MR. MAXFIELD: I should like to have some advice from Dr. Nicholson. I understand this paper applied only to the newsreel work in which the sound is recorded on the same film as the picture. In the studios a separate film is used for the sound negative.

MR. NICHOLSON: The results I have indicated are applicable to either the single or double system of recording. In the double system where a separate negative is used to record the sound the negative development is not limited to contrasts suitable for picture negatives. Unfortunately I have no slides indicating the results of recording on positive stock. For a given range of negative exposure the volume of a record made on positive stock can be quite in excess of a record made on panchromatic or negative stock. This is probably due to the higher contrast range of the positive stock.

MR. CARLTON: Perhaps I didn't follow you closely but you might clarify things for me by stating the respective contrasts which you found to give the best reproduction when recording on panchromatic stock and printing on regular positive stock.

MR. NICHOLSON: These results would not indicate the answer to such a general question. The slides showed the effect of varying the negative and positive contrasts but only for a single unmodulated negative exposure and a single positive print transmission. As was shown in Fig. 3, the contrast of the print had practically no effect on the over-all characteristic.

MR. MAURER: Did I correctly understand your statement with regard to the independence of the positive contrast and the over-all characteristic? As I understand, that is true provided the exposure is adjusted so that the unmodulated print transmission is maintained constant.

MR. NICHOLSON: Yes, Fig. 3 showed that if the print exposure is adjusted to maintain a constant unmodulated print transmission, the variation in print contrast has practically no effect on the over-all characteristic.

A SILHOUETTE STUDIO

C. FRANCIS JENKINS*

As many of the members of the Society of Motion Picture Engineers are aware, the Jenkins Laboratories have been broadcasting radiomovies from 8 to 10 P.M., E. S .T., every evening, except Sundays and holidays, for nearly two years.

Judging from the reports we receive, our broadcasts are giving novel amusement, though we have no very accurate way of knowing how many there are who are nightly entertained by our picture stories.

Perhaps we are warranted in assuming that of the hundred thousand neon lamps which have been sold since we began our broadcasts, at least one out of every five is in actual use in a radiovisor. Such an assumption seems warranted by collateral evidence, and from the reports we get from all over the United States, from Canada, Cuba, and Mexico.

We have been using black and white figures almost wholly, namely, silhouette or "cartoon pictures." For such broadcasts, we purchased some of the cartoons used in the film theater; and we also had some films made specially for our use by professional movie cartoonists.

Perhaps it may not be amiss to say here that the word "cartoon" in films was doubtless originally adopted from the old newspaper drawings in black and white figures, made by pen and ink, in exaggerated character. The adaptation of this pen and ink drawing to the telling of a movie story in continuity over a short time period has proved entertaining to many millions since.

But these pen and ink movies are too costly for us, because the whole cost has to be charged to our single broadcast station. The cost to theaters is divided by renting to many theaters. But this opportunity of subdividing the cost is not yet open to us. Our one broadcast station must absorb it all. This is prohibitive.

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* Jenkins Laboratories, Washington, D. C. (Read before the Society at Washington.)

So we decided to set up a silhouette studio, for the making of cartoon movie stories at the same speed at which regular halftone movies are made. Consequently the labor cost is greatly reduced, *i. e.*, reduced to only a very small fraction of the cost for the movie story in pen and ink.

So far as I am aware, this silhouette, or cartoon studio, is unique; and it is thought that perhaps a description of it, and the scheme

Jenkins Silhouette Radiomovie Studio.

(The camera included in the picture is actually never as near the subject as here shown.)

of its employment may be of service to others of our membership.

Much of the detail of the set-up is shown in the illustration herewith. There is a smooth white wall-surface, illuminated by incandescent lamps at the sides, top, and bottom. This produces smooth illumination of the background, while direct light from the lamps cannot fall on the performers because of the shields set up for that purpose. We are, therefore, photographing the lighted background only, and figures between this lighted ground and the camera block out portions of the ground to build up silhouettes of such figures.

The top of the platform on which our "stars" perform is elevated about a foot above the floor level, and is located 4 feet 6 inches from the illuminated background.

The camera lens we had available had too long a focus for the short length of the studio room, so we set up a mirror at the end of the room opposite the platform, and photograph our performers by reflection in the mirror (not shown in the photograph). In effect the mirror increased the length of the room by ten feet.

Obviously, when we photograph automobiles, flying machines, railway trains, fences, houses, and the like, minature cardboard figures of these are made and drawn across the lighted area on wires, while the camera photographs them from a nearby position which will make the figures properly proportioned to the living actors which are to appear in the same scene when the two are doubled in the printer.

We have found, as many another movie director has found, that if there is a mental suggestion on the mind of the observer, the thing itself does not need to be so very realistic to convey a perfectly satisfactory story. Thus, crossed wires were used to slide the airplane upon, causing the plane to loop-the-loop in such fashion as to produce a real thrill, especially when the pilot's sweetheart on the ground registers fear as he starts into the loop, and relief when he pulls the plane out of the loop close to the ground, and makes a perfect landing.

I did not spend much money on this studio, because we shall doubtless be setting up another soon to make radio "talkies," in halftone pictures and with appropriate dialog and sound.

However, the silhouette radiomovie stories are so unique, and so realistically clever, I think we shall give them up with a feeling of regret. They are as catchy and entertaining as the page of Silhouettes in the *Ladies Home Journal,* plus the action which completes the continuity of the story.

These silhouette radiomovie stories have come to have so fascinating an appeal to our broadcast audience that many seem reluctant to approve, just yet, our proposed change-over to halftones. While those who have seen our silhouette talkies find them doubly entertaining because of the realism of their story presentation.

It has occurred to me that perhaps these silhouette movies might be of interest to the theaters not yet changed over to the "talkies."

I believe their novelty would catch the public fancy. They certainly present a movie story in a very catchy fashion.

DISCUSSION

PRESIDENT CRABTREE: A few years ago I invested $2.50 in one of the Jenkins televisors but I didn't have much success with it. I am interested to know whether it was due to my dumbness or whether it is possible to maintain synchronism for any length of time. What is the longest time that anyone has kept the picture in synchronism with one of the friction drives such as you recommend?

MR. JENKINS: It is possible to run a whole picture without touching the synchronizing screw. The radiovisors now are smoother than the first, but it is astonishing that that simple little apparatus will produce synchronism. I shall be delighted if any of you will put it to your own test.

MR. ROSS: I should like to say that if Mr. Crabtree used his motor on Rochester power obtained from Niagara this failure to obtain synchronism is not surprising. The frequency of the supply varies from 59 to 61 or even 62 over a period of a few minutes.

ABSTRACTS

The Editorial Office will welcome contributions of abstracts and book reviews from members and subscribers. Contributors to this section are urged to give correct and complete details regarding the reference. Items which should be included in abstracts are:

Title of article
Name of author as it appears on the article
Name of periodical and volume number
Date and number of issue
Page on which the reference is to be found

In book reviews, the following data should be given:

Title of book
Name of author as it appears on the title page
Name of publishing company
Date of publication
Edition
Number of pages and number of illustrations

The customary practice of initialing abstracts and reviews will be followed. Contributors to this issue are as follows: E. E. Richardson, Clifton Tuttle, and the Monthly Abstract Bulletin of the Kodak Research Laboratories.

Densitometer an Automatic Timer. S. E. SNYDER. *Intern. Phot.*, **1**, December, 1929, p. 8. In this negative timing device, the film passes under a light measuring device (probably a photo-electric cell) which gives direct readings of the light transmission of an entire frame or a portion of it. These readings are expressed in terms of printer light settings. Thus the instrument eliminates the need of development of test strips necessary with the usual negative timer. The machine is equipped with a footage counter, electromagnetic scene counter, and meters for checking the current supply. It may also be used for timing variable density sound records.—*Kodak Abstr. Bull.*

Review of American Film Technique. W. GEYER. *Kinotechnik*, **11**, Dec. 5, 1929, p. 623. The author finds that the American film industry has made a tremendous advance since his visit years ago. The principal cameras used are Bell & Howell and Mitchell, both of which are briefly discussed. Panchromatic negative is most generally used. About 50 per cent of the negative is developed on racks or dums and 50 per cent on machines. The principal types of developing machines are discussed and illustrated. These are: sprocket driven machines with idle rollers for take-ups, sprocketless machines with loops controlled by automatic take-ups, sprocketless machines, each shaft of which is driven by an oil turbine and having the speed of the various parts controlled by a valve in the oil line which is governed by the rising or falling of an idle roller, the Spoor-Thompson machine, also sprocketless, which is driven by the lower set of rollers instead of the upper, and the Fearless machine in which some rollers are fixed and some are loose upon the same revolving shaft The degree of development in all these machines is controlled by speed and not by the quantity of film in the developer. The Bell & Howell printer was the only printer used for sound work, and both Bell & Howell and Duplex printers were used for pictures. Variable width and variable density sound film are briefly discussed. The important color film processes are taken up. For Technicolor pictures 50 per cent of the cameras are Bell & Howell or Mitchell. Wide film is briefly mentioned.—*Kodak Abstr. Bull.*

Wide Film Prospects. C. E. A. Committee on the Large Screen. *Kinemat. Weekly,* **157,** March 20, 1930, p. 67. The Fox Grandeur film (70 mm.), the Paramount Magnafilm (56 mm.), and other new widths are described. The Fear system uses standard stock but the picture is taken with its width along the film and occupies the space of approximately two and a half of the standard maskings. An optical device rectifies the image for projection. The Committee considers that standardization will be achieved before any general adoption is called for, and that standard films will be exposed on "sets" simultaneously with the wider films, so as to satisfy the remaining demand for the smaller prints.—*Kodak Abstr. Bull.*

Transmission of Sound by Walls. P. E. SABINE. *J. Acoustical Soc. Amer.,* **1,** Part 1, January, 1930, p. 181. A great number of measurements were made with different wall materials leading to the conclusions that: (1) For solid single walls, the per cent reduction in sound is proportional to the logarithm of the weight per unit area. (2) For double walls entirely separated, the thickness of the air separation is most effective in increasing absorption and the use of sawdust or other fillers decreases the effectiveness of insulation. (3) For double walls, partially connected or bridged, filling increases the insulation about as much as would be expected from the increase in weight. (4) By far the best way of increasing the effectiveness of "sound proofing" is to decrease the area of "contact points" between inner and outer walls.—*Kodak Abstr. Bull.*

Optimum Reverberation Time for Auditoriums. W. A. MACNAIR. *J Acoustical Soc. Amer.,* **1,** Part 1, January, 1930, p. 242. The variation in reverberation time with frequency should be such that sounds of equal apparent loudness die out in equal times. This leads to an absorption characteristic similar to that produced by an audience, thus checking observations that well filled auditoriums are acoustically good. A modification of Sabine's formula more applicable to small rooms is developed and seems satisfactory in practice.—*Kodak Abstr. Bull.*

Hearing of Speech in Auditoriums. V. O. KNUDSEN. *J. Accoustical Soc. Amer.,* **1,** October, 1929, p. 56. The author considers the four acoustic qualities of a room to be size, shape, reverberation time, and extraneous noises. He then shows that maximum "articulation" or intelligibility of speech occurs at a level of 70 decibels above the noise or threshold level and for good results a speaker should not fall below 50 decibels. Most speakers fall below this in large auditoriums. The reverberation time for speech is noticeably different from that for good reproduction of music, necessitating a compromise in practice. Even if designed specially for speech, auditoriums larger than 400,000 cubic feet should have amplifying systems for all speakers.—*Kodak Abstr. Bull.*

Beats and Related Phenomena Resulting from the Simultaneous Sounding of Two Tones. II. E. G. WEVER. *Physiol. Rev.,* **36,** November, 1929, p. 512. This, the second paper on beats, contains a review of the phenomena of beats, conditions for their excitation, their subjective nature, and their relation to auditory theory. —*Kodak Abstr. Bull.*

Frequency Characteristics of the Light Variation in the Sounding Arc. J. JAUMANN. *Z. Physik*, **59**, No. 5–6, 1930, p. 386. A carbon arc was modulated by oscillations of frequency 100 to 50,000 per second and the resulting variations in the brightness of the positive crater and the arc itself measured with a photo-cell. The results indicate that such an arrangement would be suitable for light telephony.—*Kodak Abstr. Bull.*

Should Non-Flam Be Enforced? *Bioscope*, **83**, April 23, 1930, p. 35. In the House of Commons, Captain Todd asked the Secretary of State for the Home Department, whether he was aware that there was on the market a British-made film base which was guaranteed fireproof, and whether the Government was prepared to consider the question of making the use of British non-inflammable films compulsory. In reply, the Home Secretary stated that he was not aware that any non-inflammable film had been yet produced which would fulfill the requirements of the cinema industry, and that he could not add anything at present to his reply given on January 23, last.—*Kodak Abstr. Bull.*

Safeguarding the Storage of Photographic, Motion Picture, and X-Ray Films. C. R. BROWN. *Radiology*, **14**, May, 1930, p. 454. The discussion includes the effects of various temperatures upon the decomposition and ignition of cellulose nitrate film, the composition and toxicity of the decomposition products, and storage requirements under various conditions.—*Kodak Abstr. Bull.*

Cellulose Nitrate and Acetate Film. A. H. NUCKOLLS. *Projection Eng.*, **2**, June, 1930, p. 24. A general discussion of the temperature values at which film ignites (for nitrate 230°F. to 300°F. and for acetate 700°F. to 800°F.); the type of decomposition (nitrate self-supporting or exothermic, acetate, endothermic); and the products of combustion (for nitrate the products are extremely poisonous, for acetate the effect is not so injurious). The author points out the relative ease of extinguishing a fire of burning acetate in comparison to the difficulty involved in putting out a fire due to nitrate film. E. E. R.

Two-Way Television. H. E. IVES. *Bell. Lab. Record*, **8**, May, 1930, p. 399. A permanent installation of television equipment and circuits has been set up between the Bell Laboratories and the American Telephone and Telegraph Company's offices, two miles apart. Speakers face a screen and talk into a microphone just back of it so that the entire face is visible to the other party. Listening is through a loud speaker carefully placed to avoid reaction with the microphone in the same booth. An improved 5000 element picture is transmitted, requiring a transmission band 4000 cycles wide. Blue light is used for scanning in transmission so that the observer's eyes are not blinded to the relatively low intensity of the neon receiving lamp.—*Kodak Abstr. Bull.*

Television in Colors by a Beam Scanning Method. H. E. IVES AND A. L. JOHNSRUD. *J. Optical Soc. Amer.*, **20**, January, 1930, p. 11. The positions of light source, image forming lens, and sensitive surface, with which we are familiar in photography, are revised. The lens projects a narrow moving beam of light, and the light reflected from the object is picked up by photo-electric cells which occupy the positions which in photography would be taken by the light sources. Three sets of special photo-electric cells are used, one with a green filter, one with a red filter, and one with a blue filter. The transmitted picture is produced by superposing the light from three different colored television glow lamps by means of semi-transparent mirrors. The light source and the scanning disk are the same as those used for monochrome television.—*Kodak Abstr. Bull.*

BOOK REVIEWS

Photocells and Their Application. V. K. Zworykin and E. D. Wilson. *John Wiley & Sons,* New York, N. Y., 1930, xi + 209 pp. (illustrated), $2.50. The authors have succeeded in their avowed attempt to present their material in a manner "not too technical for the untrained man nor too shallow for the specialist." The untrained reader is lead by logical and natural steps to an understanding of photo-electric theory as he follows the historical development of the science through the experiments of Hertz, Hallwachs, Elster and Geitel, and Lenard. The inadequacy of classical physics to explain black body radiation and the release of electrons in the photo-emissive effect becomes apparent and thus the reader sees the necessity for quantum theory as proposed by Planck and applied by Einstein.

Most of this first section is devoted to photo-emission though two chapters are devoted to photo-conductive and photo-voltaic effects.

Commercial photo-cells, their manufacture, and characteristics are discussed in some detail and in a manner which should prove valuable to the research worker as well as to the less trained user.

The use of the photo-cell in conjunction with thermionic tubes is described in the second half of the book. In this part also there appears to be a happy blending of the theoretical and the practical. Some of the applications which are treated are: sound motion pictures, facsimile transmission, television, relay devices, automatic inspection and control devices, and mechanical reading. While the description of these devices is not specific enough to enable "the amateur to build his own set," the details given do impart a fair amount of information as to the general principles involved.

The authors have combed the literature for material to supplement their own broad experience in the field. Over one hundred references are cited and a comprehensive bibliography is given. C. M. T.

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J. A. DUBRAY, *Chairman*
J. E. JENKINS, *Sec.-Treas.*
O. F. SPAHR, *Manager*
O. B. DEPUE, *Manager*

LONDON SECTION

SIMON ROWSON, *Chairman*
A. NEWMAN, *Vice-Chairman*
L. EVELEIGH, *Secretary*
H. WOOD, *Treasurer*
PAUL KIMBERLEY, *Manager*
ALAN WILLIAMSON, *Manager*
WILLIAM VINTEN, *Manager*

NEW YORK SECTION

M. W. PALMER, *Chairman*
D. E. HYNDMAN, *Sec.-Treas.*
M. C. BATSEL, *Manager*
T. E. SHEA, *Manager*

PACIFIC COAST SECTION

P. MOLE, *Chairman*
G. F. RACKETT, *Sec.-Treas.*
C. DUNNING, *Manager*
E. HUSE, *Manager*

REPORT FOR CONSIDERATION BY THE COMMITTEE ON LOCAL SECTIONS OF THE SOCIETY OF MOTION PICTURE ENGINEERS

FOREWORD

At a recent meeting of the Board I appointed a committee under the chairmanship of Dr. Hickman to report on the urgent problems which have arisen since local sections have been formed within the Society.

It was desirable to have on this committee certain persons who were not able to attend a New York meeting and it follows that the business of the committee has been done largely by correspondence. The present interim report is as near an average as may be of the members' differing opinions. It was read at the Board meeting held in New York City on July 29th and was passed for publication in the JOURNAL.

The report is published so that all persons interested may have an opportunity to comment either by mail or at the next convention. Guided by the consensus of opinion, the Board will then consider such modification of the by-laws as may be necessary to put the recommendations into effect. These clauses will be presented at the meeting and voted upon by the members.

The prosperity of the Society depends so much on the harmonious relations of its sections that I cannot urge too strongly the careful reading of this report. Criticism and suggestions will be welcome and no constructive ideas will fail to find their place in the final report.

J. I. CRABTREE, *President*

COMMITTEE REPORT

The members of the Society of Motion Picture Engineers who are scattered all over the world are sufficiently numerous in certain regions to make it profitable to have local meetings and to establish local sections of the Society. Sections have already been named in Chicago, Hollywood, London, and New York and certain problems have arisen in their management which make it necessary to examine the whole question of their relations to one another and to the main body of the Society.

The Purpose of the Society and Its Sections.—The Society was started by a group of technical specialists for the purpose of collecting knowledge pertaining to motion pictures. Although the Society is supported by an industry which sells products competitively, it was realized that commercialism within the Society of Motion Picture Engineers would hinder the spread of knowledge and detract from the authority of its scientific publications. The Society has maintained a standard of technical excellence and an aloofness from exploitation which is in keeping with the high tradition of other similar engineering organizations. While such a policy preserved to the full, ability to collect and advance knowledge, it hindered the speed with which this information was made available to many desirable quarters. Consequently, the Society began to grow rapidly by the admission of many persons less scientifically qualified who needed information for service work, or news or sales purposes. The Society has been proud of this extended influence but it must reaffirm emphatically to these new good friends that its whole usefulness to them rests on its continued freedom from the least taint of political or commercial influence.

The balance of power is so evenly distributed in the Society at large that there is little danger of a change of outlook. The local sections, however, cannot always be sure of an even admixture of technical and lay members and to these the warning must be sounded that the Society must be kept as wide open scientifically as it is closed commercially. The Society is careful to offer no degrees or obvious rewards which would make it desirable for one commercial organization to seek membership and discourage membership for competitors. The Society is more in the position of a telephone exchange where usefulness to one subscriber increases with each additional subscriber.

The writers of this report cannot discourage too strongly the practice of using the words "Member of the Society of Motion Picture Engineers" in displayed advertisements. If such an announcement is a useful distinction for certain persons in a locality it will discourage their inviting equally worthy competitors to form a section and thus defeat the fundamental purpose of the Society which is scientific coöperation.

Allegiance.—Members contributing to section activities sometimes find local responsibilities which are not always in direct accord with their responsibilities to the parent body. When such conflict occurs it must never be forgotten that there is *only one Society of Motion*

Picture Engineers. The sub-groups have been brought into being by virtue of the previous existence of the parent body and they have inherited the organization, prestige, and benefits created by others than themselves. We must recognize as a *fundamental axiom* that any person joining the Society *joins the whole Society* and gives his allegiance to the whole Society first and to his section second. If it is found that, as a practical matter, loyalty to a section does, in fact, conflict with loyalty to the whole group the cause of this conflict must be studied by this committee and, if possible, removed.

Eligibility for Local Membership.—Any member of the Society of Motion Picture Engineers living in the prescribed area shall automatically be eligible for membership in that section.

Membership of a section will confer benefits and entail responsibilities which will make it necessary for a national member to make voluntary application for local membership before he can be considered officially enrolled.

Although enrollment for local membership shall be voluntary, the Board of Managers of the section shall make it their business to notify all national members within the section limits of their eligibility to such membership.

If a member wishes to disregard the local section he shall have the right to do so.

The local section may not reject for membership any member in good standing in the Society.

Scientific attainments and technical ability are the only criteria whereby an applicant may be judged. If these are found satisfactory by the Board of Governors, the local social, business, or political desirability of the applicant must not be allowed to interfere with the proper exercise of judgment.

If, in the opinion of the Manager and Board of the local section, a member or an applicant is not a desirable person for their section they shall report their objection to the Board of Governors who may, at their discretion, remove his name from the Society's register or reject his application.

The officers of the Board of Governors when deciding on an applicant's fitness for admission to the Society have in the absence of personal knowledge only two means of making a correct decision. They have the written record of the applicant's experience and they have the recommendation of his seconders. Both may contribute to a false decision. The Board charges the section managers to make such full investigation into the record of the local applicant that a fair disposal of his case can be secured.

Finances of Sections.—During the past fourteen years the Treasurer and the Board of Governors have acquired a well defined knowledge of what is and what is not a proper expenditure of the Society's money. While some modification will be required to meet the needs of the sections, the underlying conception has proved too valuable to be abandoned. Proper expenditures have embraced primarily the printing of the JOURNAL, which has hitherto taken the largest portion of the funds, and the expenses of the Secretary's and Treasurer's offices. With the question of a paid secretary-treasurer or manager nearing its answer, it appears that the *expenses of the* JOURNAL *and manager's office will rightly absorb nearly the whole of the Society's income.* Other proper expenditures in the past have comprised clerical help for committees and items directly concerned with the furtherance of the Society's business.

The purchase of food and entertainment, the hiring of lecture halls, payment to speakers, and other items of a like nature when considered desirable have generally been supported by special levies in the form of registration fees or banquet tickets. No difficulty has been encountered in collecting these monies because members have recognized them as right and necessary additions to the annual dues.

At present the main body of the Society has no headquarters and temporary headquarters are secured at the hotels when conventions are held. These premises, which nominally cost the Society nothing, are in reality paid for partly by the room rent of the convention delegates, and partly by the registration fees. The cost comes indirectly from the members in addition to their annual dues; and we may restate this by saying that members pay a variable local subscription over and above their main contribution. This conclusion is of paramount importance in the development of our argument.

Local sections will desire, in general, to meet more frequently than the main body. The meetings will require headquarters, the use of projector apparatus, and in some cases the serving of refreshments. Board and entertainment for speakers, circularizing announcements of meetings, and perhaps publication of a local news letter may all be desirable. An annual dinner and other social functions will not be out of place.

The executives of the Society have every sympathy with regional activities but the money for their entire support is not available.

The JOURNAL costs over $8 per person and the clerical burden distributed over the membership is $1.50 per head. Even when the sections are allowed as little as $2.00 a member for annual operating expenses it means that an associate member is being carried at a loss of $1.50. The active membership and the Society's more vicarious sources of income cover the deficiency and leave a small margin for the future establishment of New York national headquarters. Nothing that the parent body could ever contribute could defray the expenses of a really ambitious section. These funds must come out of the private pocket in the same way as the convention expenses of the parent body.

Our established practice would suggest that in making up the annual budget the section should request the following appropriations:

Premises and Apparatus	A nominal amount
Clerical work, membership campaign, reporting of lectures for use of Society, *etc.*	Full cost
Circularizing local members, printing of posters, tickets, news letter, *etc.*	A nominal amount

This budget should be supplemented by local levy for the following items:

Premises and apparatus	To remedy deficiency
Circularizing local members, printing of posters, tickets, news letter	To remedy deficiency
Entertainment, food, and all local activities which do not concern the main body	Full cost

The possibility of making such collection equitably will be discussed in the following paragraphs.

Local Dues and Local Membership.—It is not healthy for any organization to be dependent in all its actions on a governing force situated at a distance. Our sections should have a certain autonomy which will be the more productive the more it is complete. The Society is concerned with the progress of the motion picture art and is not interested in local manners or national prejudices. It is far more important that knowledge and standardization should spread throughout the world than that the branches of this Society, which will be instruments in this work, shall be forced to behave according to some pattern devised by and most nearly appropriate to one or another section. Indeed, it seems probable that the greatest co-operation will go hand in hand with the greatest freedom in the manner of this coöperation.

The two items in which freedom is most desired are: The control of money, and the control of personnel, yet we have previously submitted that the Society has no money available for the uncontrolled local expenditure and also that the parent body must have the last word in the admission of members.

We believe the solution of this paradox lies in the institution of local dues and local membership.

There is excellent precedence for the subdivision of a large national or international society. The American Chemical Society, the American Physical Society, and the American Optical Society go farther in this direction than need ever be considered for the S. M. P. E. It allows its Rochester branch to have complete independence and adopt the title "Rochester Chemical Society" (Branch of the American Chemical Society). The Rochester section levies a $2.00 annual subscription and elects all its officers locally. In contrast to this the American Institute of Electrical Engineers, the Institute of Radio Engineers, and the American Society of Mechanical Engineers have sub-groups in large cities which are treated according to the needs of the group. In some cases the section is a single gathering of national members in the locality and its limited finances are all contributed by the national body which remits to the local treasurer a certain proportion of each man's dues. In other cases the section is a flourishing local society, open to all suitable persons who pay local dues. They differ from the Rochester Chemical Society in that the name of the parent body is rigidly adopted for the local section.

In the British Isles there are the Royal Societies of London, Edinburgh, and Dublin, whose activities overlap because one society would not cover all the territory and coöperation of effort is not required. On the other hand, the London Chemical Society and the Institute of Chemistry which have been separate institutions for many years are now seeking common headquarters because they have a common program of technological development. The German Scientific Societies prefer regional colloquia. Universities arrange gatherings devoted to specified subjects which are attended by visitors from a distance. Conviviality merges with scientific discussion and the flow of rhetoric matches the flow of good German ale. The expense is not borne by the scientific society under whose aegis the meeting convenes.

We see therefore in all parts of the world the splitting of national bodies and the consolidation of local bodies. When the former occurs local dues are generally instituted; when the latter takes place, the local subscription is already in existence.

Let there be no misunderstanding about the question of local dues. It is not intended that the imposition of these should be compulsory. Where, for example, a rebate of $2.00 a head is considered sufficient for the conduct of local business it will be simpler to retain the present section structure. Where, on the other hand, local activities and ambitions find $2.00 totally inadequate the way should be made wide open to expand the section in finances and personnel as the local board sees fit.

National members may look with some alarm on any proposal to increase their already substantial commitment to the Society by a local levy. This can be avoided by suitable technic. The local dues could be paid by local members alone, or in greater part by local members. For example, a group of 50 men receiving a rebate of $100 per annum from headquarters might be unable to make ends meet. A group of 50 national and 50 local members with a $500 income made up of $5.00 dues for local members and $3.00 local dues plus $2.00 rebate for national members would form a powerful organization. A $2.00 local membership requiring no subscription from national members might be instituted or a $5.00 local fee and still no national local fee would also be fair and possible. These are examples and are not intended to prejudice future local action.

The structure which is now advocated for the Society of Motion Picture Engineers would contain any or all of the following variations:

Members of the parent body paying full subscription and receiving all the benefits set out in the present constitution and by-laws.

Members of the parent body paying full dues and registered (with or without extra dues as the case may be) as members of a local section, having full privileges and responsibilities of the Society and the section.

Local members in those sections where local dues are imposed, such members to enjoy full local privileges and local voting power.

Officers of sections must be elected by and themselves be active members of the parent body.

Inclusion on demand after registration or the payment of local dues of any national member residing within the section limits.

Admission at the discretion of the section committee of applicants for local membership for local dues only.

Such a procedure puts into the hands of the sectional committee two dearly cherished powers: firstly, the ability to develop, unhampered, any plans which the locality feels inclined to support; and secondly, to extend the privileges of the branch to any person without let or hindrance.

The objection to local membership has been voiced that many persons will be content to pay the smaller fee, reading the JOURNAL at the local headquarters rather than shouldering the full responsibilities of the Society. This contention is refuted by experience. Our national conventions are open to all comers; our JOURNAL can be bought for less than Active membership; men who should pay Active fees can escape as Associates. Experience shows that advantage is seldom taken of these possibilities. A natural enthusiasm or at the worst a fear of public opinion makes each potential member an actual member. Sectional status in other societies has not furnished a cheap way out; the sections have proved to be a recruiting ground for national members of more value than expensive membership drives waged from headquarters.

Financial Procedure.—At the present time one section collects the dues of the local members but in the case of the other three the treasurer of the main body transacts this business. The lack of uniformity is due to the fact that the one section is in a foreign country. The advantage of local collection for the British members is that it produces an intimacy of relationship between the officers and those members which might otherwise be absent. The disadvantage is that delinquency, sometimes tolerated for local reasons, cannot be countenanced by the main body which has to pay for the printing of the JOURNAL. It is not always possible for the chief treasurer to learn from the local treasurer exactly which members are entitled to receive the JOURNAL.

We believe that with the establishment of local dues the business of collecting the main subscription should devolve in all cases on the Treasurer of the Board of Governors. If the treasurers of the sections wish to play some part in the collection they have scope for such activity in persuading delinquents to pay back dues and in forwarding application blanks and checks which they may secure personally from prospects. They will also be concerned without supervision with the collection of local dues.

Boundaries of the American Sections.—There are at least two well defined types of section limits. A section may be associated with a large town such as New York or Chicago and may by courtesy extend membership to its suburbs or to a district with a radius of so many miles; or a section may comprise a region of country but still have headquarters in a large town. The former scheme will find the most enthusiastic support until it is realized that a number of national members will have no sectional facilities because they live between the section towns. Thus, Rochester which supports many Active members would be represented in neither New York or Chicago and Schenectady and Cleveland would be as unfortunate. We suggest that the limits divide the continent into three industrially equal portions with one division passing north and south 50 miles west of Cleveland, Ohio; while the other division passes north and south 50 miles west of Denver, Colorado.

Out of Town Membership.—Bearing in mind that the business of the Society is the spreading of knowledge, it should not be considered improper to pass on descriptions of the activities of any one section to all in the Society who are interested. We propose, therefore, that any national member who cares to pay annually a sum less than the local subscription where such exists, as determined by the Board of Managers of a section, shall be placed on the mailing list to receive notices of lectures and all other literature which is circulated within the section. The payment of these out of town dues shall not permit the person to vote at meetings but shall entitle him to receive all other local benefits when visiting the sectional headquarters.

SUMMARY

The following recommendations are made:

(1) It should be understood by all Active and Associate members that they are members of the main Society first and of a section second.

(2) It is suggested that local membership shall be instituted.

(3) The imposition of local dues is advocated.

(4) Proper expenditures are defined.

(5) Collection of dues for national membership should be from national headquarters.

(6) Collection of local dues should be from local headquarters.

(7) The American sections should divide the continent into three portions, the boundaries of which can be altered when new sections are formed.

(8) Any national member wishing to be informed of the activities of any section may be placed on the mailing list for sectional information upon payment of certain dues. This shall not entitle him to other local benefits, voting power, *etc.*, unless he is a *bona fide* resident of the section.

W. CLARK	P. MOLE
H. T. COWLING	M. W. PALMER
J. A. DUBRAY	S. ROWSON
W. C. HUBBARD	K. C. HICKMAN, *Chairman*

SOCIETY NOTES

The London Section.—At a meeting of the Executive Committee held July 3rd, Mr. H. Wood resigned his position as treasurer and Mr. Paul Kimberley was appointed to carry on in his stead. The chairman on behalf of the whole Executive thanked Mr. Wood for what he had done on behalf of the Society.

The resignation of Mr. Wood having created a vacancy in the Executive, the secretary was instructed to invite Dr. W. Clark to fill the vacancy until the next election.

Board of Governors Meeting.—At the meeting of the Board of Governors held at the Engineering Societies Building, New York, N. Y., Tuesday, July 29th, a large number of business matters were transacted, including the following:

(1) Resolved that the fall meeting of the Society be held at the Pennsylvania Hotel, New York, N. Y., October 20th–23rd, inclusive.

(2) Resolved that the name of "Hollywood" only be placed on the ballot for the location of the spring meeting.

(3) Resolved that the geographical area of the Pacific Coast Section be defined as the territory of the United States lying west of a line running north and south through a point 50 miles west of Denver, Colorado; that the territorial area of the New York Section be bounded on the west by a line running north and south through a point 50 miles west of Cleveland, Ohio, and on the east by the Atlantic ocean; that the Chicago Section include the territory which lies between the eastern boundary of the Pacific Coast Section and the western boundary of the New York Section.

(4) A large number of matters relating to the London Section were discussed. To date there has been some misunderstanding with regard to the collection of membership dues. The treasurer of the parent Society had deputized the treasurer of the London Section to collect the dues, but owing to complications involved it has been agreed that the London Section forward dues in full directly to the treasurer of the parent Society. Expenses of the London Section are to be defrayed only from the budgeted allowance in accordance with the By-Laws.

(5) In order to more clearly define the relationship between the sections and the parent Society, especially with regard to finances, a committee was appointed under the chairmanship of Dr. Hickman to draw up a report. This was submitted to the Board of Governors

and is published elsewhere in this issue of the JOURNAL. Every member is requested to carefully read over this report and submit any modifications or suggestions either to Dr. Hickman or the President.

(6) A motion to reopen discussion on the matter of restoring the half-rate initiation fee to foreign members was defeated. It will be recalled that beginning October 1, 1930, the present half-rate membership fee for foreign members will be raised to the same basis as that for residents of the United States and Canada.

(7) Resolved that photographs of officers of the parent Society and sections be published annually in the JOURNAL.

(8) The Secretary read a letter received from the Chairman of the Committee on Representation for the American Standards Association requesting the Society to take up membership. The Secretary was instructed to secure further information.

(9) A committee consisting of Messrs. M. W. Palmer and J. H. Kurlander was empowered to rent office space in New York City at a price not to exceed $1500 per year when notified by the Secretary or President that the Society is ready to occupy such offices.

(10) Nominations for the various retiring officers were balloted. The retiring officers are as follows:

J. I. CRABTREE	*President*
H. P. GAGE	*Vice-President*
J. H. KURLANDER	*Secretary*
W. C. HUBBARD	*Treasurer*
H. T. COWLING W. C. KUNZMANN	*Governors*

(11) Fifty-four applications for the position of editor-manager of the Society were considered and a list of selected applications referred to a committee consisting of Messrs. L. A. Jones, E. I. Sponable, and M. W. Palmer. The committee was instructed to interview applicants if necessary and report at the next Board meeting to be held September 22nd.

OBITUARY

WILLIAM HENRY BRISTOL

Mr. William H. Bristol, inventor, educator, and manufacturer, died on June 18, 1930, after a brief illness. His age at the time of his death was seventy-two years.

Mr. Bristol was a leader in the engineering field. His inventions and developments of recording instruments, pressure gauges, pyrometers, and electrical measuring instruments have been of great

PROF. W. H. BRISTOL

service to many industries since he founded the Bristol Company at Waterbury, Connecticut, in 1899.

He was a pioneer in the field of sound recording devices and for a number of years he has devoted a large part of his time to the development of sound motion pictures.

His works are familiar to members of this Society through numerous papers which he has published in the *Transactions* and JOURNAL.

He was a graduate from Stevens Institute with the degree of M.E. and was a member of a number of technical societies in addition to our own.

NEW MEMBERS

(May to August, 1930)

ABGRALL, PIERRE J. (*A*)
Abgrall Établishmente, 16 Rue Roussel, Paris, XVII, France

ANDERSON, ARTHUR H. (*A*)
Duplex Motion Picture Industries, 74 Sherman St., Long Island City, N. Y.

BARBER, PERCIVAL A. (*A*)
52 Howbury Rd., New Head, London, S. E. 15, Eng.

BAUER, KARL A. (*A*)
Carl Zeiss, Inc., 485 Fifth Ave., New York, N. Y.

BELL, CHARLES H. (*M*)
166 Wardour St., London, W. 1, Eng.

BRADFORD, ARTHUR J. (*A*)
Visual Instruction Dept., General Electric Co., Schenectady, N. Y.

BRADSHAW, DAVID Y. (*A*)
2140 Champa St., Denver, Colo.

BRAUER, ELMORE C. (*A*)
407 11th St., Gothenburg, Neb.

BURGESS, WILFRED E. (*A*)
P. O. Box 132, Stratford, New Zealand

CANTRELL, WALTER A. (*A*)
23 Ogwen St., off West Derby Road, Liverpool, Eng.

CHEFTEL, ALEXIS M. (*A*)
22 Rue de Civry, Paris, XVI, France

CHILTON, THOMAS (*M*)
J. Frank Brockliss, Ltd., 58 Great Marlborough St., London, W. 1, Eng.

CLAYTON, ROY S. (*A*)
Metropolitan Sound Studios, Hollywood, Calif.

CRALLEY, VANE R. (*A*)
Metro-Goldwyn-Mayer Studios, Culver City, Calif.

CRIST, RICHARD (*A*)
6754 37th Ave., S. W., Seattle, Wash.

CUNNINGHAM, JAMES B. (*A*)
7023 Arcadia Ave., University City, Mo.

DEROBERTS, RAYMOND (*A*)
The Gevaert Co. of America, Inc., 423 W. 55th St., New York, N. Y.

DESAI, HARIBHAI (*M*)
Surya Film Co., 5 Cunningham Rd., Bangalore City (Mysore State) India

DOIRON, ALPHONSE L. (*A*)
Metro-Goldwyn-Mayer Studios, Culver City, Calif.

DUFFEY, EDMUND J. (*A*)
The W. H. Hoedt Studios, 212 W. Washington Sq., Philadelphia, Pa.

FALQUET, ALBERT (*A*)
Kodak S. P. z. o. o., 5 Place Napoleon, Warsaw, Poland

FELSTEAD, CHARLES F. (*A*)
Universal Pictures Corp., Universal City, Calif.

FENIMORE, ROGER W. (*M*)
Chicago Film Lab., Inc., 1322 Belmont Ave., Chicago, Ill.

FRANK, JAMES, JR. (*A*)
RCA Photophone, Inc., 411 Fifth Ave., New York, N. Y.

GEOGHEGAN, GERALDINE (*M*)
The E. S. S. Colour Filter Co., 1 Montague St., London, W. C. 1, Eng.

GEYER, KARL H. (*A*)
32 Wesbourne Terrace, London, W. 2, Eng.

GIBSON, GEORGE H. (*A*)
J. E. Brulatour, Inc., 6700 Santa Monica Blvd., Hollywood, Calif.

GIHBSSON, LEIF (*A*)
J. L. Nerlien, Ltd., Nedre slotsgate 13, Oslo, Norway

GLASSER, NAT (*A*)
Warner Bros. Theatres, 923 F. St., N. W., Washington, D. C.

GOLDEN, NATHAN D. (*A*)
Motion Picture Division, U. S. Dept. of Commerce, Washington, D. C.

GOLDBERG, JOE H. (*M*)
Publix Theatres Corp., Room 1714, Paramount Bldg., New York, N. Y.

HAEFELE, NORBERT C. (*A*)
National Theatre Supply Co., 308 Gay St., N., Baltimore, Md.

HAUSER, FRANCIS V. (*A*)
Stoll Picture Productions, Ltd., Temple Rd., Cricklewood, London, N. W. 2, Eng.

HAWKER, CHARLES L. (*A*)
Paramount-Famous-Lasky Studios 5451 Marathon St., Hollywood, Calif.

HEWITSON, ALAN E. (*A*)
Messrs. Hewitsons, Ltd., Princes Hall, High St., Smethwick, Staffs., Eng.

HOFFMAN, LOUIS B. (*M*)
Blind Brook Lodge, Rye, N. Y.

HORTON, JOSEPH W. (*A*)
General Radio Co., 30 State St., Cambridge, Mass.

INGMAN, THOMAS A. (*A*)
Paramount-Famous-Lasky Lab., 1546 N. Argyle Ave., Hollywood, Calif.

IRBY, FRANKLIN S. (*A*)
"Electronics," 36th St. and 10th Ave., New York, N. Y.

JAY, RONALD L. (*A*)
Jay's Screen Service, 23 Nithsdale Rd., Glasgow, S. 1, Scotland

JOHN, WESLEY E. (*A*)
National Bank Bldgs., Johannesburg, South Africa

KEITH, CLYDE R. (*A*)
Western Electric Co., Ltd., Inveresk House, Aldwych, London, Eng.

KELLOG, EDWARD W. (*A*)
RCA Victor Co., Inc., Camden, N. J.

KOPPRASCH, ALEXANDER H. (*A*)
Publix Theatres Corp., Room 1714, Paramount Bldg., New York, N. Y.

KUMM, ARTHUR W. (*A*)
Paramount - Famous - Lasky Corp., 5451 Marathon St., Hollywood, Calif.

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RCA Photophone, Inc., 411 Fifth Ave., New York, N. Y.

LEWIS, GEORGE (*M*)
Arcturus Radio Tube Co., 260 Sherman Ave., Newark, N. J.

LINSLEY, DOUGLAS F. (*A*)
The Replitura Corp., Melrose Ave., Stamford, Conn.

LONAS, FRANK E. (*A*)
Woolworth Bldg., New York, N. Y.

LUKES, STANLEY A. (*A*)
6910 Greenview Ave., Rogers Park, Chicago, Ill.

MACILVAIN, KARL M. (*M*)
3056 87th St., Jackson Heights, L. I., N. Y.

MANLEY, R. G. H. (*A*)
P. O. Box 772, Auckland, New Zealand

MARESCHAL, GEORGES (*A*)
168 Rue de Belleville, Paris, 20e, France

MCCANN, FRANCIS D. (*A*)
Westinghouse Electric & Manufacturing Co., 150 Broadway, N. Y.

MENEFEE, HARRY R. (*M*)
Fox-Hearst Corp., 1776 Broadway, New York, N. Y.

MESSTER, EDUARD O. (*M*)
Messter Optikon G. m. b. H., Am Karlsbad 16, Berlin, W. 35, Germany

MIKI, MINORI (*A*)
Makino Productions, Myoshinji Kyoto Shigai, Kyoto Perfecture, Japan

MILLER, ARTHUR W. (*A*)
47 Westfield Ave., E., Roselle Park, N. J.

MILLER, JAMES A. (*A*)
United Research Corp., 39th St. and Van Pelt Ave., Long Island City, N. Y.

NEU, OSCAR F. (*A*)
Neumade Products Corp., 442 W. 42nd St., New York, N. Y.

NIELSEN, JOHN F. (*A*)
United Research Corp., 39th St. and Van Pelt Ave., Long Island City, N. Y.

PEARSALL, EARLE S., JR. (*M*)
Atlas Educational Film Co., 5 N. Wabash Ave., Chicago, Ill.

PECK, WILLIAM H. (*M*)
Colorcraft Corp., 122 E. 42nd St., New York, N. Y.

PIROVANO, LOUIS (*A*)
Publix Theatres Corp., 60 Scollay Sq., Boston, Mass.

PU, MAUNG NYI (*A*)
Burmese Favourite Co., 51 Sule Pagoda Rd., Rangoon, Burma

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ROMEO, GERARDO (*A*)
31 rua Manuel Nobrega, São Paulo, Brazil

ROPER, VAL J. (*M*)
Eng. Dept., General Electric Co., Nela Park, Cleveland, Ohio

ROSENSWEIG, MORRIS (*A*)
H. E. R. Labs., Inc., 457 W. 46th St., New York, N. Y.

ROSENMANN, GEORGE (*A*)
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LOYD A. JONES, EDITOR *pro tem.*

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FACTORS GOVERNING POWER CAPACITY OF SOUND REPRODUCING EQUIPMENT IN THEATERS

S. K. WOLF AND W. J. SETTE*

GENERAL

Reproduction of speech and music with motion pictures is intended to augment enjoyment derived by theater audiences. Of the factors which contribute to ease and pleasure of listening to reproduced sound, the quantity (loudness) of sound available to listeners ranks in importance with the quality of reproduction. Quality is of little avail when satisfactory loudness does not accompany it, and increase of loudness cannot compensate for quality that is poor. Sensation level influences intelligibility and naturalness of speech and music and, therefore, must be considered an important element in the promotion of satisfaction with sound picture presentation in theaters.

It is the purpose of this paper to analyze the factors governing the power capacity of reproducing systems necessary to produce satisfactory loudness in auditoriums. The investigation readily resolves itself into a determination of the aural and auditorium factors bearing on listening conditions, a study of the characteristics of amplifiers, and the correlation of theaters and equipment to attain optimum audition. The limits for power capacity of reproducing apparatus which it is practicable to install in theaters with satisfactory results can thus be discussed, and existing limits examined in the light of these considerations.

LISTENING LEVELS

The first step appears to be to fix the desirable sensation levels for listening to speech and music. Ordinary conversation is heard at a level of about 70 decibels above threshold of audibility, for the stronger speech sounds, 50 decibels for weak sibilants.[1] In other words, vowel sounds thus spoken are ten million times as powerful as when just audible. This intensity is such that words are heard

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at maximum intelligibility, greater or less intensity both tending to reduce intelligibility. Accordingly in the theater this level may be considered comfortable from the standpoint of articulation and naturalness. However, other phenomena must be taken into account.

Noises due to audience, ventilating equipment, and external sources, ranging from 10 to 40 decibels above threshold, may be present, requiring increase in loudness of speech for good articulation. If we engineer on the basis of a recorded intensity range of 40 decibels, which represents exceptional recording, and if the minimum reproduced sound is made equal to the maximum room noise, it will be evident that the maximum sensation level will be 80 decibels instead of 70.[2] The excess level of 10 decibels would seem a reasonable reserve since speech at a level of 70 decibels is readily intelligible in the presence of an ordinary amount of room noise. In connection with this it must be remembered that it is more desirable to reduce noise than to increase the level of reproduction. In regard to music there is little data available as to natural levels for listening. We may fix the maximum average level which reproducing equipment will be required to produce in a theater as in the neighborhood of 80 decibels, selecting this figure in view of the fact that the measured outputs of musical instruments are generally higher than those for the average speaker. This selection is arbitrary, of course, and will provide for possible variation in different types of speech as well as music. The level of 80 decibels corresponds to a flux of 10^{-2} microwatts of acoustic power per square centimeter.

CHARACTERISTICS OF AMPLIFIERS

The amount of power available from sound reproduction equipment will depend on the amplifiers incorporated into the apparatus and efficiency of loud speakers. We must determine the maximum average power without distortion in quality. The distortion in which we are interested in this discussion is caused by requiring amplifiers to work at overload conditions and is evidenced by a certain fuzziness and rattle in the reproduced sounds. Overload has the effect of introducing frequencies which may not be contained in the input or, in other words, producing nonlinear amplification of the signals.[3] The effect is to be avoided as it reduces articulation and naturalness of speech and tends to destroy quality of music, the degradation in quality being dependent upon the frequency distribution or spectrum of the extraneous sounds.[4] We conclude that amplifying equipment should be designed to be capable of producing necessary power without encroaching on the nonlinear part of the amplification curve.

There are several practiced methods of rating amplifiers. Those made by the Western Electric Company are rated by their electric output at 1000 cycles as this frequency lies approximately in the middle of their pitch range and has been found to be a very useful reference frequency. With this method overload is said to occur when the added third harmonic is greater than 1 per cent of the power of the pure sine wave fundamental, in the output. It remains for

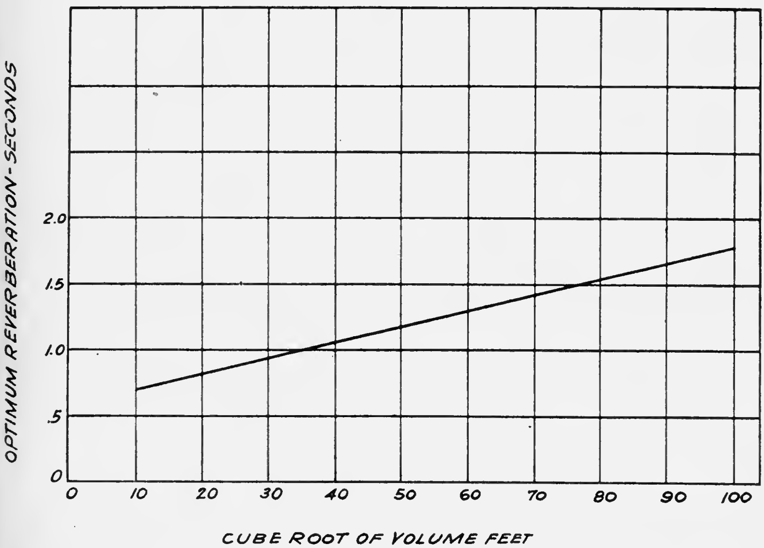

FIG. 1. Optimum reverberation time and cube root of auditorium volume.

us to translate this rated power of the equipment into something which we can compare with figures for speech powers.[5] The average for continuous speech over a long period has been determined as 10 microwatts for the average speaker. The instantaneous peak values may rise to 200 times that amount. Thus an accented syllable like "tap" will frequently be distorted in reproduction because the instantaneous power involved is greater than for most syllables. We are interested in a rating comparable to the sensation level of 70 decibels considered optimum from the standpoint of articulation, In amplification it is the peak portions of the signals that are distorted at overload. Thus the tops of sine waves may be flattened. If we assume that the peaks of speech will be distorted in similar fashion, we may set a value for speech output relative to the single frequency. For vowel sounds the instantaneous power reaches 20 times the syllabic. The latter would, therefore, be some 13 decibels less than the peak undistorted power. Since the peak of a sine wave is 3 decibels above the average in power, then the rating for speech should be in the neighborhood of 10 decibels less than that given for

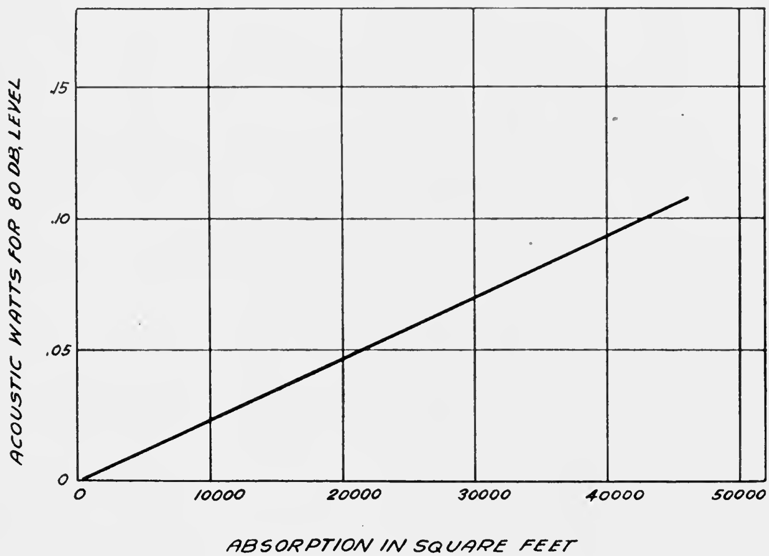

FIG. 2. Acoustic power for sensation level of 80 db. as a function of absorption.

the single frequency. This output is that which may be used in sensation level calculations. Computation of the rating in this manner is not entirely justifiable since audibility of distortion must be weighed. However, in practice it has been usually found safe to allow a difference of 5 decibels between the maximum average power of both speech and music and the single frequency rating for high quality amplification. More elaborate experimental work should be done before positive statements in this connection are made.

LOUD SPEAKERS

The electrical energy furnished by the amplifying apparatus must be converted into acoustic energy. The efficiency of this transformation depends on the type of loud speaker that is employed. With exponential horns equipped with receivers like the W.E. 555, efficiencies as high as 25 per cent are realized.[6] Thus an attenuation of 6 decibels is introduced in going from the electric to acoustic power. If the horns are placed behind the screen in a theater, power may be lost in transmission and by reflection. The amount varies with the material, porosity, and location relative to the screen, being approximately 1 or 2 decibels in tests for some screens and up to 5 decibels at 5000 cycles for poorer ones.[7]

We may summarize here and write down the acoustic power actually available for distribution into an auditorium. From the above considerations the maximum average speech power is about 13 decibels down from the single frequency electric rating for reproducing equipment installed in a theater. Thus a system whose electric capacity is given as 5 watts could produce 250 milliwatts of acoustic power, 25,000 times as great as the value for average speech.

DISTRIBUTION

Most loud speakers are directional in their distribution of energy. Horn type speakers exhibit this property to a marked degree, the usual baffle type speakers to a less extent.[8] This property appears to be a rather desirable one in theater work as it enables placement of sound energy where it will do the most good. It serves as a tool in meeting the problem of distribution in large auditoriums since much reverberation cannot be utilized without loss of intelligibility. However, care must be exercised to see that some areas are not sacrificed because of too great intensities on the axes of the horns. This may be illustrated by assuming three areas of 1 square foot each with sound at a sensation level of 80 decibels over all of them. If, through faulty distribution, one of the square feet were increased to a level of 83, both of the remaining two unit areas would be correspondingly reduced to 77 decibels.

AUDITORIUM FACTORS

Auditorium factors must next be considered. It remains to calculate the power required to produce adequate levels of sound intensity throughout a theater. This power should depend in some way on the volume and shape of a theater, the seating area, and the acoustic absorption of the surfaces. The absorption present and the configuration determine the influence of reflected energy; the seating area is the surface over which satisfactory conditions are desired. It might be expected that with all these variables weighted, the required power, in general, will increase with the cubical content; that is, the power should be expressible as a function of the volume, perhaps a constant times the volume to an exponent less than unity.

Ordinary reverberation theory, assuming a uniform distribution of acoustic energy, leads to the following relation between the equilibrium condition of sound energy in a room and the source of constant output:

$$e = \frac{4\bar{E}}{CA} \qquad (1)$$

in which e = Average energy per unit volume at steady state
$\bar{E}$ = Acoustic power of source
A = Total acoustic absorption of room
C = Velocity of sound,

where in words the formula states that if we measured the over-all average energy in an enclosed space, we would find it to be directly proportional to the power of the source and inversely proportional to the absorption in the space. Knowing the energy density throughout the room it is possible to calculate the sensation level of the sound. In decibels above threshold this is just 10 times the logarithm of the ratio of the maintained energy to the energy at zero audibility:

$$L = 10 \log_{10} \frac{4\bar{E}}{CA} \frac{l}{i} \qquad (2)$$

i = energy density at threshold.

From this formula it appears that, if equal conditions of loudness are desired in all theaters, the necessary power should vary directly as the acoustic absorption present. Thus, a theater having 10,000 units of absorption (corresponding to a volume of about 280,000 cu. ft.) would require a sound reproduction system having twice the capacity of one that was adequate for a house with only 5000 units of absorption (120,000 cu. ft.). Another angle is that, on the basis of this theory, the same equipment installed in these two houses would create hearing levels differing by only 3 decibels, a difference which is little more than just distinguishable to the ordinary ear, Attempts have been made to make the optimum absorption for theaters the yardstick for power capacity of reproducing equipment possible to install with satisfactory results. From the relation between optimum reverberation time and volume of auditorium it is possible to compute a curve connecting volume and most desirable amount of absorption. Hence, curves 1 to 3 may be calculated to show a theoretical relation connecting powers to produce a level of 80 decibels in auditoriums of different volume, assuming optimum absorption.[9] From the curves, and what we have already

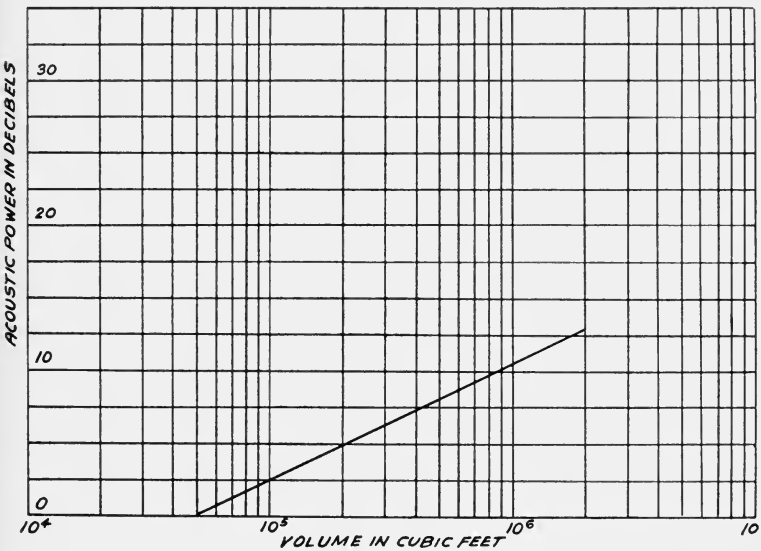

FIG. 3. Acoustic power in decibels above 0.006 watt as a function of volume assuming optimum absorption.

reviewed concerning amplifiers, limits for size of theaters and capacity of reproducing equipment could be established.

Fig. 3 shows the required acoustic power in decibels about 0.006 watt plotted against a logarithmic scale of volume. The variables are considered logarithmically since loudness and sensation level are logarithmic functions of acoustic power. It is apparent that over the limited range in which we are interested the equation rather exactly expressing the graphed relation is:

$$P_{db.} = 8.1 \log V - 38.2 \qquad (3)$$

The value of 8.1, as the slope, indicates that the power in watts will increase as V to the 0.81 power. Corresponding to this logarithmic expression is the following for the acoustic power in microwatts:

$$P = 0.91\ V^{0.81} \qquad (4)$$

From what we have previously established, it follows that the electrical must be about 8 decibels above, and the amplifier single frequency capacity some 13 decibels above its acoustic power.

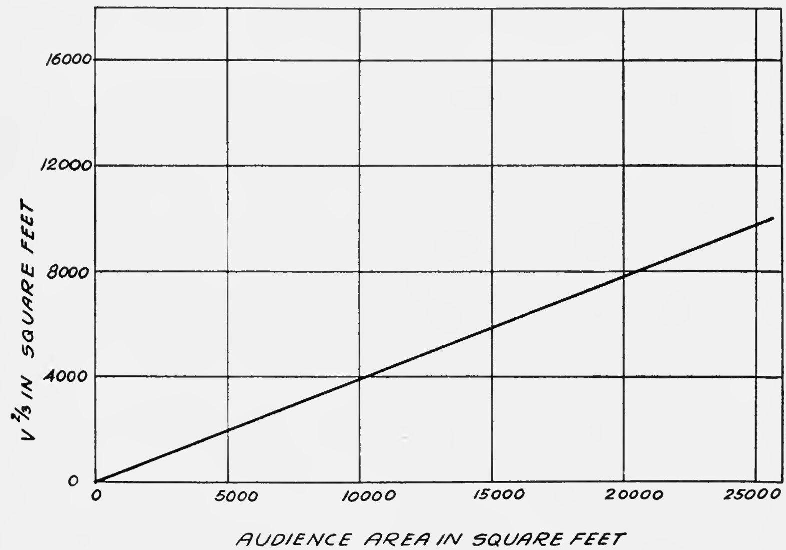

FIG. 4. Relation between area occupied by audience and auditorium volume to the two-thirds power.

The premises of the theory leading to the above equation should be examined to obtain an accurate estimate of the conclusions reported in the preceding paragraph. The formula

$$e = \frac{4\bar{E}}{CA}$$

expresses the average conditions existing when a sound source of constant power is in equilibrium with the absorption of energy at the surfaces enclosing a room. The average is to be understood as the total energy in the enclosed space divided by the volume. The condition of equilibrium means that a steady state must be reached before the equation holds true. It can be shown that the time necessary for conditions to approximate the steady state is something greater than 0.3 second for most theaters. In speech the consonant portions of the syllables require only about 0.05 second for enunciation, the vowel sounds about 0.2 second. Therefore, application of the equation to obtain loudness produced by speech sounds is open to doubt as the times dealt with are rather too short for the assumptions to apply in all but the smallest volumes. Furthermore, the theory assumes random distribution; it is desirable

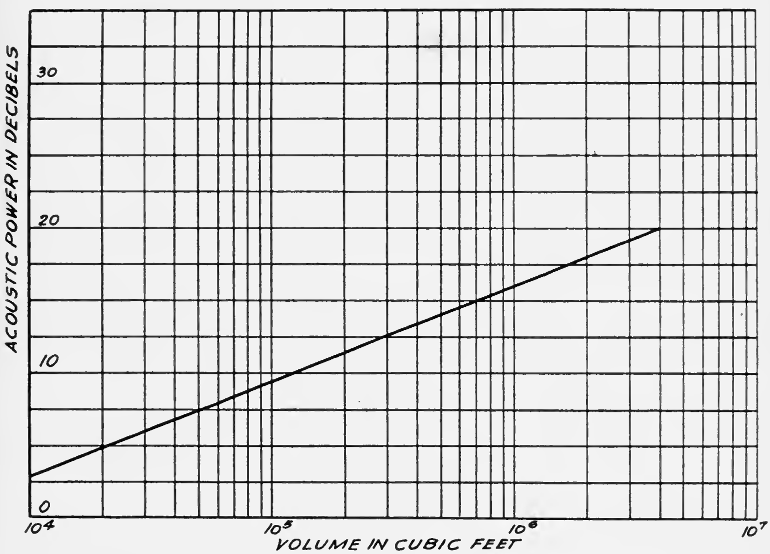

FIG. 5. Acoustic power in decibels above 0.006 watt as a function of volume on the basis of seating area.

to have sound reach the audience directly from the screen if illusion is to be maintained. Calculations have been made showing that loudness at points in an auditorium is affected less than 5 decibels by helpful reflections, that the impression of loudness is obtained mostly from direct energy, especially with directional sources such as horn speakers.[10] Accordingly the absorption present cannot be entirely indicative of sensation level.

The formula obviously breaks down in the limiting case of open air theaters, or in enclosures where the surfaces are nearly 100 per cent absorbent as here the inverse square of distance relation applies. As wall surfaces are made more absorbing, the assumptions necessary for the derivation of the formula are less applicable. Several writers have advocated acoustically "dead" auditoriums.[11] In this event, loudness, and consequently amplifier output to produce it, must be figured on some other basis as we shall see in the next section.

If we do not accept the absorption theory as a criterion, there remains little basis for a computation of the required acoustic power. However, another starting point for the theoretical calculation would be the area occupied by an audience and presented to the horn to be covered. Thus, if uniform distribution could be achieved, a reproducing system with an acoustic capacity of 50 milliwatts could produce a sensation level of 80 decibels over an area of 5400 sq. ft. neglecting any aid from reflection. The same system with proper distribution would produce a level of 77 decibels over twice the area, 10,800 sq. ft. But, obviously, area alone cannot be made the sole factor; the distribution must be uniform and effective. Accordingly, it would be better to speak of "effective area" rather than "area" where the term "effective" should weight the efficiency of direct covering and any aid from reflection.

We may assume that effective area will be proportional to the seating area and hence vary in some manner as the volume of theaters. Fig. 4 represents the variation of seating area, including aisles and crosswalks, with volume to the two-thirds power. The relation is suggested by the geometrical consideration that on an average the surface of enclosures increases according to the square of the cube root of the volume. Of course, over a large number of theaters there will be considerable deviation from the values indicated by the curve, but a general average is of interest and serves our purpose. The equation connecting volume and seating area is:

$$S = 2.56\ V^{2/3} \qquad (5)$$

If we assume that aid by reflection just compensates for the increase of power that would be needed because of faulty distribution, then the effective area will be equal to the audience area. The acoustic power in microwatts required to produce sensation level of 80 decibels in an auditorium would be, therefore,

$$P = 23.8\ V^{2/3}\ (V \text{ in cu. ft.}) \qquad (6)$$

The acoustic power in decibels referred to 6 milliwatts as a zero level is shown in Fig. 5. The relation is:

$$P_{db.} = 6.7 \log V - 24 \ldots\ldots\ldots\ldots\ldots \quad (7)$$

The exponent of the volume here, 0.67, compares with the value of 0.81 obtained on the premise that the optimum absorption should govern the required power.

EMPIRICAL RESULTS

Our theoretical considerations involve assumptions which leave conclusions based on them open to doubt. They offer no conclusive

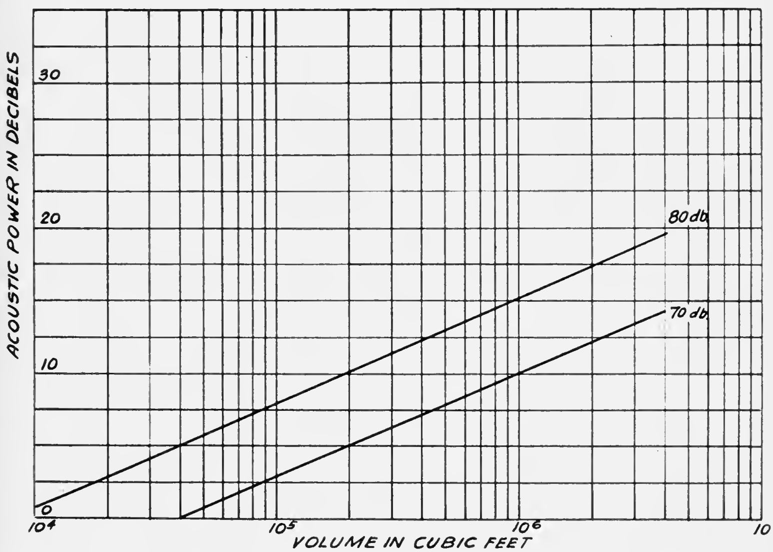

FIG. 6. Acoustic power in decibels above 0.006 watt as a function of volume from experimental data.

relation for fixing limits of amplifier capacity for auditoriums. Empirical results in this connection are of interest. Fig. 6 shows curves computed from data on public address systems collected by D. G. Blattner and J. P. Maxfield. Measurements were made by several observers of the electric power into the loud speakers at optimum audition in auditoriums of different sizes. The results indicate that the required power increased according to the volume to some exponent of the order of 0.71. The lower curve in the figure shows the relation with the electric converted to acoustic power. Because of the manner of making the adjustments, the sensation level produced should correspond to that considered satisfactory for ordinary speech reception in the previous sections of this paper, 70 decibels above hearing threshold. The upper curve, elevated 10 decibels from the observed one, corresponds to the level of 80 decibels already mentioned, and is intended to demonstrate the power required for music and fluctuations in dramatic speech. In the theater provision is made for reserve amplifier capacity for large

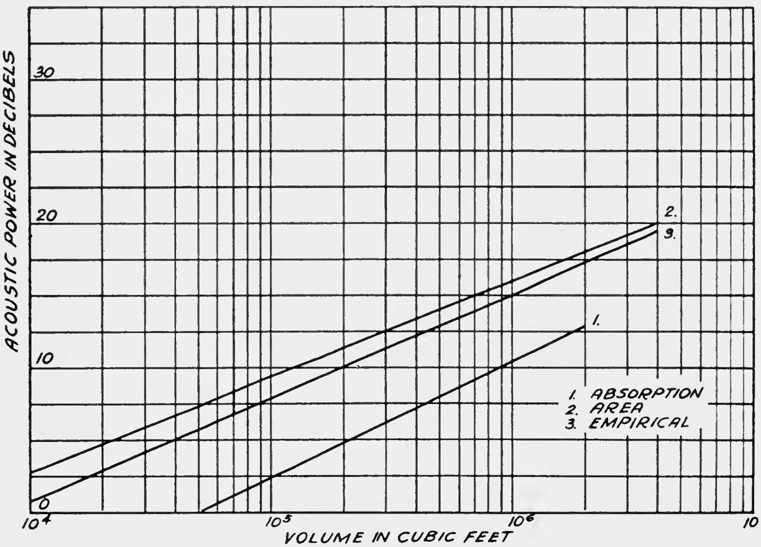

FIG. 7. Comparison of acoustic powers calculated for sensation level of 80 db.

musical numbers, explosions, wrecks, *etc.* The equation for the upper curve is

$$P_{db.} = 7.1 \log V - 27.7 \quad (8)$$

The power in microwatts is given by

$$P = 10.2\ V^{0.71} \quad (9)$$

DISCUSSION OF RESULTS

Fig. 7 shows the three curves for the required power for an 80 decibel sensation level, calculated from the optimum absorption, from the seating area, and from the actual observations. The load carrying capacity of amplifiers must be taken as some 13 decibels higher than the acoustic power given here. The empirical curve lies between the others, as might be expected, with the seating area curve representing the better approximation to it. The value of the slope, 7.1, which may be considered of more interest than the actual magnitudes of the power, is also nearer in about the same proportion to 6.7, the slope of the upper curve, than to 8.1. This seems to check our view that absorption in theaters cannot be the correct criterion for computation of power, while it is a factor of some importance.

The agreement among these curves is surprising and should be regarded as substantiating but not final evidence of the correctness of our conclusions. There are involved too many variables which are impossible of sufficiently exact estimation. The results may be used to forecast requirements in most new instances. In practice some deviation due to differing structure of theaters and efficiency of distribution of sound is to be expected as we have attempted to deal with averages here.

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GALVANOMETERS FOR VARIABLE AREA RECORDING

G. L. DIMMICK*

In the process of recording sound on film by the variable area method, it is necessary to modulate a narrow beam of light in such manner that its length at any instant is directly proportional to the sound pressure on a microphone diaphragm. This result has been successfully accomplished in four steps as follows: (1) A microphone converts the sound energy into electrical energy. (2) An amplifier makes it possible for the microphone to control a relatively large amount of electrical energy. (3) A galvanometer converts this electrical energy into mechanical energy in the form of rotational vibrations of a small mirror. (4) An optical system enables the mirror to control the length of a small beam of light which is focused upon the film. This paper is concerned with a description of several types of galvanometers used in this process and a discussion of factors in their design.

A method of coupling the vibrating mirror to the recording light beam is shown in Fig. 1. The filament of an incandescent lamp, *1*, is focused upon a small galvanometer mirror, *5*, by means of a condenser lens, *2*. In the horizontal plane the light stop, 3, is focused upon a narrow slit, *8*, by means of lens, *4*. In the same plane, lens, *7*, produces an image of the mirror, *5*, at the objective lens, *9*. In the vertical plane the mirror is focused upon slit, 8, by the cylindrical lens, *6*. The objective lens forms an image of the slit upon the film. Under normal conditions, one-half of the slit is covered with light, and the other half is dark. If the galvanometer mirror executes rotational vibrations, the light beam vibrates linearly across the slit, thereby changing the length of the illuminated image at the film.

If the galvanometer is to introduce negligible distortion into a sound record, it should meet certain definite requirements as to its characteristics. A linear relation should exist between mirror de-

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* Radio Victor Corp., Camden, N. J. (Read before the Society at Washington.)

flection and applied voltage, within the working range. The amplitude of the mirror deflection for a constant applied voltage should be substantially constant throughout the audio frequency range. No appreciable change in the phase relation of various frequencies should be introduced by the galvanometer. It is impossible with any type of vibrating mechanical system to exactly meet these requirements. The principal factors upon which distortion depends and the degree to which it can be eliminated appear from a brief analysis of the equations of a rotational vibrating system.

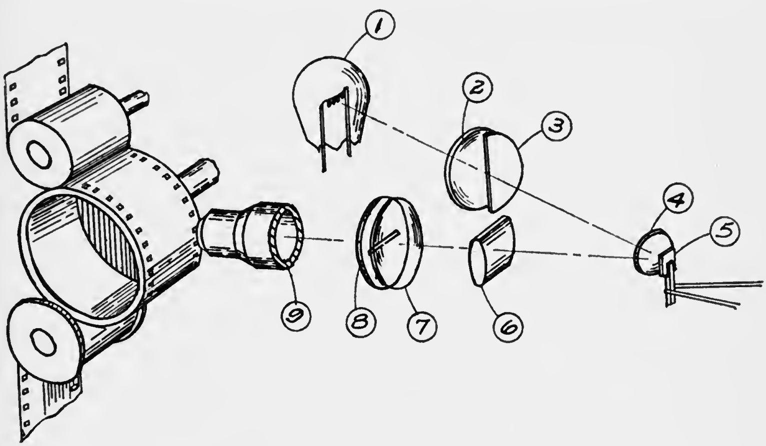


FIG. 1. Optical system for variable area recording.

The vector equation of such a system containing mass, stiffness, and resistance is

$$\Theta_m = \frac{T_m}{(s - mw^2) + j\,r\,w} \qquad (1)$$

where Θ_m is the maximum angular displacement, T_m is the maximum value of applied torque, s is the elastic restoring moment, r is the moment due to resistance, m is the moment of inertia, and w is 2π times the frequency. The phase angle between displacement and applied torque is

$$a = \tan^{-1} \frac{rw}{s - mw^2} \qquad (2)$$

The interpretation of these equations is somewhat simplified by substituting for m its equivalent s/w_0^2 where w_0 is the value of w at resonance. Also the fraction w/w_0 is replaced by u and $r\, w_0/s$ is replaced by B. Equations (1) and (2) then take the form

$$\theta_m = \frac{T_m}{s[(1 - u)^2 + j\, B\, u]} \qquad (3)$$

and

$$a = \tan^{-1} \frac{Bu}{1 - u^2} \qquad (4)$$

where B, which is called the bluntness, is the ratio of maximum

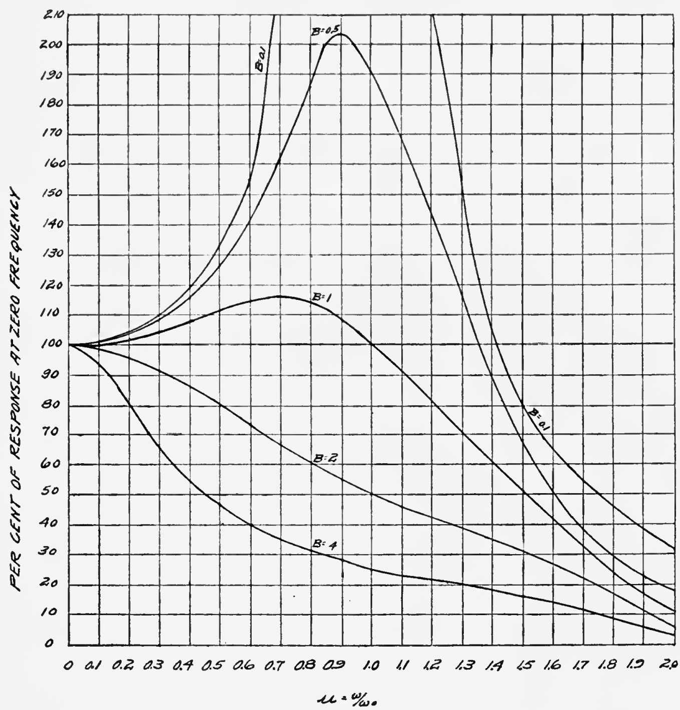


FIG. 2. Response curves for a damped vibrating mechanical system.

deflection at low frequencies to that at resonance, and u is the ratio of w at any frequency to its value at resonance. From equation (3) it is seen that θ_m at low frequencies is equal to T_m/s. If we let R be the ratio of galvanometer response at any frequency to its response at low frequencies then

$$R = \frac{1}{(1 - u^2) + j\,B\,u} \quad \ldots\ldots\ldots\ldots\ldots (5)$$

In Fig. 2 is a family of curves plotted from equation (5). These curves show that if the galvanometer is too heavily damped, that is, $B = 2$ or more, high frequencies will not receive proper emphasis in the sound record. Underdamping, $B = 0.5$ or less, results in an exaggeration of the frequencies near resonance. A galvanometer which is damped to a bluntness of one produces very little amplitude distortion between the frequency limits of zero and resonance.

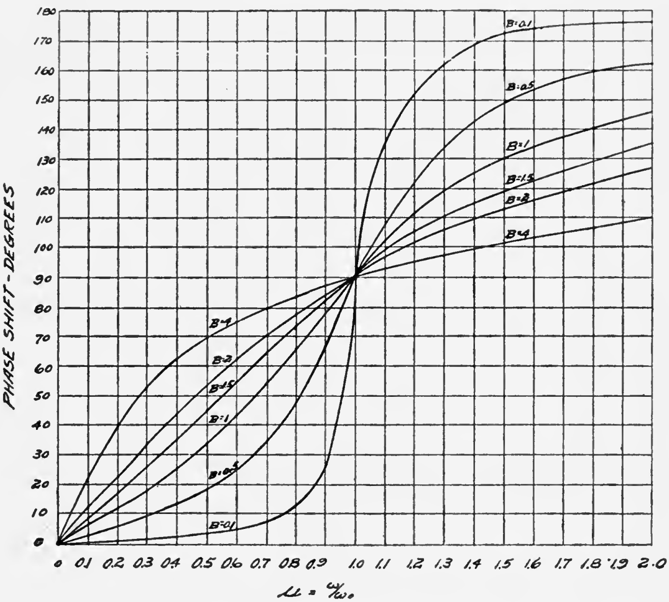
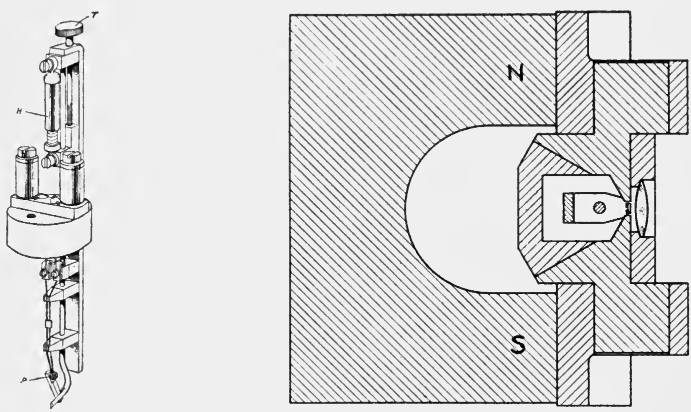


FIG. 3. Curves showing the phase shift produced by a damped vibrating mechanical system.

Within a given frequency range, it is possible to make the amplitude distortion entirely negligible by so designing the vibrating system that resonance occurs at a much higher frequency than it is desired to record. The efficiency of such a system would, however, be poor since the power required at low frequencies for a given angular deflection is proportional to the fourth power of the resonance frequency. The best condition for high efficiency and minimum distortion is obtained when resonance occurs at a frequency slightly lower than the maximum which it is desired to record and the bluntness is approximately one.

In Fig. 3 is shown a family of curves plotted from equation (4). These curves show the relationship between phase shift due to the galvanometer and the fraction w/w_0. An inspection of these curves shows that at resonance a phase shift of 90 degrees occurs regardless of the amount of damping used. A very small amount of damping, $B = 0.1$ or less, produces practically no phase shift below resonance, a sudden reversal of phase at resonance, and 180 degrees shift for higher frequencies. Excessive damping, $B = 4$ or greater, causes a rapid change of phase with frequency up to resonance. For values



A B

FIG. 4. (A) The construction of vibrator unit for the oscillograph galvanometer. (B) The magnet assembly for the oscillograph galvanometer.

of u greater than one, overdamping produces less phase shift than that resulting from insufficient damping, but for values of u less than one, this condition is reversed. A most interesting condition arises when the damping is such that $B = 1.5$. From Fig. 3 it is seen that the curve for $B = 1.5$ is almost exactly a straight line from $u = 0$ to $u = 1$. In other words, the phase shift is directly proportional to frequency within this range. If a galvanometer which fulfilled the above condition were used to record a complex wave on a film traveling at constant speed, each of the component frequencies would be given the same linear displacement, and no phase distortion would result for frequencies within the range from zero to resonance. In the case of a galvanometer resonating at 5000 cycles per second with a film speed of 90 feet per minute, this displacement amounts to approximately nine-tenths of a mil.

Nearly all of the Photophone recording units in use at the present time are equipped with oil damped galvanometers of the type shown in Fig. 4. This particular design is the one used in oscillographs manufactured by the General Electric Company. The requirements of an oscillograph vibrator are very similar to those for variable area sound recording. This made it possible to incorporate into the design of the first recorders a galvanometer which had already been in use for many years.

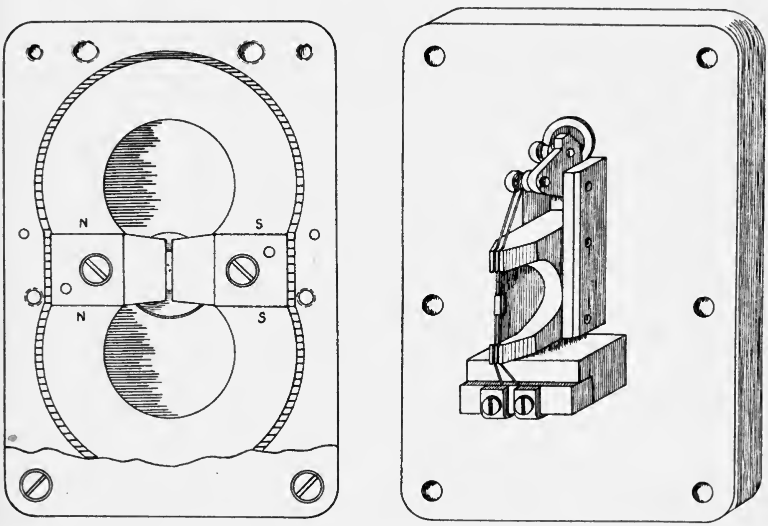


FIG. 5. The construction of an improved oil damped galvanometer.

The construction of the vibrator unit and magnet assembly are shown in Fig. 4. A continuous loop of thin molybdenum strip is stretched over an insulating bridge and around a pulley as shown. The two ends of this strip are fastened to the vibrator frame and insulated from each other. The loop is kept in tension by a spring which is enclosed in a housing, *H*. This spring acts on pulley, *P*, with a force which can be controlled by thumb nut, *T*. A small mirror is cemented to the two strips midway between the bridge supports. The vibrator unit is lowered into a well of oil which encloses the ends of two soft iron pole pieces. A small gap between the pole pieces accommodates the two strips. The flux from a large permanent magnet is concentrated in this gap in the plane of the strips. If a voltage is applied to the vibrator terminals, current passes down one strip and up the other, producing a torque, proportional to this current. The mirror, suspension, and oil form a damped rotational vibrating system, some of the properties of which

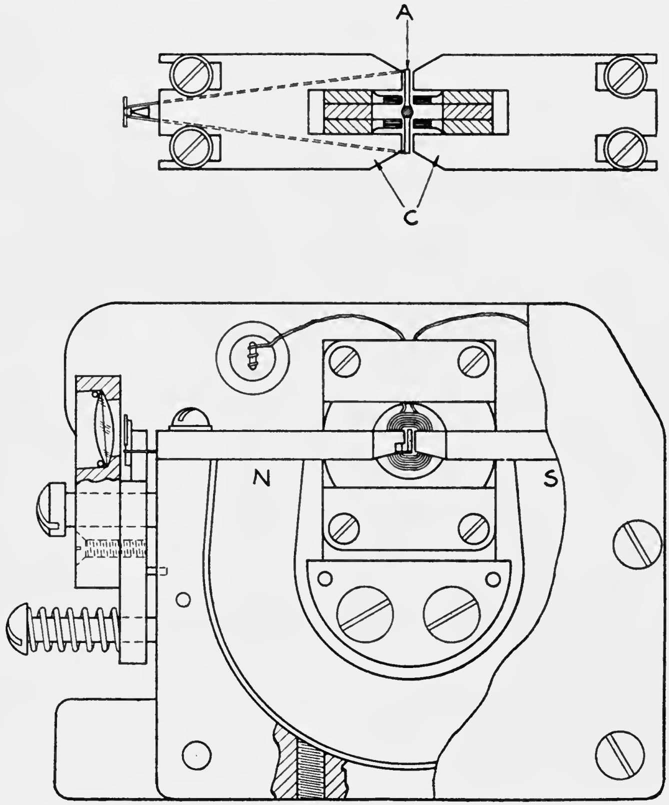


FIG. 6. The construction of the new dry damped galvanometer.

have been discussed. Sufficient tension is applied to the strip to make the system resonate at about 5000 cycles per second. At ordinary room temperature, the bluntness is about seven-tenths. Galvanometers of this type are rugged enough to be practically unaffected by external vibrations and will stand considerable abuse without failing. When used with a reasonable amount of care, they are capable of making excellent sound records.

Another galvanometer of the oil damped type has recently been designed, which incorporates several features not found in the oscillograph vibrator. A photograph of this galvanometer is shown in Fig. 8 (center), and a sketch illustrating its construction is shown in Fig. 5. The principal improvements are its small size, its oil-tight construction which enables it to be used in any position, and its complete freedom from external adjustments of the vibrating system. The mirror size, dimensions of strip, and distance between bridge supports are the same as in the oscillograph galvanometer. Molybdenum strips are used under sufficient tension to make the system resonate at about 6000 cycles per second. The bridge,

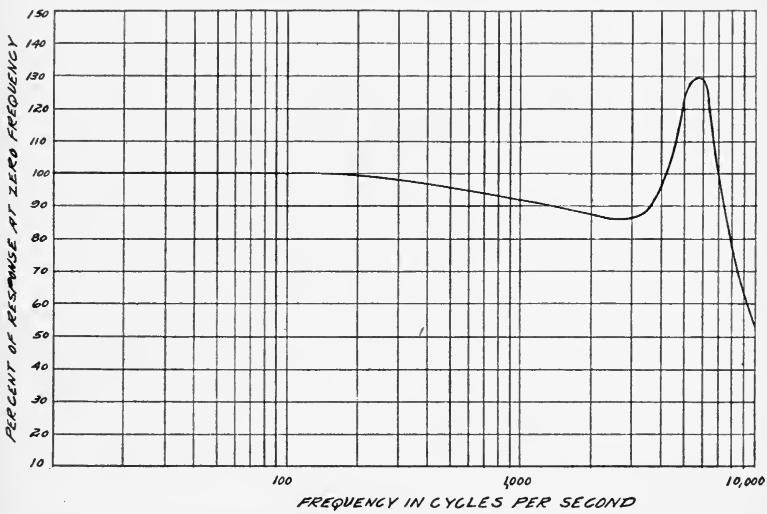


FIG. 7. Frequency characteristic of the new dry damped galvanometer.

between supports, clears the suspension strips by about five mils. This construction provides the necessary damping with a thinner oil than was previously used, and results in a decreased effect of temperature upon damping. Two cobalt steel magnets in parallel furnish the necessary flux in the air gap.

In order to keep the resonance frequency high and at the same time attain sufficient sensitivity, the galvanometer mirror in both of the previously described designs is necessarily small. Its light-gathering power is adequate to meet the needs of sound recording in its present stage. The coming of wider sound tracks and higher film speeds, and the desirability of using slower photographic emulsions in order to gain resolving power, will greatly increase the requirements as to light-gathering power of recording galvanometers. To meet this demand, a new galvanometer has recently been developed which utilizes a mirror of approximately fifteen times the area of the oscillograph mirror. A photograph of this galvanometer is shown in Fig. 8 (right). Its design is a radical departure from that of the others described in this paper. The principal features of this new galvanometer are its large mirror, its method of damping without oil, and its rugged construction.

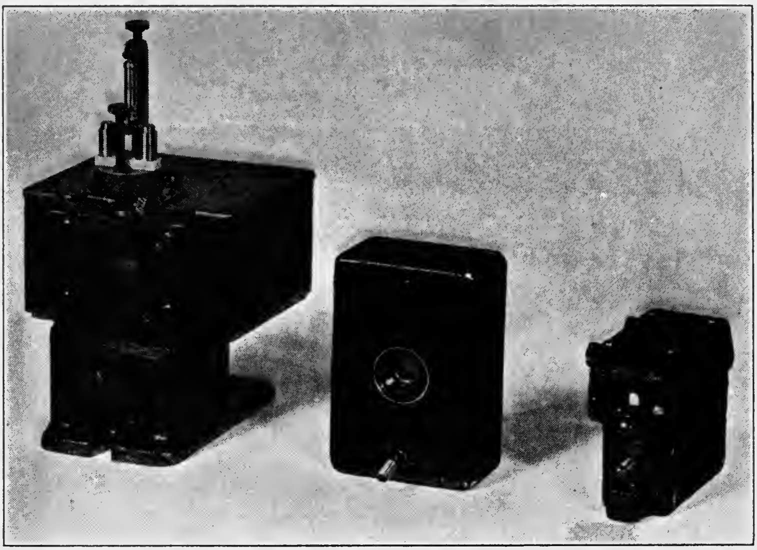


FIG. 8. Comparison of three types of galvanometers.

Work on dry damped galvanometers of the electro-magnetic type was started about a year and a half ago by Mr. C. R. Hanna of the Westinghouse Electric and Manufacturing Company. Shortly after this, the writer took up the idea and began work on the design which will be described here. Continuous development lasting for a period of more than a year was necessary to bring this design to its present form.

In Fig. 6 is a sketch showing the general construction. A soft iron armature, *A*, is supported at the upper end of a small steel rod, the lower end of which is solidly clamped to the frame. Two annealed silicon steel pole pieces are placed one on either side of the armature and fastened to the main casting. Both pole pieces are slotted at the ends nearest the armature to provide room for two coils of copper wire which surround the armature but are not in contact with it. The two ends of a loop of phosphor bronze ribbon are fastened by means of solder to the two ends of the armature, A. The loop of ribbon passes through slots in one of the pole pieces, and around a small semi-cylindrical rod, carrying the mirror. The flat side of this rod is provided with a groove which allows it to pivot about a knife edge upon which it rests. The ribbon is kept under tension by a spring. This arrangement is in effect a mechanical transformer which steps up the amplitude of the rotational vibrations of the armature in the ratio of about ten to one. The flux from a permanent magnet is concentrated in four air gaps, two at each end of the armature. The width of each air gap is about twenty-five times the maximum armature displacement necessary for full modulation. The armature is in stable equilibrium between the pole pieces and has no tendency to shift from its position after it has been centered.

Damping is effected in this galvanometer by a rubber pad placed between the coils and straddling the armature. This pad is of pure gum, long-life rubber, impregnated with tungsten powder to increase its mechanical resistance.

The effect of sending a current through the two coils in the same direction is to increase the flux density in two diagonally opposite air gaps and to decrease it in the other two. A torque is thereby set up which is proportional to the current, up to the point where the armature saturates. The magnetic circuit is so designed that armature saturation occurs for a current about three times that required for maximum modulation. Saturation protects the galvanometer from mechanical injury in case of abnormally large surges of current which often occur when the microphone receives a sudden jar.

There are many advantages resulting from the use of a mechanical transformer for increasing the armature deflections. The smallest armature which it is practical to use in this type of driving unit weighs many times as much as the mirror which it is desired to drive. It can be shown that under this condition maximum mirror deflection per unit armature torque is obtained when the mirror and armature are coupled together in such manner that the moment of inertia of the mirror multiplied by the square of the ratio of transformation is equal to the moment of inertia of the armature. The increased efficiency obtained in this way is utilized to increase the galvanometer sensitivity, to make its construction more rugged, and to improve its frequency characteristic.

Fig. 7 shows a frequency characteristic taken on a galvanometer of this design. Constant voltage was maintained at the grid of the last amplifier tube while the frequency was varied. The power sensitivity of a dry galvanometer having the above frequency characteristic is greater than that of the oil damped galvanometers previously discussed. The relative size of the three types of galvanometers is shown in Fig. 8.

DISCUSSION

Mr. Kellogg: Mr. Dimmick gave credit to Mr. Hanna for stimulating our work on the dry galvanometer. Mr. Hanna has told me the considerations which lead him to look for success in the application of this type of magnetic system to recording and oscillograph galvanometers. He had made an analysis of the iron armature type of loud speaker motor, in a 1925 I. R. E. paper. In this paper he established the relation between the magnetic reduction of stiffness and the force produced for the given amount of power from an amplifier. The analysis showed that the more of this magnetic reduction of stiffness you can permit, the more efficient you can make the motor. In a loud speaker the magentic reduction of stiffness is a limitation. This factor is not present in the moving coil design. That is why the moving coil design has won out for loud speaker drives. We didn't get good loud speaker reproduction until we began to use diaphragms with very low natural frequencies. The necessity for a very flexible mounting was such a handicap to the motor which depended on a magnet pulling on a piece of iron that that type of motor was killed. Mr. Hanna applied the same reasoning to the oscillograph and there the boot is on the other foot. The oscillograph galvanometer must have a high natural frequency and here a moving iron armature shows up to much better advantage. As Mr. Dimmick pointed out, with the same input from the amplifier, he is able to move a mirror of fifteen times the area through the same angle, and keep the natural frequency as high as with the standard or dynamic type, which belongs to the moving conductor class.

Mr. Ross: I should like to ask what kind of mirror is used. Unless a perfectly plane reflecting surface is used, there is apt to be a good deal of light dispersion causing fringing at the recording edge of the light beam introducing distortion in recording.

Mr. Dimmick: The mirror is made of a good quality glass and is 100 mils wide, 125 mils high, and 5 mils thick. We have had no trouble from the source which you mention.

PROGRESS IN MICRO CINEMATOGRAPHY

HEINZ ROSENBERGER*

At the fall meeting in 1927 a paper on *Micro Cinematography* was given in which the usefulness of the motion picture not only for the demonstration of microscopic phenomena but also its application in medical and biological research work was described.

The work done in the last two years has been toward improving the technic of taking micro cinema records and also toward the improvement and the standardization of the necessary equipment. At the spring meeting in 1929, a description of the Standard Micro Cinematographic Apparatus was given. With this apparatus every scientist is able to obtain good results as the handling of the apparatus is very much simplified. It is fully automatic and can be left going for days without attention excepting the control of focus from time to time and more often when higher magnifications are used.

For accelerated film records, and most of the cell work is accelerated, the frequency, for instance 1, 2, 3, 4, 6, 8, 12, *etc.*, exposures per minute can be adjusted on a dial of an electric clock. The length of exposure can be adjusted on a screw on the timing device, so also can the time be set when the machine should start or stop by the use of an additional time clock.

The number of adjustments on the standard apparatus is now reduced to a minimum and therefore the handling is much simplified, leaving the attention of the operator mainly on the subject to be photographed. When an object, for instance a living cell, is to be photographed the following manipulations have to be done: After placing the slide under the microscope the object can be viewed through the focusing device in very much the same way as by ordinary observation. The rate of exposure is then to be adjusted by turning a hand on the dial to the proper number. Then a test strip of film can be taken and developed. Under or over exposures can be regulated by turning the adjusting screw of the timing de-

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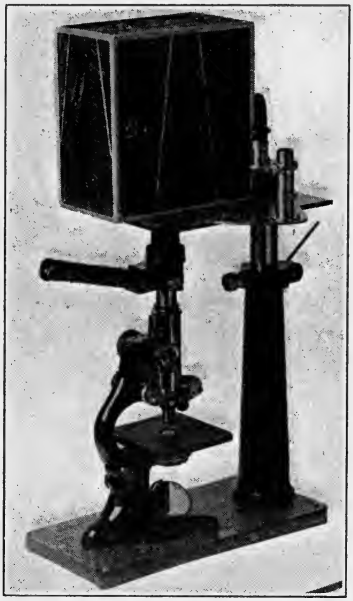
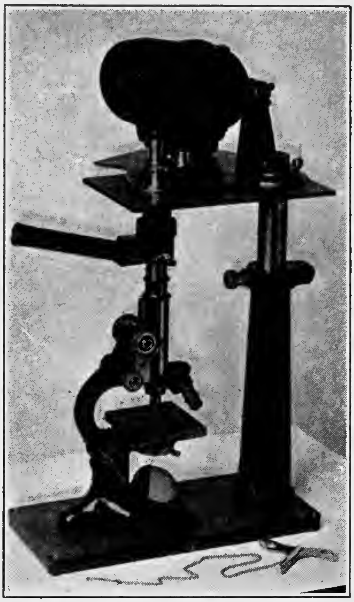
vice either to the left for longer exposure or to the right for shorter exposure. For higher frequencies and when using arc light, the sector of the revolving shutter has to be adjusted.

The main direction of our research work during the last two years, since the micro film was shown, was toward higher magnifications in order that something about the structural details of living tissue cells may be revealed. It was also anticipated to keep cells alive and under observation for a longer period of time than was possible

With Cine Kodak Model A With Filmo Camera
Micro cinema apparatus for 16 mm. cameras.

before. This was accomplished by the development of a special culture chamber, which was manufactured with the coöperation of Zeiss.

I want to point out here that the difficulties of micro cinema work with high magnifications increase by arithmetical progression. Suppose we are looking at the moon through a telescope. When it is a low powered telescope the moon will move slowly across the field of vision, due to the rotation of the earth. With medium powered telescopes the moon apparently will move very much faster across the field, while with high powered telescopes one can hardly follow the motion.

The same is true with the microscope. The higher the magnification, apparently the faster is the speed with which the objects move. The faster the speed of the objects, the more frequent exposures we have to make. The more exposures we take per minute or second, the greater must be the light intensity to give the film the proper exposure, but the more injurious is the light to the delicate objects. And last but not least, the higher the power of the objective the less depth of focus we have in the field and the more difficult it is to keep the preparation in focus. I have not yet mentioned the great danger of transmitting vibrations from the moving parts of the apparatus or from some outside disturbances to the microscope, for naturally vibrations also are magnified.

Magnifications are measured with an object micrometer, in which one mm. is divided into 100 parts. This micrometer is photographed on the film.

The magnifications which were mainly used several years ago were ranging from 60 to 120 X on the film frame. Last year's experiments were generally made with a magnification of about 600 X on the film frame. In several cases, however, a magnification of 1250 X, which is about the limit, was used. It should be mentioned here that these figures should be multiplied by about 2.5 in order to obtain the magnifications with the same optical equipment when one looks through the microscope. The highest magnification would then be around 3000 X. Abbe claimed that the limit of microscopic magnification in white light is reached at about 1500 X.

Another point of consideration, especially when dealing with living cells under high magnifications, is the lack of contrast of these delicate structures. Very often these cells cannot be recognized by a layman at all when he looks through the microscope, as their appearance is clear as glass and there is very little difference between the cells and the surrounding medium. A vital stain, such as neutral red or Janus green, as frequently used in tissue culture work has not been used with high magnifications as these stains seem to have a deleterious effect on the cells in combination with the strong light. Because of some chemical reactions within the cells or else because of the absorption of heat, the cells either do not behave normally or else die very rapidly.

It is possible, however, to increase contrasts photographically. It is a well-known fact that various photographic emulsions can reproduce an object with greater contrast than actually exists. It is possible to photograph, for instance, an article with very slight variations of gray, hardly noticeable to the human eye, so that these variations become almost black and white in the reproduction. The photographic emulsion can detect differences in shade which are invisible under normal circumstances. We have employed the above-mentioned properties with great advantage in micro cinema work in the detection of cell structures which are otherwise invisible. Motion picture records have been made, for instance, of white blood cells which show clearly that these cells are surrounded by an undulating membrane, much larger in area than the cell itself. Furthermore, records have been taken of *fibroblast* cells in which the *mitochondria* move about like snakes. The function of these cell bodies is not as yet clearly understood.

A MICRO CINEMATOGRAPHIC APPARATUS FOR 16 MM. MOTION PICTURE CAMERAS

In order to enable the owner of a 16 mm. motion picture camera to make film records of microscopic phenomena a small and inexpensive outfit has been designed which has many uses in a scientific laboratory, especially where objects have to be photographed without going through cumbersome preparations.

The outfit consists of the following parts: the base plate on which the microscope is placed, an adjustable column with two key ways and two set screws, a fixed plate with camera opening, a swivel plate, a camera holder, a combination focusing and beam centering device, and a telescope connecting sleeve. This apparatus adapted for the Bell & Howell Filmo and for the Eastman Cine Kodak Model A is illustrated in the figure.

The handling of the apparatus is very simple. The microscope, of any make, can always be used in the ordinary way and is only placed on the base plate when film records have to be taken. When brought in line with the focusing device once it will always be in line thereafter, when metal strips are screwed on the base plate after the first adjustment. Then the connecting sleeve is put in place. It should hang from the fixed plate into a microscope collar of cardboard or metal without touching it. The object can be viewed through the focusing tube in very much the same way as by ordinary microscopic observation, using coarse or fine adjustment on the microscope. Then the picture can be taken at once by swinging the camera in position over the microscope. The beam of light needs only to be adjusted once by looking into the beam centering tube and at the same time turning the microscope mirror into the proper position so that there is an even distribution of light over the field.

For general work there is practically no vibration transmitted from the camera to the microscope and many pictures have been taken even with very high magnifications, being absolutely sharp in focus. Sometimes, however, it may become necessary, especially when preparations in the "hanging drop" are to be taken, to safeguard them from the slightest amount of tremor. This is easily done by placing the microscope on a separate table and turning the entire upper part of the apparatus 180 degrees, so that the focusing tube is again in line with the microscope. The focusing and taking of films are otherwise done in the same manner as described above.

Any make of 16 mm. motion picture camera can be used with this outfit.

SYNOPSES OF TWO REELS

DEMONSTRATING MOTION PICTURES OF MICROSCOPIC OBJECTS

Reel 1.—Living Cells of the Blood.

- The beating heart of a frog.
- The blood flow through arteries, veins, and capillaries.
- Various types of white blood cells.
- *Macrophages* from Jensen *sarcoma.*
- Sudden death of a *macrophage.*
- Cells of *necturus* showing thread-like *pseudopods.*
- Cells of *necturus,* high magnification, showing membrane.
- Records of cell divisions and *phagocytosis.*

Reel 2.—Cells of Living Tissue.

- Beating fragment of heart tissue from a chick embryo.
- Growing culture of *fibroblasts,* low power.
- Two single *fibroblast* cells, high magnification, showing details of structure.
- Normal rat *fibroblast.*
- Malignant rat *fibroblast.*
- Details of cell structures under very high magnification, nucleus, *nucleolus mitochondria, etc.*
- Rat *fibroblast* forming new cell branch.
- Culture of nerve fibers.
- Growing end of a single nerve fiber.

Pigment *epithelium*, high magnification.
Cell division of a *fibroblast* (high power).
Cell division of a *fibroblast* (very high power) showing interior of cell.

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DISCUSSION

PRESIDENT CRABTREE: Gentlemen, I think we have witnessed one of the finest motion photomicrographs ever made. No doubt these researches of the photomicroscopist are going to throw a great deal of light on metabolism and the causes of health and disease.

MR. ZWORYKIN: Is this rapid motion of particles shown on the film similar to the Brownian movement, and is it the result of the bombardment of the larger particles by the random motion of the molecules with some oriented components?

MR. ROSENBERGER: It may be that there is a flow of protoplasm inside of the cells. Those granules in the film are very large compared with the small ultramicroscopic particles, the motion of which is presumably caused by bombardment. I have taken a film of ultramicroscopic particles in motion (Brownian movement) of gold and silver colloids which I have here and which I can show if you wish. In order to shorten my paper I refrained from showing it.

TELEVISION SYSTEMS

C. FRANCIS JENKINS*

So far as I am aware all the thousands of engineers who are engaged on television development are working on the same method of analysis and synthesis.

This consists of the scanning of the object as a single point at any instant considered; and similarly building up the received picture point by point, with never a moment when there is more than a single point on the eye of the observer.

There is, therefore, no picture except in the persistence of the brain image of these successive elementary areas. But the light points of the picture are assembled so quickly that the picture seems to be a real image, and to reside in the plane of the scanning disk, or comparable mechanism.

Persistence of vision is, therefore, an essential factor in the present system of television and radiomovies, just as it is in the movie theater.

But this persistence of vision is thousands of times more handicapped in radiomovies than it is in theater reproduction of film pictures.

In theater projectors the shutter wastes half the light; but in television reproduction the observer sees but a twenty-five hundredth part of the light.

Really, it is nearly three thousand times worse than even this first loss would seem to indicate; it is a loss represented by the product of one sum by the other. The loss is in the order of six million to unity.

This, then, explains why the present accepted system of television cannot be expected ever to produce entirely satisfactory pictures. It is astonishing that we get the pictures we do; and that is not saying very much, either.

With the present method, no large pictures can be produced

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with the drum and quartz rod mechanism, although with this drum scanner we are getting the largest pictures yet obtained, but they are only about 6 × 8 inches. The drum is only an improvement on the disk scanner; the fundamental principle remains the same. In either device the light which reaches the eye is never more than that which gets through a single aperture, namely, that representing an elementary area of the picture, or about one twenty-five hundredth of the whole picture surface.

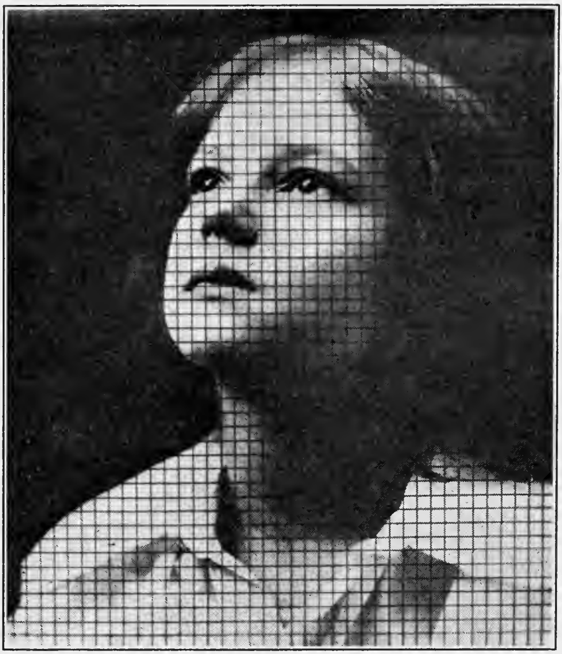

Illustration of a lantern slide made up of elementary areas.

I am not suggesting that the drum type scanner is to be abandoned; it is the best yet found, and serves a useful purpose in the home. But neither the drum nor the disk can ever be made to project a theater picture, because no light can reasonably be expected ever to be found which will be six million times more intense than those now available, and still have the required light-change time-factor, say, a million light changes a second. Opportunity for development must be looked for in other directions.

A study of the problem seems logically to suggest a lantern slide in which the density areas of its picture are changed in accord with the changes in the lens image of the subject-scene at the distant broadcasting station.

In standard use today we have two projection schemes to serve a large audience; one is the usual magic lantern slide, a still picture; the other is a moving picture, made up of a great number of stills projected onto the screen in rapid succession to simulate motion. The newly proposed scheme is a magic lantern slide, the density areas of which may be changed at will. That is, if these elementary areas of the picture could be changed in density from moment to moment, then the resultant picture itself would change.

Our concept consists, as shown in the illustration, of a picture divided into 2304 elementary areas, *i. e.*, 48 lines of 48 elementary areas in each line, much like halftone picture dots; and if these elementary areas or dots can be changed the picture changes, and we have a motion picture.

Structurally, this new lantern slide consists of a cellular structure of 48 rows with 48 cells in each row. These cells may be of any desired size, for example, a quarter inch square, making up a lantern slide one foot square.

It resembles a honeycomb, with miniature square cells 4 inches long. These are built up of 48 glass strips, 12 inches long and 4 inches wide. The strips are set into a frame fixedly at top and bottom. Between these vertical glass strips, other little strips of glass, about $^1/_4$ inch wide and 4 inches long are placed like shelves, the whole making a cellular frame having a combined one foot square clear opening therethrough.

Now if a satisfactory scheme could be devised for closing at will each of these tiny cells, dark areas could be built up, and these dark areas might easily represent figures. And changing the figure means only that some of the closed cells would be opened and new ones closed. If this rearrangement is completed every fifteenth of a second, for example, a motion picture results. And again as these changes are made by incoming controlled radio signals, each change of figure represents the image at the distant broadcast station.

Now for opening and closing the cells, there is in each cell an electrostatic valve of aluminum foil. Each foil blade lies on the floor of the cell, and is changed by voltage-amplification of the incoming radio signals. Each charge either closes the cell for totality, or only partially closes it for halftone values. The values must also discharge in one tenth of a second at longest to make good motion pictures; and are in staggered relation to prevent mutually induced capacities.

Now to project this changing figure onto a theater screen, it is only necessary to place an arc light, or other acceptable light source, behind this cellular lantern slide; and to put a projection objective in front of it to image this changing lantern slide figure on the screen in front of the audience.

Perfectly simple, isn't it? I hope some day to say it is simply perfect, and to demonstrate it by actual transmission of radiomovies from our broadcast station, and projected reception of the same at one of our subsequent Society conventions.

So the day seems now within sight when distant scenes and events may be reproduced on the screens of theaters; and when motion pictures will be distributed from Hollywood to the nation's theaters direct by radio instead of film.

DISCUSSION

MR. E. D. COOK: As I understand it, there were 48 lines with 48 elements in each—probably about 2500 dots which had to be reproduced about 16 times per second and this makes about 40,000 cycles for pictures now being sent by Mr. Jenkins' station. I was interested in the way the cells were actuated to reduce the speed requirements of each cell and in the problem of bringing the frequency mentioned before into the broadcasting station from an outside source. I should think that every time the weather changed the signal would vary so much that it would give trouble in the picture.

MR. JENKINS: The contact for each cell has identically the same time factor as is employed in the single light spot. That factor has not been changed, but the light valves have 1/15 second action time instead of 1/35,000 second. That is probably the greatest merit of the system. We are setting up a multiple plate for a fixed source of light to be projected on the screen. I have spoken of it as a lantern slide because it is fixed. If we make the elementary picture areas, factors to control at will, we have a changing picture on the screen. The time factor is identical in both schemes and is the contact time. This is the same as the duration time of the signal representing that area—1/2304 second.

MR. COOK: How about the transmission line? Do you have trouble there?

MR. JENKINS: I don't think so, because we have been broadcasting for almost two years, and our reports have come not only from amateurs but also from the radio supervisors of three radio districts. The supervisor for the district including Detroit is one of the most enthusiastic boosters for the scheme we employ.

MR. ROSS: I should like to ask if a differing transmission frequency is used for each valve.

MR. JENKINS: No, the radio signals are distributed by commutator to each cell in turn.

MR. GAGE: To those familiar with the work which has been done on television in the past, particularly with the device using such a distributor as set up in the Bell Telephone Laboratories, the practicability of the whole thing is apparent provided we can get a cell which will respond as Mr. Jenkins suggests, and it is only necessary to construct one cell which can be reproduced, and then we can make as many million as we desire. I should like to ask if any of these cells have been constructed that are satisfactory.

MR. JENKINS: Yes, we built 36 elementary cells—6 each way. Each little valve is an independent thing, to be pulled out with your fingers for repairs. You make any modification you like and put it back. I should like to take occasion at this point to call your attention to what the Bell Telephone Company did in the twisted neon tube cell. No one of these elementary areas persisted in luminosity, and that is particularly the merit of the new scheme. As long as our eye is employed to maintain the persistence of the apparent glow of each spot, we have gained nothing, but if we can substitute persistence of valve action to produce persistence of light of each elementary area we have solved the problem. That is the distinction between the long neon tube with tinsel spots fastened to the back of the glass, employed by the Bell Company. I don't think my idea was ever anticipated. Remember we will never succeed in radiomovie projection as long as we depend on persistence of vision to complete the image. It must be completed in the mechanism itself, and not built up in our heads. There is no picture on the whirling disk or drum, as there seems to be. When you slow the motor to a stop you find you have been looking at one spot only and the picture was built up in your brain. But the new picture can be photographed with the snapshot camera. If the Doctor will make a liquid cell for us and sweep across it radiation of some kind causing varying densities where the radiation strikes the cell, I will give him a million dollars for it, because I can then sell it for ten.

MR. TAYLOR: If Mr. Jenkins would be satisfied to show slow action, it would not be necessary to use so many light charges. Usually in television we have a close-up of a person talking. Such a picture might be shown with materially less than 16 a second and the screen image would be just as bright.

MR. JENKINS: That is true, but it seems hardly worth while to tackle anything but the hardest problem first. If we expect to distribute motion picture plays from Hollywood by radio, we might as well accept the difficult situation as it stands. So we have built a valve having 1/10 second action time. Thus we have solved the problem, and if we can get one satisfactory valve acting that fast, we have only to multiply it by the number needed for the entire lantern slide.

We have found a pair of satisfactory blades, the heavy one of which is 0.008 inch thick, the other of aluminum foil; we slide it into the cell so that it will be held on the floor of each of the little cells, and as we slip it in, it makes contact with the wire. These are parallel to the projection light so as not to interfere therewith. The wires with their insulation are only equal to that of the glass thickness, that is, lantern slide glass cut into strips. On top of the fixed blade is the one of movable foil. We are using 15 pictures a second because we want to use it to receive pictures from our broadcasting station at that rate. If we want to use synchronous motors we tackle only one problem at a time as both motors would be in synchronism with the power house. We do know that 15 pictures a second are quite possible with these electrostatic valves. I have not mentioned why the valve blade performs so fast. In front of the charging blade of the signal distributor is a discharging blade so that if the valve is not to be recharged on the second trip of the distributor, the valve is discharged and shuts down, and light passes through; but if it is again charged on the second trip around, the discharging valve drains the static charge off the valve so that it doesn't stay open. Obviously we can have light passing through the cells all the time and then make the valves close to build up the shadows, or have them closed all the time and open them for our pictures.

MODERN PRACTICE IN INCANDESCENT CINEMA STUDIO LIGHTING*

W. A. VILLIERS

The following notes are intended to give a brief description of methods of incandescent lighting employed in British studios with particulars of the theory and design of some of the apparatus used, showing how this apparatus differs from Continental and American practice.

There are a great many difficult problems involved which have needed the combined experimental and research work of studio engineers and equipment manufacturers.

A great deal of such work has been done here during the last few years so that some of the British studios now have incandescent equipment which is superior to any such equipment in other countries.

A good many different types of lighting units are used in the production of a picture, but for descriptive purposes these may be conveniently grouped under five headings:

1. General lighting over the whole set.
2. Lighting for close-ups.
3. Spotlighting.
4. Sunlighting.
5. Effect lighting.

All of these are probably not used on any particular set, but the lamps and fittings required for each type of lighting are distinct and made for their own particular function—to give a certain intensity of illumination over a certain area.

For general lighting a flood of lighting is required over the set. The intensity of illumination depends largely on the character of the set and the methods of the cameraman; some cameramen use a great deal of light and stop down; others prefer to use larger apertures and less light. An average illumination for general lighting, however, is about 400 foot candles.

* Read before the London Section.

The lighting units employed for general lighting consist of banks of lamps having a reflecting surface behind them which are slung over the set. Various sizes of lamps have been tried but 1500 watts is now becoming standard.

These overhead units are designed to accommodate different numbers of lamps, the most used sizes having 4, 6, and 12 lamps (See Fig. 1.) Tests have been carried out on many materials for these reflectors. First of all mirrored glass was used and was found to be very efficient, the reflection factor being about 85 per cent. It had disadvantages, however, in that it was fragile, expensive, and

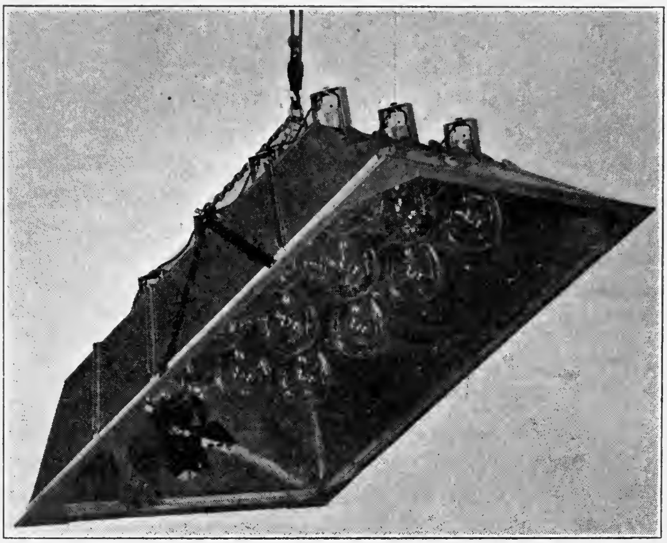

FIG. 1. Overhead lighting unit.

extremely heavy, also difficulties were experienced due to the silvering failing under the action of heat from the lamps. It is still employed in some general lighting fittings in America.

Chromium plated brass and stainless steel have also been tested. These again, while being fairly efficient—57 per cent for stainless steel and 63 per cent for chromium plate—are heavy, expensive, and deteriorate under the action of heat.

The next material used was white enamelled sheet steel. This is comparatively light, has a reflection factor of 75 per cent when new, and is inexpensive. Reflectors made of this material have been successfully used in a number of studios, and are still employed in some. In Germany practically all bank type fittings are constructed of this material.

The latest practice in this country is to use polished aluminum as this has the advantages of white enamelled sheet steel, together with the most important advantage of extreme lightness. Its reflection factor is approximately 76 per cent and this does not deteriorate greatly during use.

For general lighting and close-up lighting from the floor similar bank type units with a number of lamps mounted on stands were at first used, and this is still done to a large extent in German studios. It has been found more convenient here, however, to make use of single lamp units and flooded spotlights for general side lighting as these are more mobile and the lighting may be made more flexible.

The close-up fitting most generally used here consists of a simple rectangular aluminum reflector fitted with one 1500 watt lamp and mounted on a telescopic stand, provision being made for diffusers in front of the lamp.

For these close-up fittings mirrored glass has also been tried and, in fact, a circular mirrored glass reflector is largely used in America at the present day. We found, however, that the silvering deteriorated under the action of heat and that aluminum reflectors gave better results with less cost.

For spotlighting very high intensities indeed are required in order to produce high lights in a scene which is already brilliantly illuminated to, say, 400 foot candles. The actual intensity required varies from about 500 to 4000 foot candles.

In Germany and in America the first incandescent cinema studio spotlights used were adapted arc lamps with the carbons removed and an incandescent lamp substituted. Later models have had a number of alterations made but in general they follow arc lamp practice very closely.

In this country spotlight apparatus has not been evolved in this manner but designed from first principles and the lamps and lamp houses have been designed together in order to obtain the maximum efficiency and greatest ease in operation. (See Fig. 2.)

Various optical systems were tried out with numbers of different kinds of lamps, mirrors, and lenses. A lot of tests were carried out with rough models at Elstree before the spotlights were actually manufactured and many designs were tried out and discarded before a satisfactory spotlight was made.

The requirements of the studios are that the spotlight should give a very high intensity with even light over the area of the spot, that is to say, there should be no black center or filament image; the light must be variable from almost parallel to a wide angle beam.

It was found that the best all-round results were obtained with a

FIG. 2. Spotlighting unit.

ground glass parabolic mirror of special focus used in conjunction with a 3 kw. projector lamp. The filament of the lamp is curved roughly to the contour of the mirror so that the whole of the filament may be brought near the focus of the mirror.

At first, difficulties were experienced due to overheating and melting of the glass bulbs when the lamps were burned at large angles. This difficulty was overcome by using a harder glass and altering the position of the filament in the bulb. The spotlight mirrors are made detachable, and three types of mirrors may be used:

1. Parsons parabolic, which is the most useful.
2. Facetted glass for greater diffusion.
3. Polished aluminum which gives a softer beam than the silvered glass.

In front of the lamp provision is made for two diffusing glasses.

Another type of spotlight that has been developed is known as an effect spotlight. The object with this spot was to obtain the highest possible intensity from the smallest practicable spotlight. A special 2 kw. lamp is used which has a 6 in. diameter bulb.

As the spotlight must be very small, it is not feasible to employ the same optical system as that with the 3 kw. lamp house because, if a parabolic mirror were used, most of the light issuing from the spotlight would have first to pass three times through the bulb of the lamp, resulting in inefficiency. The German practice is to compromise by making the spotlight considerably larger and using a facetted parabolic mirror.

In this country we collect the light with a spherical mirror which reflects it back on to the filament. In front of the lamp is placed a special lens which is made of short focus so as to reduce the over-all length of the spotlight and to enable the lamp to be brought near to the lens for high efficiency. This lens is not thick like a normal short focus lens but is of stepped construction in order to keep its absorption low.

The American practice for small effect spotlights is to use a similar optical system but with an ordinary thick longer focus lens in front as is used on condenser arcs. For this reason the American effect spotlights are larger and less efficient.

For sunlighting much higher intensities are required even than for spotlighting, a normal figure being of the order of 4000 foot candles so that the maximum candle power in the beam of the lamp must be three or four million; 5 and 10 kw. incandescent lamps are used in a lamp house having very much the same optical system as the 3 kw. lamp house. With these 5 and 10 kw. lamps special construction is necessary in order to get the heavy current of 50 and 100 amperes into the glass bulb without cracking the glass. Further problems are also introduced due to the power of the lamps and the heat which they produce.

The effect of excessive heat on a lamp is to increase the tendency toward blackening of the bulb due to particles of metal thrown off from the filament, and several methods have been employed to overcome this difficulty. Lamps have been manufactured in this country with cooling chimneys above the filament so that the hot gas inside the lamp rises up the chimney and any blackening that occurs, does so at the top of the chimney. This method succeeds in its object but is very expensive and it is difficult to accommodate a lamp having a long chimney over the filament in a lamp house which must be tilted at various angles.

In other lamps blackening is allowed to form and tungsten powder is introduced into the bulb so that, when the lamp is inverted, the blackening may be partially cleaned off by rinsing the powder round the bulb. This method has found particular favor in America.

The method which is employed in the latest British projectors—which are probably the largest successful ones that have been constructed for incandescent lamps—is to make the bulb comparatively large and to cool it by means of a silent air blower. It is also kept vertical by gearing for all positions of the lamp house.

With very large incandescent lamps it is desirable, for reliable service, to start the lamps up gradually through a resistance because the filament itself has a very small resistance when cool and, if it were switched directly on to the mains, approximately 14 times full load current, that is to say, over 1000 amperes would flow. The resistance is made in a separate unit and is arranged with an automatic self-resetting circuit breaker in such a manner that it is impossible to switch the lamp on without going through the resistance, and it is necessary to pause for about a second at each step of the resistance.

The 3 kw. spotlight produces 1500 foot candles at 10 ft. distance, 800 at 15 ft. distance, and just over 500 at 20 ft. The 2 kw. spotlight also gives about 1500 foot candles at a distance of 10 ft. and about 750 foot candles at 15 ft. With the 10 kw. projector an intensity of about 6000 foot candles is produced at 10 ft. and 2500 at 25 ft.

Heat from Incandescent Lamps.—When incandescent lamps were first used it was found that the heat produced was somewhat oppressive, this being due to the fact that with incandescent lamps most of the heat is radiant, whereas with arc lamps it is conducted and convected. Thus, people working in the set feel the effects more with incandescent lamps.

In order to obtain some idea of the heating effect of various spotlights at different distances some tests were made a few days ago.

If a thermometer is placed in the beam of a spotlight and a reading taken, this reading has practically no value as it depends chiefly on the reflection and absorption of the thermometer. For our tests, therefore, we first measured the reflection factor of a lot of human faces, finding the average to be about 50 per cent.

We then constructed a disk of chromium plated brass equipped with a thermopile and painted it to a reflection factor of 50 per cent. We used chromium plated brass so that there should be no appreciable absorption from the reverse side. Tests were then made holding the disk in the middle of the beam from a spotlight at various distances, readings being taken of temperature rise after steady conditions had been reached. It was found that conditions became steady after about 10 minutes.

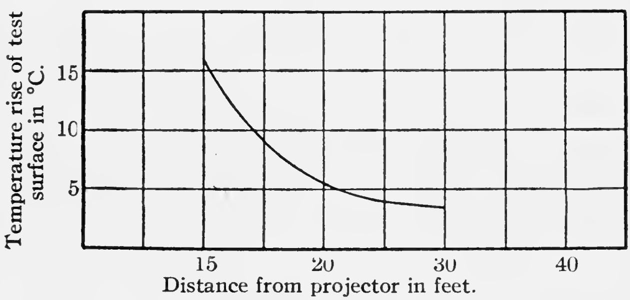

FIG. 3. Variation of temperature with distance from 3 kv. spotlight.

Fig. 3 shows the results of these tests for the 3 kw. spotlight. It is interesting to note how rapidly the temperature rise falls off as the distance from the spotlight increases.

The problem of heat is now becoming very much less acute for a number of reasons:

1. There is a tendency to use much larger lens apertures which means less light is required and less heat produced. Recently, a British firm of lens makers has produced a new $f/0.95$ lens.
2. There is a tendency in this country to use more spotlights instead of bank type illuminators. The spotlight produces more light in proportion to heat than the bank type fitting.
3. There is now a more proper understanding of studio ventilation requirements and, in the latest studios, there is a complete change of air at least twice in every hour.

4. Faster film emulsions are being made which again reduce the amount of light required and, therefore, heat.
5. Research work is still being actively carried out in the endeavor to increase the intensities of incandescent spotlights, and it is probable that these intensities will be materially improved in the near future.
6. Glass screens have been devised and are now being tested out for absorbing radiant heat from the lamps.

Color.—Even for black and white film the color of the light is very important, and it was the coming of panchromatic film which has led to the use of incandescent lamps.

It seems likely that in the near future we shall have an era of colored films just as we have had an era of talking films during the last year, and with colored films the spectral properties of the light are even more important.

It is possible to use color carbons but the light from these tends to cover limited spectrum bands. With incandescent lighting the whole of the visible spectrum is covered and the amount of light in the various parts of the spectrum may be readily altered by varying the filament temperature of the lamps.

DISCUSSION

MR. CLARK: There are one or two points which struck me. One of these concerns the method of measuring temperature. Mr. Villiers has devised a means of getting some idea of the temperature at various distances from the spotlight by taking a plate which has an absorption characteristic similar to that of the human face. I wonder if he has taken into account the fact that the plate probably bore no comparison to the face from the point of view of heat capacity and conductivity of the human flesh. I think the figures given may not really give any real impression at all. I would like to be corrected if I am wrong.

You raised the question of heat absorbing glass. I do not know of any English manufactured heat absorbing glass which does not break when it gets hot. There are, however, glasses of Continental make which have a transmission for visual light as high as 70 per cent.

MR. VILLIERS: Dealing with Dr. Clark's point that the temperature measurements we made are of no practical value, I submit that these temperature measurements were made to determine the effect on people in the set. Now if you are under a fairly hot light your skin feels the heat; it is not inside your head you feel it but on the surface, and it was an endeavor to get the measurement of temperature of a surface which absorbed, in effect, approximately the same amount of heat as the human being would. They did not attempt to be accurate experiments, but they are, I think, an approximation. What they do show is the way the heat falls off with distance under these conditions and I think it is quite fair to assume that the effect of heat on someone's face would fall off in about the same manner.

With regard to Dr. Clark's second point I was very interested to hear about the absorbing glass he has been testing out. As a matter of fact I think I heard about it the other day from our own research laboratories and I can tell Dr. Clark that we are investigating types of glass of this kind at the present moment, although I personally do not think it is the most important method of getting rid of the heat. I think the most important method is increasing the efficiency of the spotlight which is being rapidly done.

ONE TYPE OF ACOUSTIC DISTORTION IN SOUND PICTURE SETS

R. L. HANSON*

The addition of sound to motion pictures has introduced many new problems in acoustics which have heretofore been subjected to but meager quantitative analysis. Judgment of "good" or "bad" acoustics has been based on the results of direct listening rather than on those of sound recording. A room or sound picture set may be acoustically good for binaural listening at a given place but may not be good for recording with a microphone placed at that particular position. One reason is that when one listens to a sound he uses two pick-up devices, the two ears. Any distortion of the sound at one ear may be balanced by that which the second receives. In the case of recording we use a single pick-up device, a microphone, which sends on to the sound record any distortion which may be present at the point where it is placed. Due to the fact that the ears add sound effects without reference to phase while multiple microphones combine amplitudes, the use of two microphones does not accomplish the balancing process obtained by the ears. Distortions of the sound field at the position of the microphone should, therefore, be avoided. If a sound record is to give a satisfactory reproduction of the original sound, the microphone must be placed at a point where the intensities of all the frequencies bear the same relation to each other that they did near the source.** Any departure from this relation results in distortion. One of the main causes of this type of distortion is the interference at the microphone of two or more sound waves coming from the same source by different paths. While this phenomenon is not novel, the character and extent of the

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* Bell Telephone Laboratories, New York. (Read before the Society at Washington.)

** Either dead or live room conditions will satisfy this requirement provided that in the latter case the reverberations are well diffused. Of course a distorted sound field may in some instances be desirable in order to reproduce the condition being portrayed.

distortion which it introduces in sound picture recording has not been fully appreciated. Recent experiments carried on in the Bell Telephone Laboratories have shown that this distortion is responsible for a hollow unnatural quality when it occurs in sound picture records.

The experimental work consisted of making a study at various

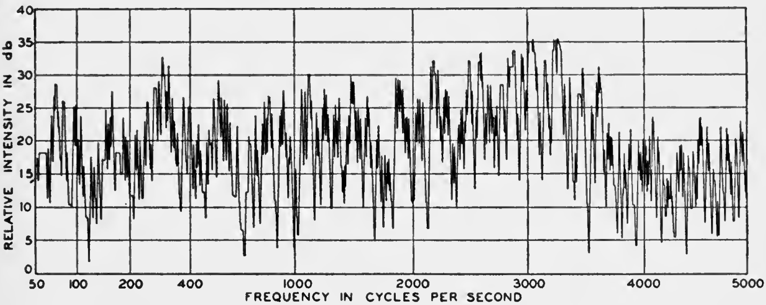


FIG. 1. Variation of intensity level at microphone located as shown in Fig. 2.

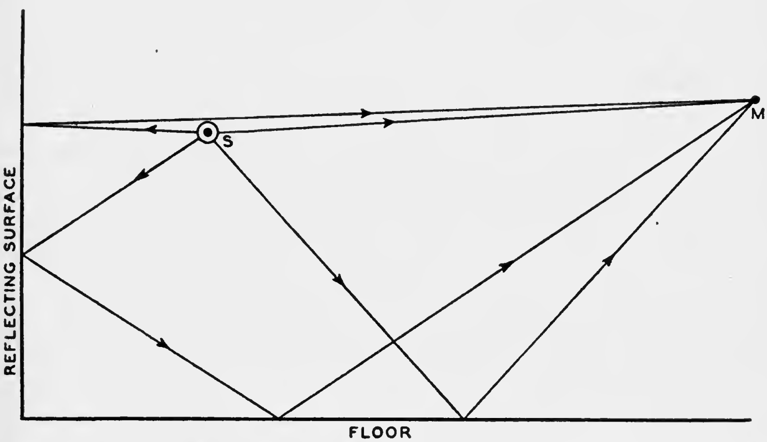


FIG. 2. Paths by which sound from source, *S*, may reach microphone, *M*, when located in the neighborhood of two reflecting surfaces.

points in a sound stage of the relative intensity level resulting from the sound given out by a loud speaker connected to a constant frequency oscillator. The number and nature of the reflections were controlled by means of hard flats and absorbing material properly placed relative to the source. The distortion of the sound at any given point was determined by comparing the relative intensity level at the point with that near the source for frequencies from 50 to 6000 cycles per second.

Fig. 1 shows a curve taken with a 12 × 12 foot reflector placed about 4 feet from the loud speaker. The microphone, which was 12 feet away, received sound which traveled from the speaker by four different paths illustrated in Fig. 2. The vertical axis in Fig. 1 shows the relative intensity level, while frequencies are shown on the horizontal axis. It should be noted that variations in level of

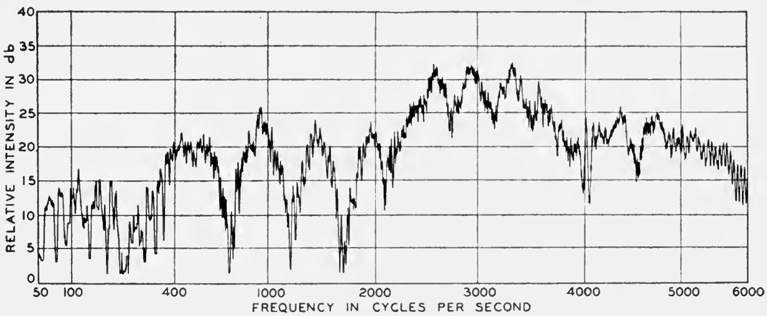


FIG. 3. Variation of intensity level of sound at a microphone 10 feet from a source 5 feet above a reflecting floor.

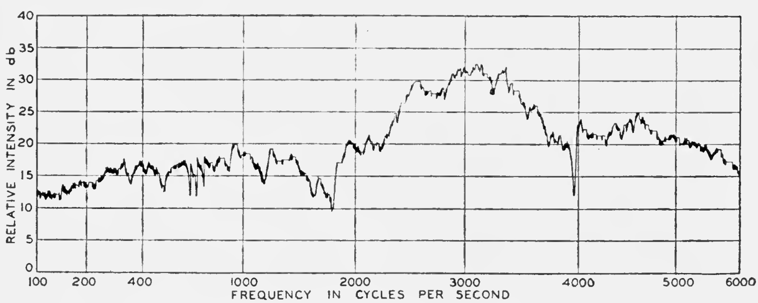


FIG. 4. Relative intensity level of sound at a point near the source.

30 db. were obtained between certain frequencies. A simpler case involving a single reflection from the floor is shown in Fig. 3. The distortion is evidenced by comparison with Fig. 4 which represents the relative intensity level given out by the source over the same frequency range. This curve was made with the microphone about six inches from the source and shielded from all reflections. The difference between the two curves represents a gain frequency characteristic between the sound source and the microphone. Such a

characteristic plotted on a logarithmic scale is shown in Fig. 5 for the case of a loud speaker and microphone separated by 10 feet, each being 5 feet above the bare floor. The difference between the length of the path of the sound traveling directly from the loud speaker to the microphone and that of the sound reaching the microphone after reflection from the floor was in this case 4.14 feet. Fig. 6 (*A*) shows a similar characteristic taken under the same conditions except that the distances were changed as shown, the path difference, however, remaining 4.14 feet. As much distortion would be introduced into a sound record made under these conditions as would be introduced by any other unit of the recording system having a similar gain frequency characteristic. Curve *B*, Fig. 6, represents the result

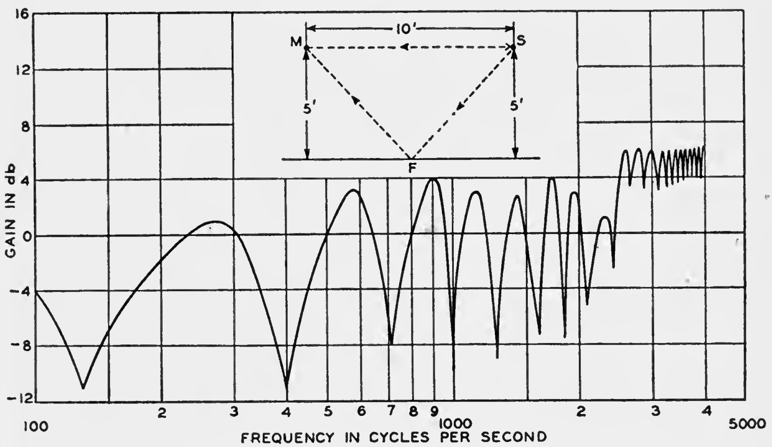


FIG. 5. Gain frequency characteristic between source, *S*, and microphone, *M*, located as shown.

obtained by reducing the intensity of the reflected wave with sound absorbing material. The similarity to curve *A* at the low frequency end is due to the lower absorption of the material for that region.

After removing all reflecting surfaces, and substituting a second microphone 14.14 feet from the loud speaker and combining the outputs, the curve shown in Fig. 7 was obtained. The distance 14.14 feet from the loud speaker to the second microphone was chosen in order that the distances traveled by the two sound waves before reaching the microphones differed by the same amount as did those of the direct and reflected waves in the other cases, namely, 4.14 feet. The resulting phase relations were, therefore, the same in all cases. It is evident from these results that the distortion which has been commonly noticed with multiple microphones is basically of the same type as that introduced by reflecting surfaces.

The explanation of these phenomena is simple. Let us consider the case of the microphone 10 feet from the loud speaker, both being 5 feet above the bare floor. The sound which reaches the microphone travels by two paths, one directly from the loud speaker and the other from the loud speaker to the floor and then by reflection into the microphone. Since the reflected wave travels a greater distance than the direct, there will be certain frequencies for which

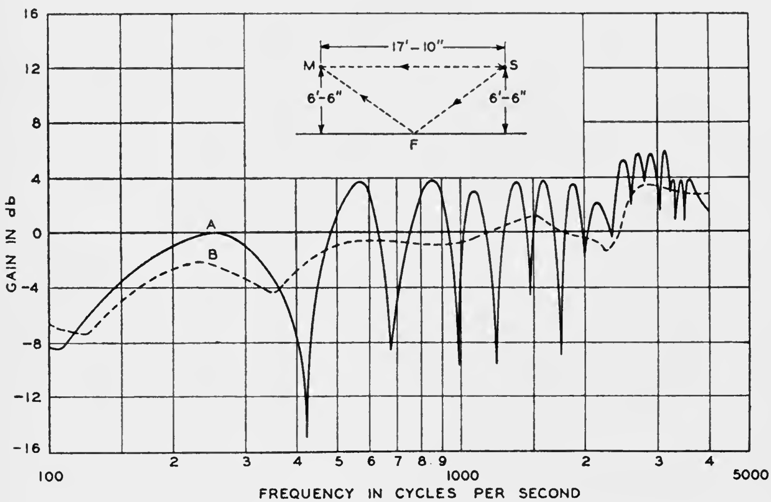


FIG. 6. (*A*) Gain frequency characteristic between a source and microphone located as shown. (*B*) Characteristic obtained after reducing intensity of reflected wave by the introduction of absorbing material on the floor.

the two waves arrive at the microphone 180 degrees out of phase. There will be other frequencies for which the two waves arrive in phase. The intensity level at the microphone will be greater or smaller than that which would have resulted from the direct wave alone, depending upon whether the phases are such that the amplitudes of the waves add or subtract.* In the case of the two microphones we have a similar phenomenon except that the interference takes place between the output currents. If for any given case we

* It is assumed, of course, that the reflector is large enough to give complete reflection at all frequencies of interest.

know the difference in the lengths of the paths traveled by the two waves, we can calculate the frequencies for which they will be in phase or 180 degrees out of phase. The intensity of the wave which has traveled the longer path will be lower than that of the other and hence, even though they may be out of phase, there will not be complete neutralization. If we know this difference in path length and the fractional part of the energy absorbed by the reflector we can calculate for a few simple cases the resulting intensity level for any frequency. Such a calculated curve for the case of a microphone and speaker 5 feet above the concrete floor and separated by a distance of 10 feet is shown in Fig. 8. The peaks come at those frequencies for which the two waves are in phase while the dips come at those frequencies for which the two waves are 180 degrees out of

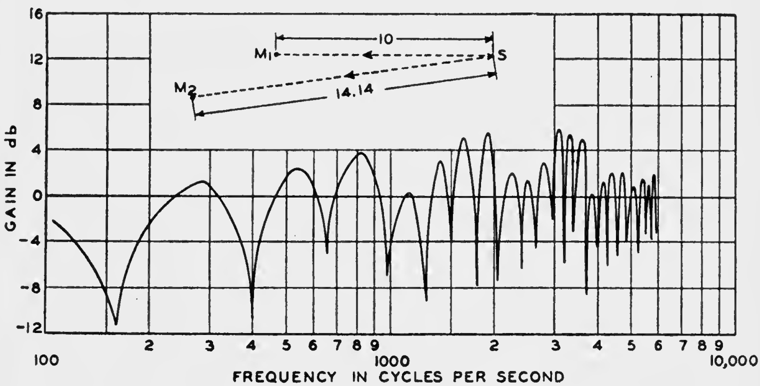


FIG. 7. Gain frequency characteristic between source and the combined outputs of two microphones located as shown.

phase. The frequencies at which the peaks and dips occur, and also the total variation of intensity level of 15 db. correspond very closely with the results shown by the experimental curves. The zero line represents the level which would have been obtained by the direct wave only. The distortion of the sound field at the microphone is dependent upon the difference in level resulting when the two interfering waves are in phase and that when they are 180 degrees out of phase. This is represented on the curve by the difference in level between the peaks and the dips. Fig. 9 (*A*) shows the manner in which the maximum difference in intensity level depends upon the ratio of the distances traveled by the two interfering waves, neglecting absorption by the reflector. For example, this curve shows that in order that the maximum variation in level at a point shall not be over 2 db., a reflected sound must have traveled eight and one-half times as far as the direct sound. If part of the energy of the wave is absorbed during reflection, the maximum variation in level is reduced. Curve *B* of Fig. 9 represents the conditions if the reflected wave has had 20 per cent of its energy absorbed at the reflecting surface. Thus it is clear that the undesirable effect of reflecting surfaces can be reduced by increasing their distances from the sound source and microphone.

These results show that even if we have but a single reflecting surface too near a speaker or microphone the sound reaching the

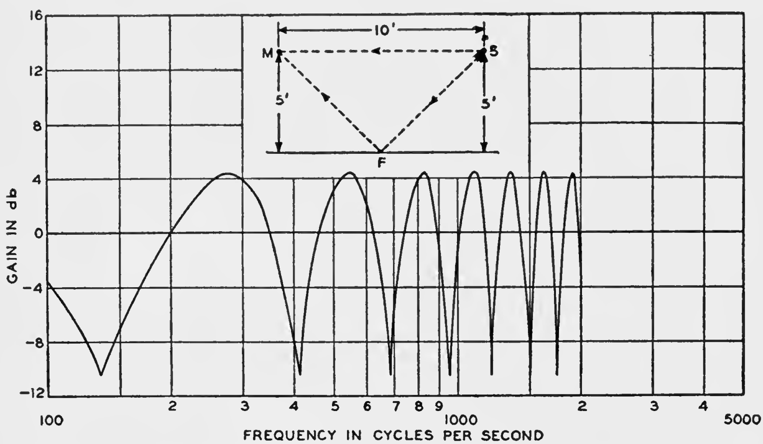


FIG. 8. Theoretical gain-frequency characteristic between a sound source and microphone separated by 10 feet, each 5 feet from a reflecting surface which has a reflection coefficient of 0.95.

microphone may be badly distorted from its original quality as certain pitched sounds are accentuated while others are greatly reduced in intensity. Since the quality of a voice is dependent upon the frequencies present and their relative intensities, any system which changes these relative intensities will change the quality. If the speaker alters his position relative to the microphone and reflector, he at the same time changes the phase relations of the direct and reflected sound waves as they strike the microphone and therefore not only the original voice quality is distorted but the resulting quality will vary as he moves from place to place.

Experimental sound records made under conditions where distortion due to interference existed, as illustrated in Figs. 5, 6, and 7, show an unnatural quality which is designated by some listeners as "hollow." One example is a record made of a speaker sitting at a table. The microphone was suspended about three feet from the speaker as shown in Fig. 10 (*A*). The quality of the reproduced sound from the record was very unnatural and hollow. A second recording was made placing the microphone just below the table top, as shown in Fig. 10 (*B*), care being taken to so place it relative to the table top that the direct wave was not interrupted. The resulting quality

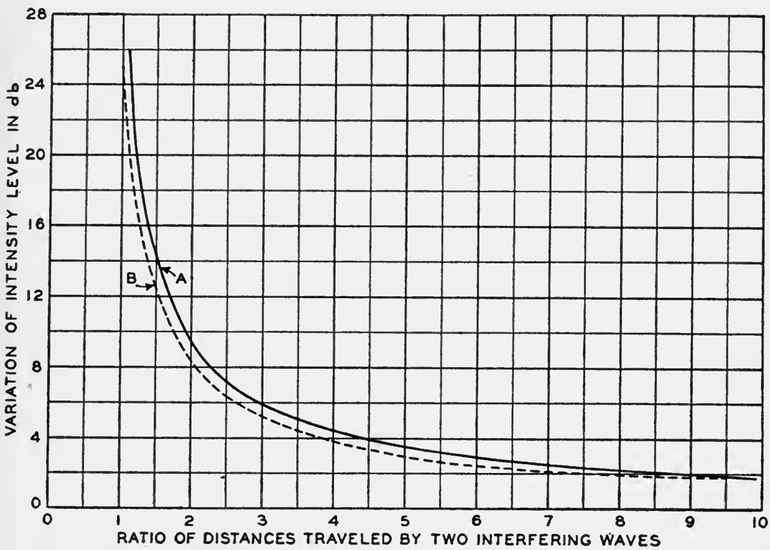


FIG. 9. (*A*) Showing the way in which distortion due to the interference of two sound waves may be decreased as the ratio of the distances traveled by the two waves is changed. (*B*) Showing the effect of absorbing 20 per cent of the energy of one of the interfering waves.

obtained on the reproduced record was natural and entirely lacking in the hollow quality previously noted. The difference in the two cases lay in the fact that in the first the microphone received not only the direct wave from the speaker but in addition one reflected from the table top. In the second case the only sound reaching the microphone was that coming direct from the speaker.

To verify the conclusion that this hollow quality is the result of distortion caused by acoustic interference the following experiment was made. Two disk speech records pressed from the same matrix were placed on two accurately synchronized turntables. Two similar phonograph reproducers connected in series were placed on the two records and their positions so adjusted that the currents generated by them had the same phase relation as did the interfering

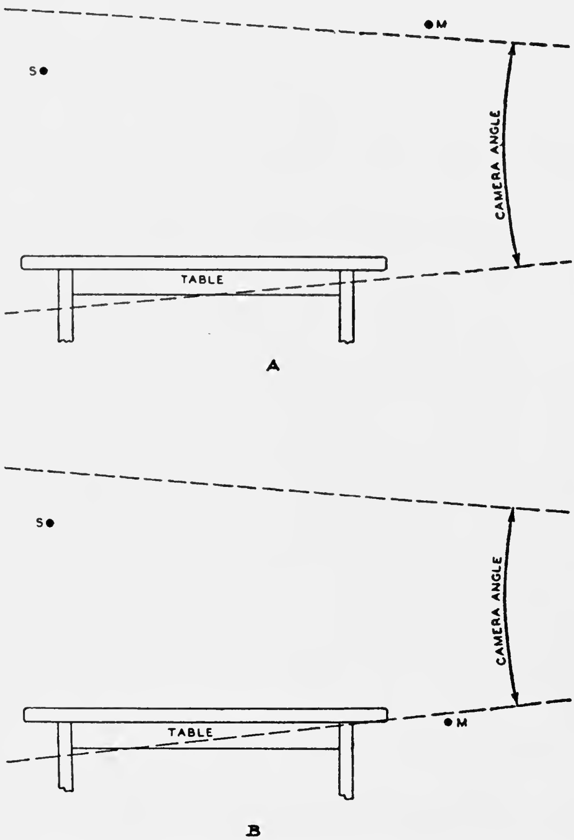


FIG. 10. (*A*) An arrangement of speaker, *S*, and microphone, *M*, which would result in a sound record of poor quality due to the interference at *M* of the direct sound and that reflected from the table. (*B*) The location of the microphone in a position such that it receives the direct sound only.

sound waves at the microphone in the acoustic case. For example, to simulate the phase relation of two sound waves having a path difference of 4.14 feet, as in the case illustrated in Figs. 5 and 6, the needles on a seven inch radius of a $33^1/_3$ rpm. record must be separated by 0.096 inch. With the effective separation of the needles on the two records thus adjusted, the quality of the reproduced sound was similar to that obtained from sound records made under conditions where acoustic interference took place at the microphone. The natural quality of the record was restored by bringing the needles to corresponding points on the two records so that the generated currents were in phase and no interference existed. The quality in this case was the same as that obtained by using one reproducer. Thus it was shown that interference between the currents generated by two phonograph reproducers when properly separated gave rise to the hollow quality in question.

Due to restrictions placed by the camera on the choice of microphone positions, the solution of the problem of interference in sound picture sets is not always a simple one under practical studio conditions. The most obvious solution is to eliminate reflecting surfaces in the immediate neighborhood of the sound source and microphone. In cases where this is not possible, conditions can be improved by either of two methods: by so placing the microphone relative to the source and reflector that it does not receive the reflected sound as was done in the case previously described, or by covering the reflecting surfaces by highly absorbing material thereby reducing the intensity of the reflected wave.

It is not the intention of this paper to imply that dead recording is preferable to live recording. The effect here described is caused by discrete reflections and is entirely different from that caused by the diffused reflections in a reverberant room.

SUMMARY

These experiments have shown that reflecting surfaces in a sound picture set may give to that part of the recording system between the sound source and the microphone a transmission characteristic which would not be tolerated by any other component part of the system. The distortion caused by acoustic interference was shown to be very similar to that obtained electrically by two microphones. Experiments performed with two phonograph reproducers on synchronized disk records verified the conclusion that interference can give rise to the distorted quality, observed in sound records made under conditions where interference existed. This acoustic distortion can be eliminated in sound picture sets by elimination of reflecting surfaces in the immediate proximity of the speaker, the

proper placement of the microphone, or by reducing the intensity of reflected waves by means of absorbing material placed over the reflecting surfaces.

Note.—The presentation of this paper before the S. M. P. E. was accompanied by a sound picture demonstrating the effect on speech of interference caused by reflecting surfaces or multiple microphones.

DISCUSSION

MR. COFFMAN: There is a marked analogy observable between the effects produced in recording by differences in microphone placement and those effects produced in photography by differences in focal length. In the demonstration material just exhibited, the microphones and the reflecting surfaces were both close to the speaker, and the acoustic perspective was quite different from the photographic perspective. The low ratios of the distances, speaker to microphone, speaker to reflecting surface, and reflecting surface to microphone, tend to produce recording results comparable to the characteristic photographic distortion caused by the use of lenses of too short focal length. As is well known, the use of short focal length lenses to photograph a subject with feet extended toward the camera results in a picture in which the feet are of huge size. Similarly, the low distance ratios in this case result in an abnormal proportion of the reflected sound, which also has a large phase difference with the direct sound. Neither of these conditions would be present if the microphone were comparatively distant from the speaker as related to the speaker's distance from the reflecting surface. Do experiments with a set-up of this kind indicate the same type of distortion as was evidenced in the demonstration?

MR. HANSON: Over fifty records, similar to those shown, taken under conditions where the distances between the source, microphone, and reflector were varied over a wide range show the distortion to be dependent upon the difference in the lengths of the two paths traveled by the sound and upon the distance from the speaker or the microphone to the reflecting surface. In speech records the amount of distortion is dependent upon the particular voice. One voice may have a frequency distribution such that with a given arrangement of reflector, microphone, and speaker, the intensity of the fundamental frequency is greatly reduced while the fundamental frequencies of other voices might not be affected by this particular condition. A small amount of distortion is introduced in cases where the ratio of the distances traveled by the reflected and direct sound is large. As this ratio decreases the distortion increases.

MR. COFFMAN: The question was asked because within the last fortnight a scene came to my attention in which it was necessary to record dialog around a hard surface table. If the microphone had been placed relatively near the table, the distortion indicated in the demonstration would have been experienced, but by keeping the microphone near the camera, 15 feet distant from the table and the speakers, the recording quality was all that could be desired.

MR. HUNT: I should like to emphasize two points which the experiment brings out: First, the advantage of being able to study these acoustical effects under laboratory control where one factor can be varied at a time. That was done in this experiment. It was thus possible to subject this complicated acoustical situation to a quantitative study. The second point I want to bring out is that the experiments indicate quantitatively that under certain conditions there is an effect on the recorded sound quality depending on relative positions of the microphone and the reflecting surfaces near it.

MR. RINGEL: In this interesting work, I believe it is important to consider the dimensions of the reflecting surfaces and of the sound radiating source as well as the separations between them and the microphone. The size of the source will determine to a great extent the directional radiation characteristics, while that of the walls will determine what wave-lengths will be reflected. It is theoretically possible with a certain size of source, to so orient it as to obtain no reflection at all from the walls, the microphone receiving sound only from the loud speaker. This condition is determined by the relative size compared with the wave-length of the sound being used. In some practical cases on actual sets, use of a reflecting wall is advantageous in improving the high frequency response. At times, when one of the actors has his back to the microphone, I have had him speak at a more suitable angle to the walls of the set, so as to reflect the higher frequencies in his voice back to the microphone. Naturalness and intelligibility are thus oftentimes improved.

MR. EVANS: It has been our experience that an orchestra recorded with multiple microphones in a dead room sounds better than that recorded with a single microphone; there is more detail in the music and people prefer it. This is in line with Mr. Hanson's conclusions that multiple microphones in a dead room simulate room resonance.

MR. HANSON: I cannot explain why you should obtain better quality with multiple microphones unless it is due to the fact that the distances from one microphone to the various instruments of the orchestra were such that a poor balance was obtained. Distortion caused by interference is less noticeable in music than in speech and might in this case be less objectionable than the loss of balance.

MR. EVANS: We have done recording in a live room and one microphone is better than more than one. In a dead room, if you put in more than one, you get the same effect as in a live room with one microphone.

MR. COFFMAN: Dr. Fletcher's film brings out that point. As will be recalled, the multiple reflections present in the case of speech were ruinous, but the music was even more pleasing. The cause is to be looked for in the realm of the psychological. We like to feel that music fills the space in which it is created. Carnegie Hall in New York City has the reputation of being very good from the standpoint of musical acoustics, but it is reverberant; one has only to listen to the Philharmonic Orchestra playing there and then in the open-air Lemisohn Stadium to realize how much liveness contributes to our enjoyment of music. Multiple microphones in a dead room are a substitute for the reflecting surfaces necessary for the most satisfactory recording of music.

MR. MAXFIELD: I have had no experience with the dead studios. In the case of live studios, I have never heard a record made with two microphones better than the best made with one. In the limited time allowed for setting up the orchestra and microphone you can get better results by using two equidistant microphones and letting them alone, meaning that when one is in a bad spot, the other probably isn't. When we have taken the time necessary to get the proper place for the one, we have had a better result.

MR. ROSS: With a large orchestra, a very large number of sound frequencies are being generated simultaneously and it is possible that this condition causes an accelerated decay of the reverberant sound actually preventing its reaching the microphones to produce distortion. For that reason it is possible to employ a number of these instruments for such recording.

MR. KELLOGG: The question comes to mind in the course of the discussion as to why a reflecting surface doesn't bother us when listening direct. I have been playing with sound for a good many years, and I am just beginning to learn how much your sense of direction does for direct listening. You don't seem to hear in adequate magnitude sound from other sources than that from which it first comes. A very simple calculation based on the theory of comparisons in a room shows that if you have an unprotected source in a living room, six feet away, you get six times the energy reverberated around the room that you get from the source itself although the ear tells you the sound is coming from only one source. It fools you with regard to the amount of sound you are getting. It is interesting in a room where you have some noise to try the experiment of plugging one ear. I am convinced that one of the effects introduced is a marked rise in background noise.

PRODUCTION ASPECTS OF A TECHNICAL LECTURE SOUND PICTURE

FRANKLIN L. HUNT*

The use of motion pictures for purposes of instruction had received the serious attention of educators prior to the advent of sound pictures, and collections of motion picture films on a wide variety of instructional subjects had been made by government organizations and private institutions in this country and abroad. The recording of current events in newsreel form and films illustrating industrial processes are popular types of such pictures. Additional subjects prepared specifically for instruction in public schools and in advanced institutions of learning were also available.

The addition of sound has greatly enhanced the possibilities of educational films, for the appeal not only to sight but also to hearing has greatly increased the effectiveness of this means of communicating ideas to the mind. However, sound pictures have so recently reached a state of practical development that their possibilities have not as yet been fully realized. This paper describes one which was recently recorded by the Bell Telephone Laboratories. It exemplifies the possibilities of sound picture films for technical instruction.

The title of the film is *Acoustic Principles of the Recording and Reproduction of Speech and Music* by Dr. Harvey Fletcher of the Bell Telephone Laboratories. It presupposes a fairly advanced technical training on the part of those to whom it is presented and was intended primarily for the instruction of engineers. The subjects discussed in the order named are as follows:

1. The range of audibility of the ear.
2. The effect of loudness of reproduction on the quality of speech.
3. The effect of eliminating low and high frequencies from speech and music.
4. The effect of resonance at different frequencies in the recording system on speech and music.

* Bell Telephone Laboratories, New York. (Read before the Society at Washington.)

5. The effect of electrical overload in the recording system on speech and music.
6. The effect of varying the speed of a sound record on speech and music.
7. The effect of room reverberation on the quality of speech and music.

The audibility range of the ear is discussed with the aid of the chart shown in Fig. 1, which gives the curves of minimum and maximum audibility plotted with intensities in bels as ordinates and pitch in

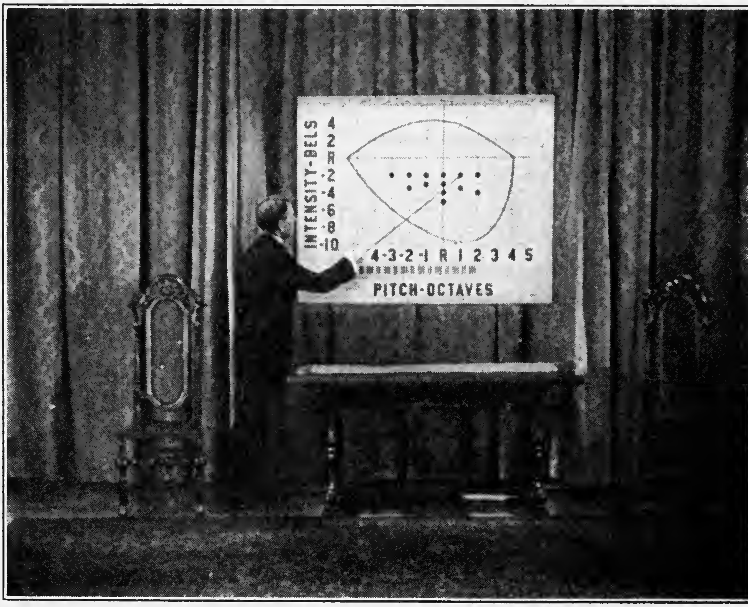


FIG. 1. Auditory sensation area.

octaves as abscissas. The piano scale was added to aid in interpreting the pitch. The series of dots shown was used to illustrate the pitch and loudness of representative tones in the audible range. The corresponding tones were recorded at the time the pointer of the lecturer touched the various dots, by having an assistant simultaneously apply the requisite frequency, produced by an electrical oscillator, directly to the recording machine.

The effect of reproducing speech at a higher power level than the original speech is to accentuate the low frequencies relative to the high and thus produce what is sometimes called a "boomy" effect. This is demonstrated with the aid of the chart shown in Fig. 2. While the lecturer described the experiment off stage an assistant pointed successively to the words "CONVERSATIONAL SPEECH" and "FALSE POSITION." The recording engineer simultaneously varied the power level at which the lecturer's voice was applied to the recording system, with the result that when reproduced, a part of the speech is natural in quality and at conversational level, and other

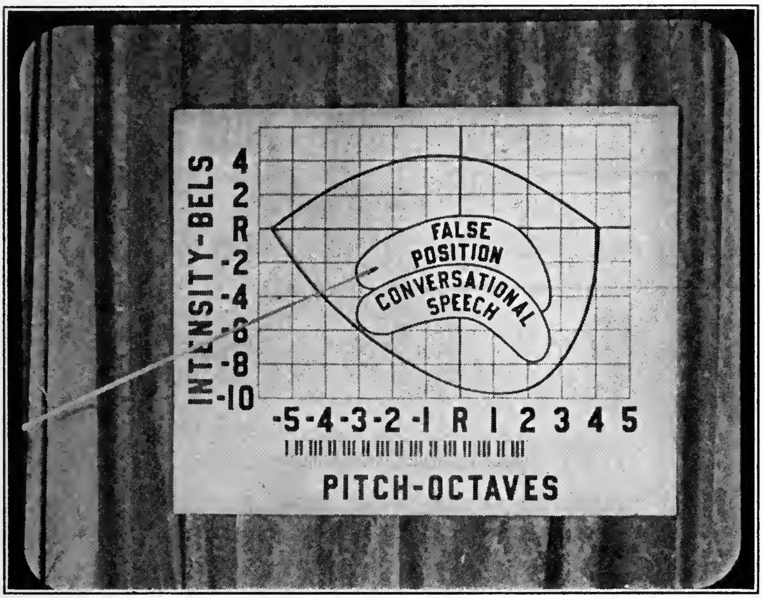


FIG. 2. Speech reproduction at normal and excessive power level.

parts are very loud with accentuation of the low frequencies.

The effect of eliminating low and high frequencies from speech and music is illustrated as shown in Figs. 3 and 4. While the lecturer spoke, or while the string quartet was playing, electrical filters were introduced between the recording microphone and the recorder to eliminate all frequencies below or above a series of predetermined values. These filters were switched into the recording system by an assistant who simultaneously signaled to a second assistant stationed at the side of the set, off scene, whose duty it was to push

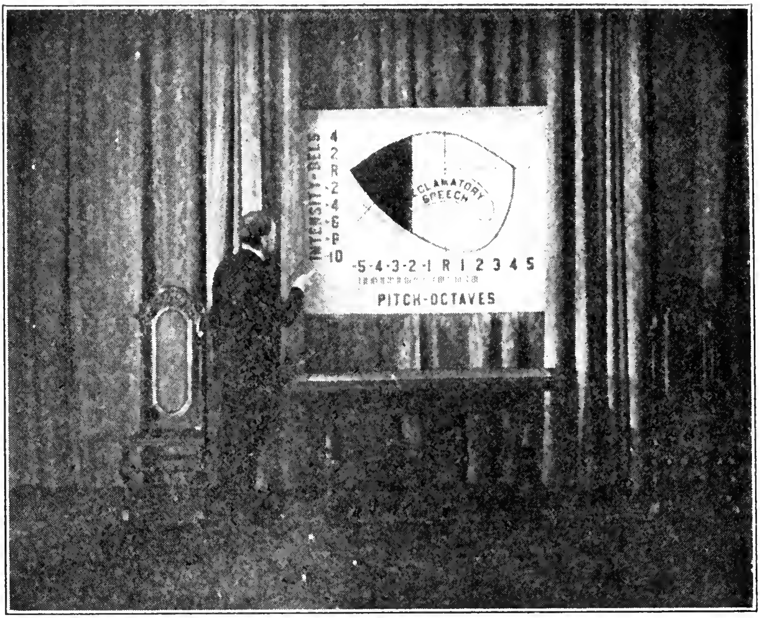


FIG. 3. Elimination of low frequencies from speech.

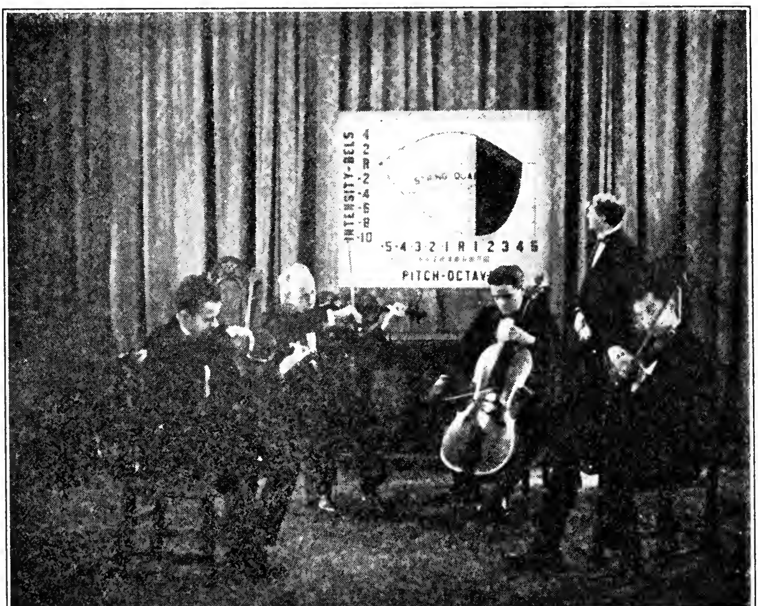


FIG. 4. Elimination of high frequencies from music.

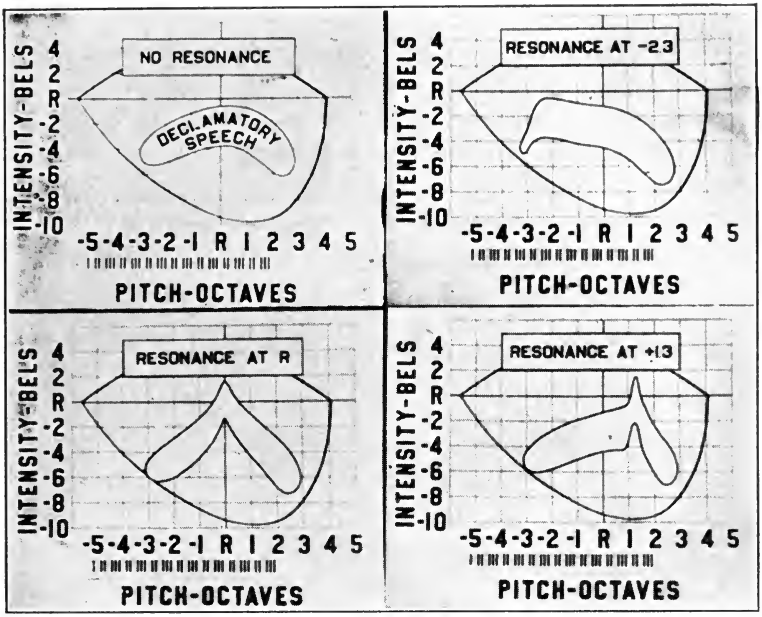


FIG. 5. Effect of electrical resonance on speech.

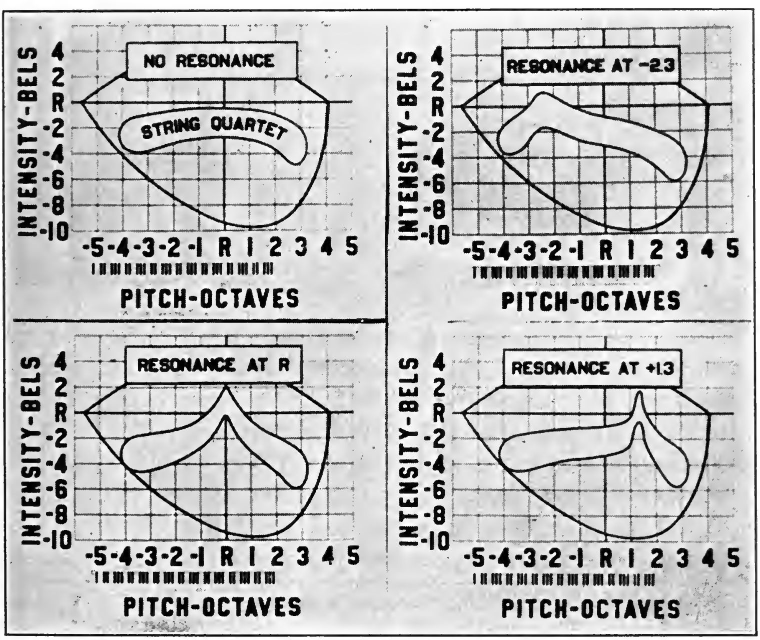


FIG. 6. Effect of electrical resonance on music.

the black shield in and out to cover the corresponding parts of the audible range. To effect this, the chart* was made of two parallel boards, separated sufficiently to permit the black shield to slide between them. The front board had a large hole cut out at the center to conform to the auditory sensation area. The cross-section lines within this area were painted on the back board. These were therefore covered by the shield as it was pushed in by the assistant.

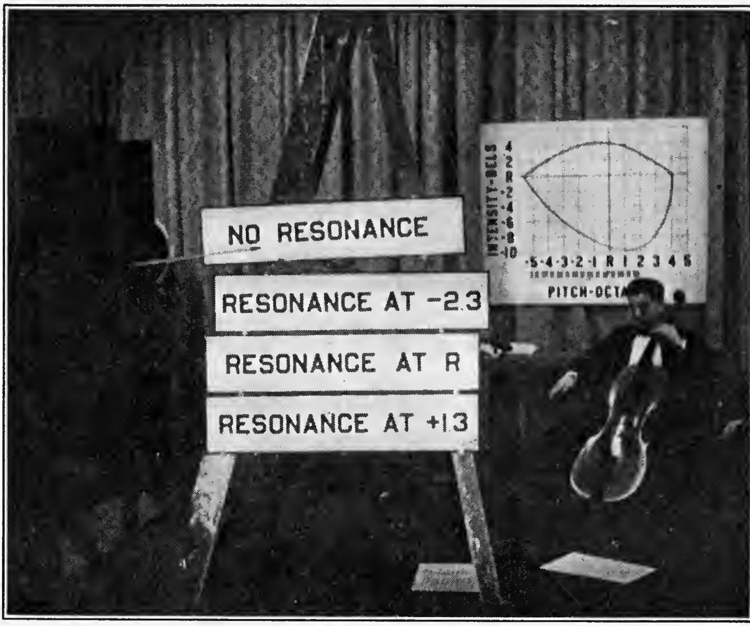


FIG. 7. Pre-scoring for the effect of resonance on music.

To demonstrate the effect of resonance pre-scoring was used. Charts shown in Figs. 5 and 6, representing the different conditions of resonance, were made and another chart, shown in Fig. 7, listing the titles of the resonance charts was prepared. While the lecturer spoke off stage and again while the string quartet played off stage, an assistant pointed successively to one after another of the titles of Fig. 7. This chart was photographed while the speech or music record was being made. Simultaneously another assistant connected

* This method of constructing the chart was suggested by Mr. W. B. Snow of the Bell Telephone Laboratories.

into the recording system the corresponding resonance network so that the recorded sound effects were distorted in accordance with the indications of the pointer on the chart. Afterward enough footage of each of the charts shown in Figs. 5 and 6 was photographed to correspond to the several positions of the pointer in Fig. 7. These were substituted in the picture for the corresponding pointer indications of chart 7. When the effects are reproduced the charts change instantly on the screen in synchronism with the changes of

FIG. 8. Effect of electrical overload on music.

the resonance frequencies in the music or speech which is reproduced simultaneously off scene.

The effect of overload in the electrical system on speech is illustrated by having an assistant switch from a normal to an overloaded condition in the recording system while the lecturer indicated as he spoke which condition at the moment prevailed. The effect on music is illustrated with the aid of the chart shown in Fig. 8. While the string quartet played the lecturer pointed to the words

"NORMAL" and "OVERLOADED" successively, and the assistant switched the circuits of the recording system correspondingly to give a normal or overloaded sound record.

The effect of variations of speed of a sound record on the character of reproduced speech and music is illustrated with the aid of phonograph records and the speed indicator shown in Fig. 9. Records of a woman's voice and of a full orchestra were used. The output of the phonograph reproducer was connected to the recording system. While the record was being played the speed indicator was simultaneously photographed. An assistant varied the speed indicator first to increase its reading above normal, then to decrease it below normal, and finally to cause it to fluctuate about the normal position. At the same time, a second assistant changed the speed of the phonograph turntable to correspond with the indications of the speed meter. When the picture of the speed meter is projected the speech or music simultaneously heard varies in pitch in accordance with the indications of the speed meter. In this manner the voice of a woman was transformed from a high, almost inarticulate prattle to the

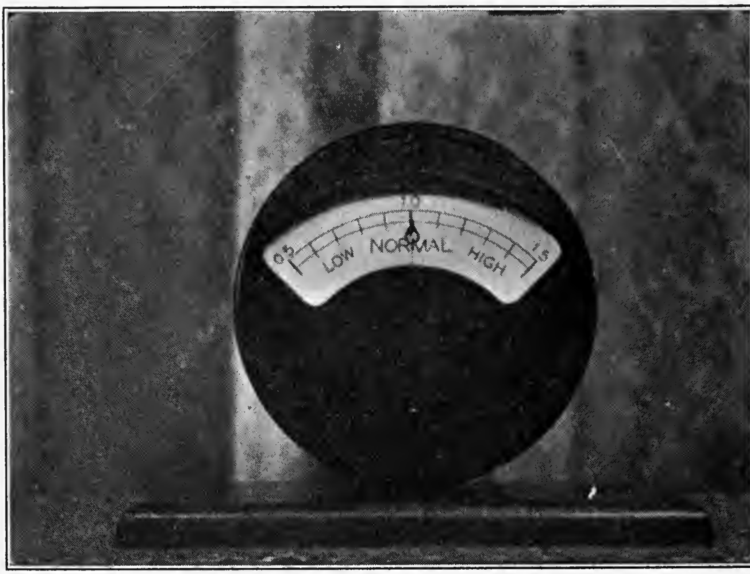


FIG. 9. Effect of speed variation on sound record.

extremely slow enunciation of a deep bass and music was correspondingly distorted. The experiment clearly indicates that small fluctuations in speed produce a more displeasing effect on music than on speech.

The effect of room reverberation is illustrated with the aid of the chart shown in Fig. 10. Phonograph records of a woman's voice and a full orchestra were used in this experiment. The effect of reverberation in a room was simulated by placing several phonograph reproducers a few inches apart in the groove of a phonograph

FIG. 10. Effect of reverberation on speech and music.

record.* The phase differences of the several reproducers correspond to the multiple reflections obtained in a room with hard walls. The output of all the reproducers was combined in the sound record made. As the lecturer pointed successively to the condition of "REFLECTING WALLS" and "ABSORBING WALLS" an assistant switched

* This method of artificially simulating reverberation was resorted to for emphasis but in practical sound picture recording it is usually not desirable to use artificial sound effects if these can be avoided.

the output of several reproducers or of a single reproducer, respectively, into the recording system, thereby obtaining the effect of a room with reflecting walls or one which gave no reflections. This experiment brings out the fact that speech is more seriously affected by excessive reverberation than music.

One other aspect of the technic of the picture may be worth mentioning. To make the charts clear and distinct they were painted in black and white on wood. It was thought that it would be awkward and distracting to have the charts changed on the scene. The subterfuge of projecting the speaker in close-up while introducing each successive experiment was therefore resorted to, to give an opportunity for the charts to be changed out of the picture, supposedly in the meantime.

It is hoped that this lecture film may serve to indicate the manner in which rather complicated technical demonstrations can be handled with the aid of sound pictures. This is but one example of many more of similar type which will suggest themselves to those interested in the possibilities of sound pictures in the field of education.

DISCUSSION

MR. RINGEL: Mr. Fletcher and his associates are to be congratulated for turning out such a fine piece of work. In the film I was especially pleased to note an effect described in the first part of my paper. When Mr. Fletcher spoke from the foreground and then moved to the background, a change was produced. You noticed considerable loss in intelligibility, and the quality of his voice was not the same as his original voice. I am glad to have this point made clear.

MR. HUNT: It is generally recognized that the most perfect articulation can be produced without reverberation, but it is necessary to have a certain amount for other effects.

MR. E. D. COOK: I believe the Bell Laboratories have always been very kind in passing on to the public the results of their tremendous expenditures in this pioneering work, and most of us have good cause to be grateful to them. I should like to have this film made available to laboratories throughout the country in connection with the instruction of the younger men brought in year by year. If the purchase of this film is possible, it would help considerably, and I hope the Bell Laboratories will give this consideration.

MR. SHEA: We hope that a limited distribution of this film may take place but it should be understood that our sound picture laboratory is not engaged in the production of films for general commercial distribution. The prime purpose of making such films as the Fletcher film in our laboratory is so that we may learn things we don't know about sound recording.

MR. MAXFIELD: In connection with the apparent loss of articulation, the amount of depth of this picture was exaggerated over and above the amount used in commercial recording. For the benefit of those interested in the amount of the loss for the depth effect I suggest that you see *The Locked Door*, *Three Live Ghosts*, *Putting on the Ritz*, *The Bishop Murder Case*, and *Sweetie*. They were all made that way.

MR. ROSS: In the overloading demonstration the sound level of the normal and overload appeared the same. If the whole system was overloaded why was not the overload demonstration at a higher level than the normal one?

MR. HUNT: The volume levels in the recording machines were so arranged that there would not be an appreciable volume change between the normal and overloaded condition.

MR. EVANS: In connection with Mr. Cook's statement that overloading sometimes helps out, I am also of the opinion that this can occur. I have conducted tests of this kind in connection with broadcasting. I had a loud speaker which could be switched from the output of the speech amplifiers to the monitoring rectifier on the end of the transmitter. It is obvious that the output of the loud speaker cannot be a faithful reproduction of the transmitter input. Blindfold tests have been made a number of times by a number of different people. Invariably they select the output of the radio transmitter as more satisfactory than the input. Apparently the explanation is that certain harmonics are produced by modulation or overloading which improve the pleasing reproduction of the sound.

SOME CONSIDERATIONS AFFECTING THE DESIGN OF PHONOGRAPH NEEDLES

R. T. FRIEBUS*

However simple a piece of apparatus the phonograph needle appears to be, as a necessary link in the chain of reproducing equipment it must be as strong qualitatively as every other link, or the elementary principles of design are violated. One needs to calibrate only a few kinds of phonograph needles to find that quality of sound which has been achieved at the cost of thousands of dollars can be considerably impaired by using an improperly designed needle costing only a fraction of a cent.

The purpose of this paper is to discuss some practical considerations about needles and to give data showing the relation between certain dimensions of the needle and its response-frequency characteristic.

At the outset, in order to have a visual image of what we are discussing, Fig. 1 shows a photomicrograph of a recorded disk in profile with a needle placed in one of the grooves before playing. This illustrates the relative size of groove and needle, an important consideration as will be shown later. Fig. 2 shows the response-frequency curves of a few general types of needles. The response below 700 cycles is not shown since it is practically the same for all commercial needles.

Curve *D*, Fig. 2, shows the response-frequency characteristic of a Western Electric 4-A reproducer and a standard commercial make of soft tone needle. We note that the response is materially down at 2000 cycles and rapidly decreases thereafter. The response of fiber needles also is somewhat similar.

Curve *C*, Fig. 2, shows the response using a commercial medium tone needle. Here the gain begins to drop off at 3000 cycles, is 10 db. down at 4000 cycles, and is of very little use at 5000 cycles.

Curve *B*, Fig. 2, shows the response with the best needle now

* Electrical Research Products, Inc., New York. (Read before the Society at Washington.)

available commercially. We note that this curve is quite satisfactory up to 4000 cycles and that at 5000 cycles the response is sufficient to have an effect upon the quality of speech and musical sounds.

Curve A, Fig. 2, shows the response with an experimental needle. We note here that the flat part of the curve has been extended from 3300 cycles to 4500 cycles and that the response at 5000 cycles is only slightly down. The frequency range for disk reproduction may be considered to have been increased approximately 700 cycles.

Method of Testing.—The data for these curves were obtained by using constant frequency records of known amplitudes to test the various needles in a Western Electric 4-A reproducer working into a 500 ohm resistance load.

FIG. 1. Photomicrograph of a recorded disk in profile with needle in groove.

The electrical analogue of this elastic mechanical system is shown in Fig. 3 where the various constants indicated are the effective values measured at the needle point. From this sketch it can be shown that if the voltage developed shall be proportional to the transverse velocity of the record groove at all frequencies of interest, then the ratio, Vm/V, should remain constant. This condition can be stated mathematically as follows: *

* ELMER, L. A., AND BLATTNER, D. G.: "Machine for Cutting Master Disk Records," *Trans. Soc. Mot. Pict. Eng.*, **XIII** (May, 1929) No. 37, p. 227.

$$\frac{Vm}{V} = \frac{S}{(S + S_d - w^2m)} + j\,Rw$$

where

$$S = \frac{S_n S_r}{S_n + S_r}$$

In this equation the component, S_n, of the stiffness factor, S, is the factor we are interested in. As S_n is increased, S becomes greater;

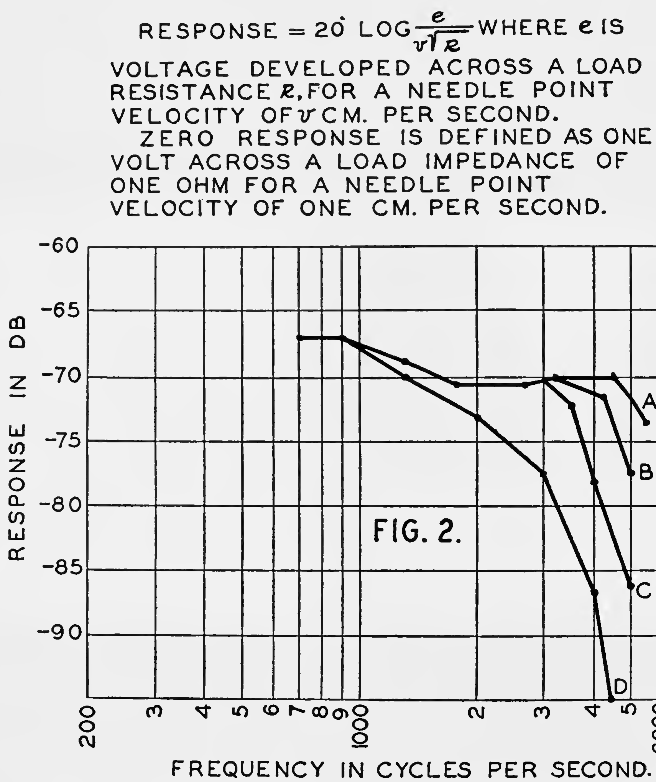


FIG. 2. Response-frequency curves of several needle types.

and as S becomes greater, the effect of the frequency terms, w^2m, and $j\,Rw$ have relatively less effect, and the ratio, Vm/V, tends to remain more nearly constant.

Structurally, the needle is a cantilever supported at the needle holder and loaded at the needle point. There are two sections of this cantilever that may be considered as critical. One is just below the point of support where the total bending moment is greatest. The other is practically at the needle point where there are both sheer and bending.

Wire.—The size and stiffness of wire from which the needle is made determine whether there will be any decrease in response due to bending at, or just below, the needle holder. Response measurements on various sizes of wire from 0.035 to 0.075 inch, all with the same rate of taper of point, indicate that 0.070 inch wire safely takes care of the loads normally applied without showing attenuation due to bending at that section. Any increase beyond 0.070 inch apparently yields no further benefit.

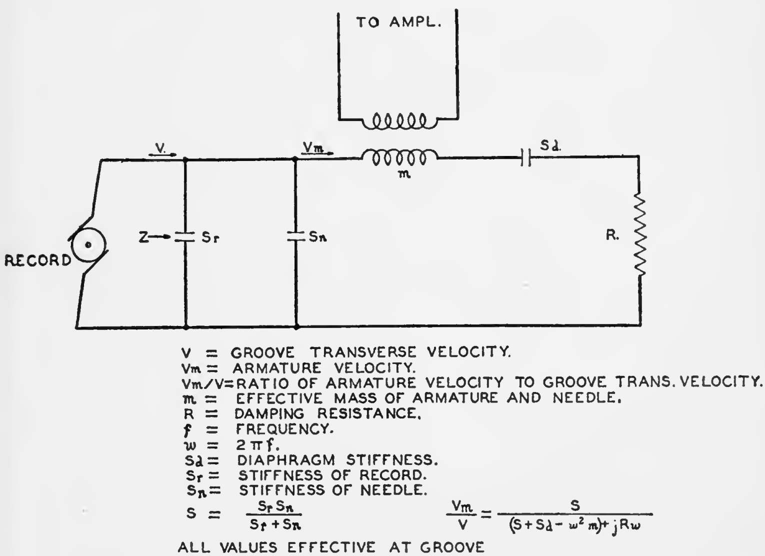


FIG. 3. Electrical analogue of the elastic mechanical system.

Taper.—A series of tests were made on needles of uniform size wire to determine the effect of varying the rate of taper only. These tests indicate the fact that for loud tone needles the change in response due to the taper is limited to the high end of the frequency scale. Although soft tone needles appear to be an exception to this rule, their sharp taper extends so far back that in reality it may be considered as a change of wire size. It was further found that as the angle of taper is increased, the response is raised at 5000 cycles. The curve *A*, Fig. 2, was obtained when we reached 60 degrees.

However, a needle of any practicable wire size with a straight 60 degree taper cannot be used for the reason that it quickly wears into the groove to a depth where its diameter is as great as the width of the groove. With further use it develops shoulders on the sides of the point which ride on the top of the groove. The point of the needle then rattles in the groove, producing a sound that may be characterized as fuzzy.

Wear.—Another point of interest in the design of needles is the change of quality as the point wears. Fig. 4 shows the shape of a

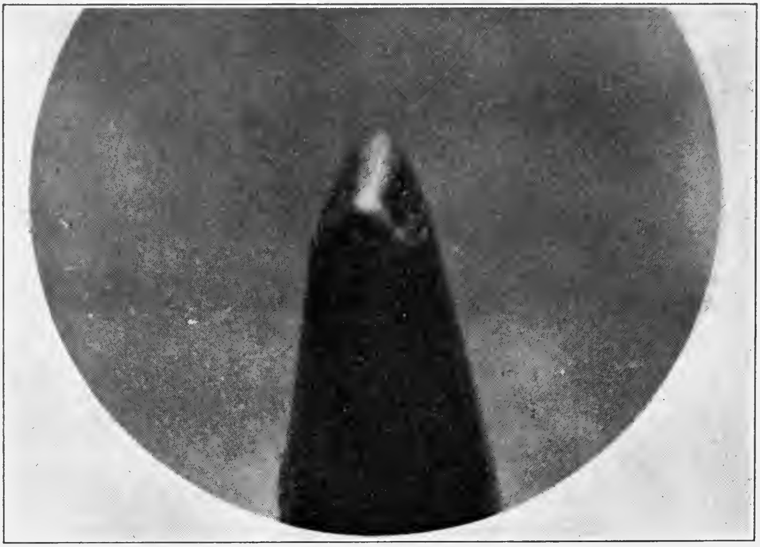
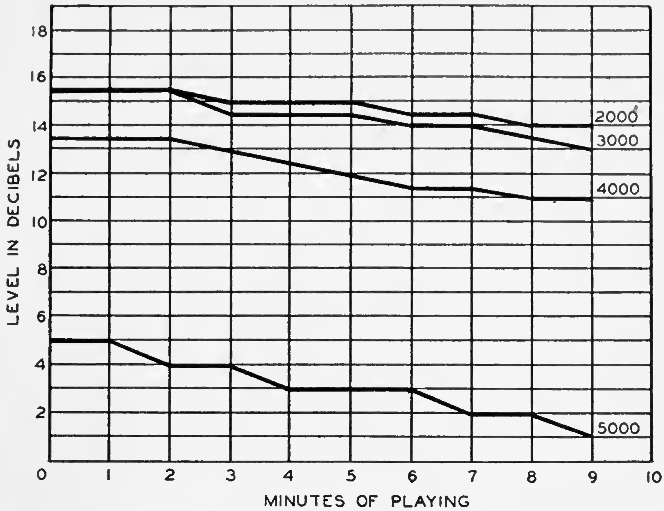


FIG. 4. Shape of point after playing ten 16 in. $33^1/_3$ rpm. records.

point which has been used in playing ten 16 in. $33^1/_3$ rpm. records. Fig. 5, drawing *A*, shows the relative size of a needle point and a 5000 cycle wave on the inside diameter, or beginning, of a 16 in. record and drawing *B* shows the same at the end. We note the round needle point is able to enter and follow the waves, however short, in the beginning of a record. As the point progresses over the record, the length of the recorded waves increases in length due to the increasing linear speed. At the end a 5000 cycle wave has a length of 0.005 inch. It would be expected that the increasing length of the waves would compensate for the increase



Measured attenuation per minute.

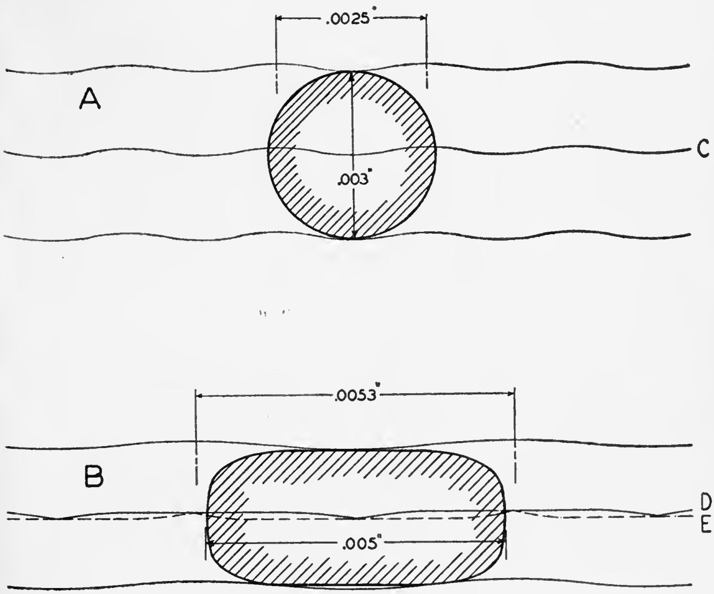


FIG. 5. Relative size of point and 5000 cycle wave at inside diameter (A) and outside diameter (B) of a 16 in. record.

in size of the point due to wear, but it appears that the needle wears considerably faster than the wave-length increases. The group of curves, Fig. 5, shows the measured attenuation per minute at 2000, 3000, 4000, and 5000 cycles. The amount of wear can, of course, be reduced by increasing the hardness of the point within certain limits; however, an excessively hard point will damage the record in a few playings. We have in progress tests of similar needles of varying degrees of hardness to establish an optimum value. The data are not as yet conclusive enough to be included in this paper.

Attenuation is not the only phenomenon met in reproducing 5000 cycle tones. It is obvious from drawing *B* that, whereas the 5000 cycle note is recorded as a sine wave, the motion of the needle in attempting to follow the groove is not sinusoidal. The motion of the needle after it wears down is approximated in drawing *B*, by curves *D* and *E* from which it can be seen that the original sound is not accurately reproduced and that harmonic tones will be introduced. However, these harmonics are of the order of about 10,000 cycles which are not reproduced by loud speakers ordinarily used.

Curve *D* traces the actual motion of the needle if it followed one side of the groove, curve *E* shows the motion if it followed the other side. Obviously both sides cannot be followed at once; the result is that the needle rises and falls slightly in the groove, riding higher at the spots where the groove due to its curvature becomes too narrow for the flattened point.

Scratch.—A study of needles must necessarily include the relation between needle design and scratch noise. Electrical measurements of the amount of scratch noise made in a band of blank grooves recorded for the purpose indicate:

(1) that there is no change of scratch noise with change in size of wire within the limits of the sizes found in good commercial needles;

(2) that there is no change in scratch noise with the change of taper until we get down to the narrow tapers of the medium tone needle where there is also a noticeable loss in the quality of the sound itself;

(3) there is no change in scratch noise measured with needles of varying hardness.

Shadowgraphing.—That needles in packages be uniformly good is of considerable importance. Whereas a few bad needles in a package mean nothing to a person playing a phonograph at home, they are of considerable commercial importance to a motion picture exhibitor. They may cause a few bad performances with the corresponding bad impression on the patrons. This may be avoided

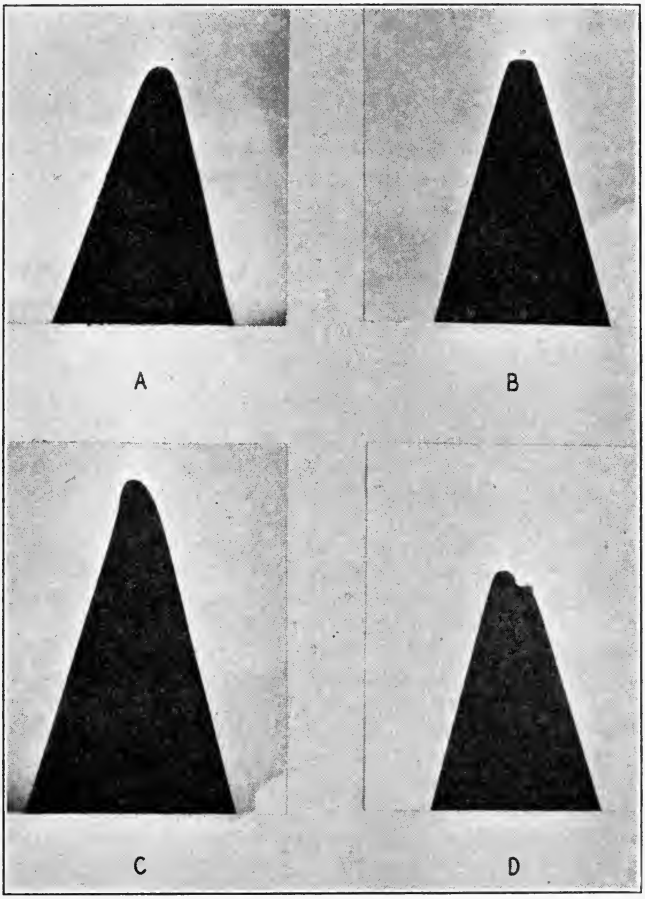


FIG. 6. Shadowgraphs of needles from a new package not 100 per cent factory inspected.

if the manufacturer inspects each needle by means of a greatly enlarged silhouette called a shadowgraph and rejects the poor ones before they leave the factory. Needles that have been shadowgraphed are so labeled on the package. Fig. 6 shows a reproduction of shadowgraphs of some needles taken from a new package which were not 100 per cent inspected at the factory. *A* is a good point, *B* is a flat point, *C* is a bent point, *D* is a broken point.

In the foregoing, we have endeavored to show that needle design has a very definite influence on quality of reproduction, also the relation between performance and certain parameters of the needle such as diameter of wire, shape of point, and hardness of material at the point.

We wish to express our indebtedness to Mr. W. S. Moody for his careful preparation of the many needles of special design with which much of these data were gotten.

DISCUSSION

MR. RUSSELL: I am wondering whether you have any data on fiber needles and whether they will drop off proportionately more than soft-surfaced ones. Have you any data on the cactus needle and also the sapphire or ball point needle?

MR. FRIEBUS: The fiber needle response is similar to that of the soft tone needle, curve *D*, Fig. 2. It wears longer, but from the point of view of the reproduction of sound in theaters its response at high frequencies is so low that it was not considered suitable. The cactus, also the Burmese, are similar to the fiber needle. We have used a diamond point, and at a high degree of taper found a high response all the way up to 5000 cycles, but considerable wear of the record is the result.

MR. TAYLOR: Why is no mention made of the tungsten needle of the same diameter as the groove? How does this show up on comparison with the steel?

MR. FRIEBUS: Such a needle after playing once would have a cross section at the point of bearing as shown in Fig. 5 in the bottom drawing, and the response would be indicated by the values at the end of the curves, Fig. 5, showing the attentuation per minute. I recall that the response-frequency curves of the tungsten point are very similar to curve *B*, which is a standard loud tone needle.

MR. TAYLOR: As I recall the figure, the length of the "canal boat" is greater than the diameter of the tungsten needle.

MR. FRIEBUS: That diameter must be less than the width at the top of the groove which is 0.006 in. The length of the "canal boat" I have measured varies with hardness and runs between 0.004 and 0.006 in. Therefore, it could not be longer than in the case of the tungsten whose diameter is approximately 0.006 in.

MR. TAYLOR: Slightly more, on account of the angle.

MR. FRIEBUS: Yes.

PRESIDENT CRABTREE: The behavior of the needle is so closely associated with the nature of the record that it is difficult to mention one without the other. Have any measurements been made on the resistance of the record to wear?

MR. FRIEBUS: I rather hesitate speaking before the Society on that because I am not grounded, and it would be half guessing. I should like to be excused.

MR. MILLER: The same surface scratch appeared on all needles. Why is that so?

MR. FRIEBUS: My statement was that there was no change in scratch noise until we got a loss in quality itself which comes with the softer tone needles.

MR. BRAUN: I should like to ask whether better results are obtained if the needle wears away more rapidly than the record and how rapidly should the needle wear as compared to wearing of the record for best reproduction?

MR. FRIEBUS: I think that question involves the economics of the situation. With records for amateur playing of phonographs, companies are concerned with the wear of the record. For reproduction in theaters, the price of the record is such that they can be concerned more with quality than with wear on the record. There is no established standard of hardness for needles or records, and both divisions of the game are working in a medium that they think best fitted for their purpose.

MR. BRAUN: I was referring to the $33^1/_3$ rpm. records and my question might be put in this way, which is theoretically the proper needle, one which wears more quicky than the record or one which wears less rapidly?

MR. FRIEBUS: Theoretically, a needle which doesn't wear at all is best.

MR. RUSSELL: If you have such a needle, then the record wears?

MR. FRIEBUS: Yes.

MR. RUSSELL: If that were true, a needle with the angle which was blunt or broad should give better quality than the soft needle.

MR. FRIEBUS: The broader needle does. Curve *A*, Fig. 2, was obtained by using a needle of 60 degree taper, but it cannot be used commercially because the point, after a few minutes playing, wears a shoulder on itself and rattles in the groove giving a fuzzy sound. The cactus needle doesn't wear the record.

MR. RUSSELL: Then with the cactus needle which also has a broad angle you may well get much of the quality without the wear on the record.

IMPROVED SYNCHRONIZING APPARATUS FOR SIXTEEN MILLIMETER FILMS WITH DISK RECORDS

WILLIAM H. BRISTOL*

The purpose of this paper is to describe and demonstrate an improved synchronizing apparatus for 16 mm. films with disk records which in general may be attached to any 16 mm. projector without any change being required in the projector itself.

The design of the synchronizing attachment is such that the projector may be operated in synchronism, with a disk record at either amateur speed of 16 frames per second or at a standard professional speed of 24 frames per second, the speed of the record disk in either case always being maintained at $33^1/_3$ revolutions per minute.

In the present design the main idea has been to produce a portable outfit, compact, and of light weight, by which professional synchronized disk records may be reproduced in the home, school, church, club, *etc.*, without in any way sacrificing the quality of the reproduced sound.

The synchronizing apparatus is made up in two types, one where the turntable is mechanically connected to the projector by flexible shaft and another where the turntable is electrically connected to the projector by a pair of synchronizers, such as have been described in previous papers, which permit of resynchronizing the picture with the sound while it is being projected on the screen.

In order to obtain perfect quality of reproduction of sound from disk records, it is absolutely necessary that the turntable revolve at a perfectly uniform speed and that it be practically free of any vibration. Both of these requirements are more difficult to accomplish when the turntable is driven at standard synchronizing speed of $33^1/_3$ revolutions per minute than at the standard phonograph speed.

For permanent installations as in theaters, the parts of the turntable may be made massive with heavy flywheels to overcome

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* Wm. H. Bristol Talking Picture Corp., Waterbury, Conn. (Read before the Society at Washington.)

vibration and variations in speed, but in a portable equipment, other expedients must be employed.

In order to meet the requirements for a portable outfit, a special small high speed synchronous motor has been developed for driving both types of equipment. For the model which permits resynchronization, the synchronizers have also been greatly reduced in size.

The complete turntable attachment for direct mechanical drive is shown in Fig. 1, which shows the motor, the worm and gear housing

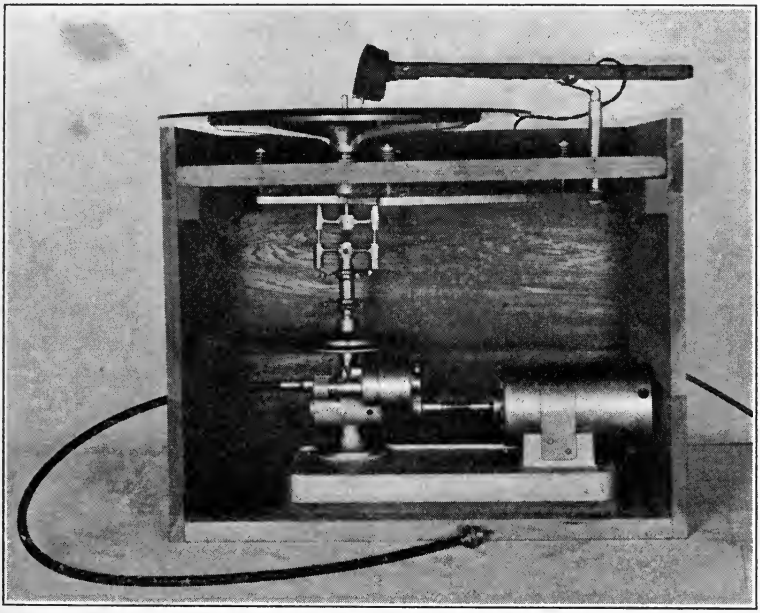

FIG. 1. Turntable attachment for direct mechanical drive.

for driving the turntable, and a flexible shaft with a union joint at the end for conveniently making direct connection to any type of 16 mm. projector.

Two projecting drive shafts are provided at the gear housing, one of which will drive the projector at 16 frames per second and the other at 24 frames per second. The object of furnishing the two different drives has been to make the equipment capable of reproducing synchronized pictures which have been made at either of these speeds

As described by the author in a previous paper, 35 mm. films which have been made at the standard speed of 24 frames per second may be optically reduced to 16 mm. width at the same time omitting every third frame, thus allowing for a synchronous projection at 16 frames per second. Advantages of this method have been described in a previous paper.

The turntable is driven by a vertical shaft shown in Fig. 1 which was described as follows in a previous paper:

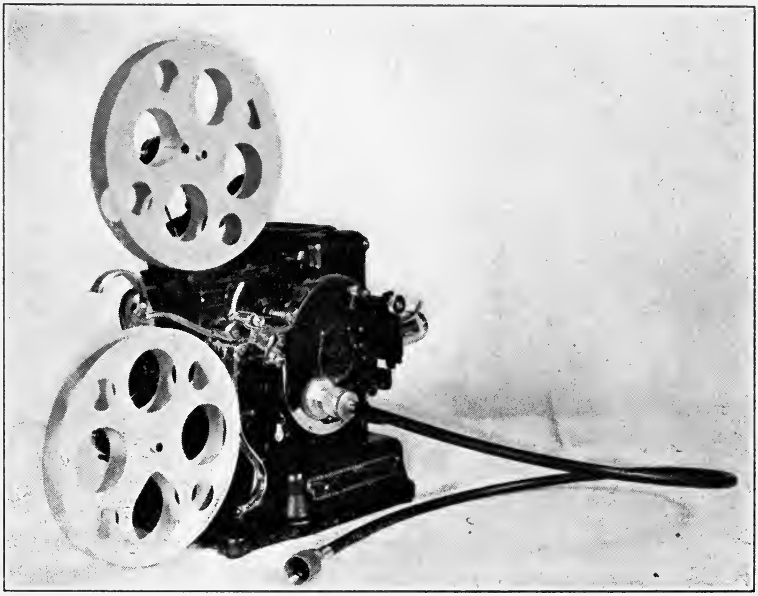

FIG. 2. Eastman Model B Kodascope with flexible shaft drive for synchronizing attachment.

"It is of the utmost importance that the turntable be absolutely free of vibration in order to obtain perfect reproduction, especially of music. To accomplish this, we have developed a mechanical filter system which has proved very simple and efficient. It consists of mounting the turntable as shown, on a tripod, which stands on the floor independent of the base carrying the motors. A vertical shaft connecting the motors with the turntable is provided with several flexible metal disk joints, designed particularly to filter out the vibration that would otherwise be transmitted to the turntable from the motor base.

"In addition to the flexible disk, there is a double sliding joint which is clearly shown in the illustration. This double sliding joint, working in conjunction with the flexible filter disks, has proved to be a most practical way of eliminating vibration, which is always present at the driving motor."

In Fig. 2, an Eastman Model B self-threading projector is shown

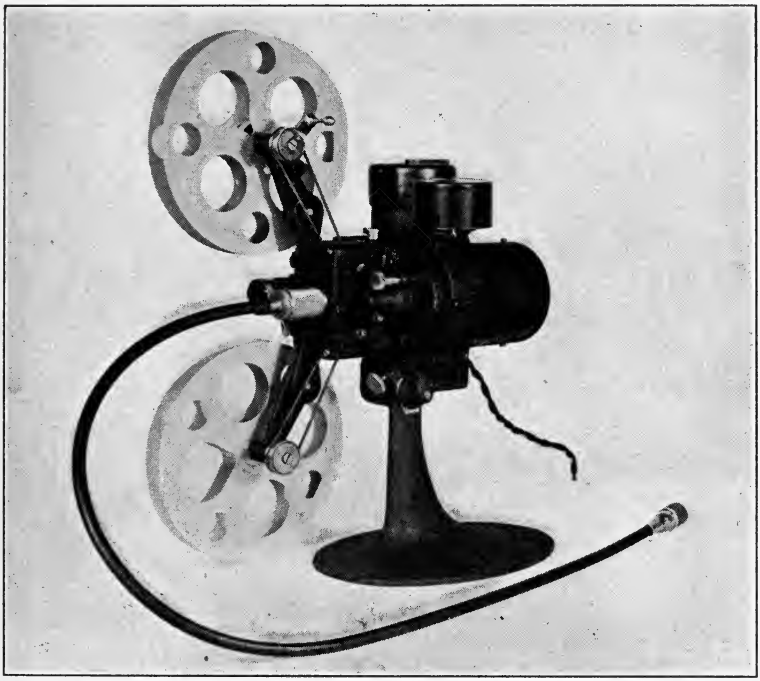

FIG. 3. Bell & Howell projector with flexible shaft attachment.

with attached flexible shaft for making direct connection to the drive synchronizing attachment previously shown in Fig. 1.

Fig. 3 shows a Bell and Howell projector with a flexible shaft attached ready for connection to the synchronizing unit.

Fig. 4 shows an Ampro Superlite 16 mm. projector, with a flexible shaft for connection to the synchronizing unit.

The complete turntable unit for electrical synchronizing drive is

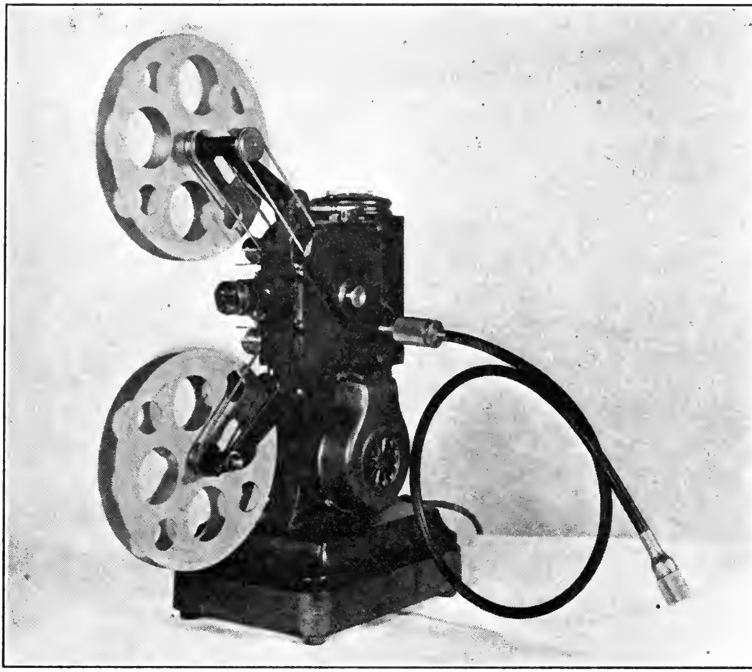

FIG. 4. Ampro Superlite projector with flexible shaft attachment.

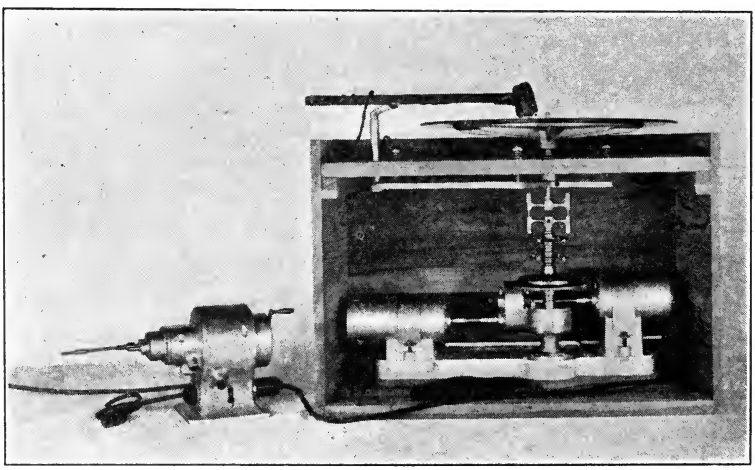

FIG. 5. Complete turntable unit for electrical synchronizing drive.

shown in Fig. 5. The synchronous drive motor at the left drives the synchronizer through a shaft; current is generated by the synchronizer and through a small five wire cable drives the second synchronizer which furnishes the power to operate the projector.

The field of the second synchronizer is provided with trunnion bearings for manual rotation of its field for resynchronizing as described in previous papers.

This synchronizer which drives the projector is also provided

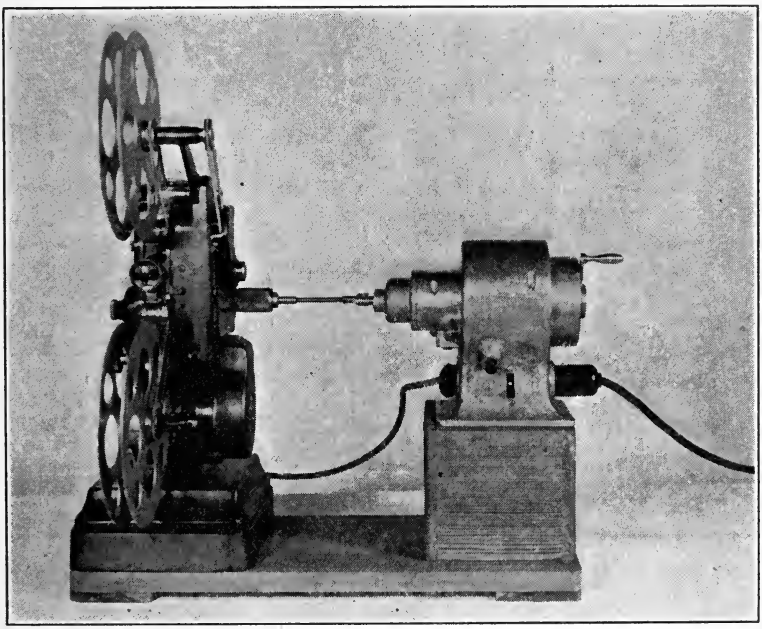

FIG. 6. Resynchronizing attachment.

with two projecting drive shafts. Through a short flexible connection one of these shafts drives the projector at 16 frames per second; the other is geared to drive the projector at 24 frames per second by simply changing the flexible connection.

In Fig. 6, the resynchronizing element is shown mounted close to the projector for convenience of the operator.

The turntable part of the unit used with the resynchronizing device may be located at any convenient distance from the projector.

DISCUSSION

PRESIDENT CRABTREE: What is the tolerance of synchronizing; suppose it is out fifty frames, can it be resynchronized quickly?

MR. BRISTOL: Yes. There is one revolution for each frame, so that resynchronizing is a simple matter.

PRESIDENT CRABTREE: Then it takes 50 turns of the handle?

MR. BRISTOL: Yes, as rapidly as you can turn it, which takes about 10 seconds to resynchronize it.

PRESIDENT CRABTREE: I should like to see you throw it out of synchronism and get it back as quickly as possible. (This was demonstrated.)

MR. R. C. HUBBARD: I should like to ask Mr. Bristol if the negative was made on 35 mm. film.

MR. BRISTOL: Yes, on 35 mm. and photographed at 24 frames per second, the same as professional pictures. We took this negative and put it on a special printer made so that it cuts out every third frame. In that way, we reduce the speed of the 16 mm. projector to its normal speed of 16 frames per second and still maintain synchronism.

MR. EVANS: Does the motor of the projector run with the synchronized motor?

MR. BRISTOL: Yes, it runs so as to ventilate the lamp and at the same time do the work of driving the small projector. The other motor driving the turntable is independent of this and is designed so that it runs at uniform speed without a governor.

PRESIDENT CRABTREE: I think the experiment demonstrates that in the case of the dancing subject used, the picture and sound can be out of synchronism quite appreciably before it becomes objectionable.

MR. W. B. COOK: In the projection of a slow motion picture, is the elimination of the third frame obvious enough to show an apparent jump on the screen?

MR. BRISTOL: No, it is less obvious than with normal speed pictures.

THE MAINTENANCE OF SOUND FILM IN EXCHANGE OPERATION AND THE DEGREE THAT SOUND REPRODUCTION IS AFFECTED BY THE CONTINUED USE OF SOUND TRACK FILM

TREVOR FAULKNER*

The papers committee asked me to outline the results of my observations on the proper method of maintaining correct screening continuities and synchronization in the handling of sound film in exchange operation. I have also been asked to state my opinion of the effect that dirt, oil, and scratches accumulated in average projection runs on sound track prints have on sound reproduction.

Of course, the exchange would like to furnish complete and unspliced prints to every account. This, however, is quite impossible.

Most black and white prints received by the exchange from the well equipped laboratory have no splices in them. The laboratory has printed and developed the film in one continuous strip, and from the beginning of the part titles down to the end of the end titles of each reel, each answer print is the exact duplicate of the master print in complete continuity down to the frame. If the negative is damaged in the laboratory and a few frames lost, either blank frames or duplicate frames are inserted in the negative so that all prints from that negative are exact duplicates in footage of the master print. Occasionally, the exchange receives prints that have one or two splices in them. The positive was damaged in printing, but in such cases a sufficient overlap is printed by the laboratory to permit a splice to be made without the loss of a single frame.

In the laboratory, after the sample print has been approved, the negative is cut to fit it. Footage numbers are then placed on the margin of the cut negative, starting with the numeral zero at the picture start-mark and then appearing numerically at frequencies of every one foot or sixteen frames down to the end of each reel. These footage numbers are printed onto the margin of each positive print, thereby making it an easy task to check against the amount

* Paramount Famous Lasky Corporation, New York City.

of footage of any deletion where a splice does occur, and inasmuch as these marginal footage numbers occur at the identical frame of every print of the same subject, the insertion of replacement parts is a simple task.

A number of these distributing companies which are furnishing film to the exhibitor so that he may reproduce the sound from either sound-track film or the synchronized disks, according to the type of equipment he may have, are having their entire quota of sound film printed with the sound on the film. The sound is also recorded on synchronized disks to fit these prints. This procedure makes it possible to serve a maximum number of accounts with sound track prints at the time of the peak demand for a subject, and then as many prints with sound track as necessary are converted into synchronized disk prints by splicing in film where it may have been deleted until the complete footage equals the footage of the original film and each scene is synchronized with the disk record.

It is, of course, necessary that the projection equipment through which these converted prints are projected be equipped with a mask at the side of the aperture, to keep the sound track from being projected onto the screen. However, the fact that sound track prints can be converted into synchronized disk prints has meant an enormous saving in the laboratory cost of printing, and has made available to the theater which has only the disk equipment many subjects which otherwise would not be made in disk form. The cost of printing additional synchronized prints with full screen width photography over and above the quota of sound track prints would not be consistent with the revenue derived from disk equipment only, in many instances.

At the time prints of a subject are received in an exchange, it is essential that all reels of these prints have a close inspection, and if any splices do occur in the film they should be checked by inspection of the marginal footage numbers appearing on each side of the splice to determine if there is any film removed. As closely following the printing of a release as is possible, the exchanges should be furnished with positive information as to the footage of each reel of that release. This information should come to them in the form of a correct continuity sheet which is descriptive of the scenes and the definite footage of them and the dialog that they contain. In addition, the exchanges should be furnished with riders that are to be attached to the in and out cards of each print of that subject, which carry the exact footage and frames of film in each reel between the picture start-mark and the end of the first scene that ends without a fade-out or a dissolve.

Repairing of a film while it is being served to the sound track accounts can often be done by deletion, providing the sound track on the film removed does not contain any dialog or rather any essential words in a dialog. A close inspection of the sound track modulations will usually reveal whether the sound is speech or music, and a check-up with the dialog continuity sheet will show whether the part which it is necessary to remove is important. A replacement can be ordered if the continuity of the dialog is interrupted.

A sound track print thus handled will come up to the time that it is to be converted into a synchronized disk print with a number of splices in it. Most splices that are in these prints before they are converted will appear between the picture start-mark and the first scene of action in the reel, as some projectionists will insist on mounting two thousand feet of film onto one reel. In doing this they remove the ends of the reels, from the last scene of action down to the end of the reel and from the beginning of the following reel down to the first scene of action, and join the two actions together in order to reduce the number of machine cut-overs in their evening's program. This practice of mounting more than one thousand feet of film onto one reel is prohibited by the fire ordinances in some cities, is banned by some of the larger theater operating chains, and should be discouraged by everyone in the industry. It changes the reel assembly for the distributor in many cases; there is the loss of important film where the projectionist fails to return it to the exchange; there are mix-ups in the consecutive arrangement of the reels in following shows where the projectionist has erred in affixing the part titles on their respective reels; and it makes it most difficult to retain the reel in proper condition to be converted into a synchronized disk print. In addition, when film is scratched or otherwise damaged by passing through a projector that is so damaging it, the amount of damaged film is usually in proportion to the amount of film footage mounted on the reel being projected.

Up until a sound track print is converted into a synchronized disk print, it should not be booked to a disk account because of the probable lack of synchronization between it and its accompanying disk, due to the few frames that may have been removed at various places without any reinsertion of film to make up for the loss of footage. Before a print is converted, as I have already said, the exchange can make deletions that do not interrupt the dialog continuity or make the action jumpy without replacing film to make up for the loss in footage. But the splice where the two ends are brought together should be one that could be identified by quick inspection as an exchange splice. The inspector should stop at every splice and if it is an exchange splice, then it is reasonable to suppose that the inspector who made the splice has approved any missing footage as all right.

At the time that a print is converted into a synchronized disk print, a very careful check-up of every splice must be made and replacements inserted at every point where there is any footage missing in order to bring the print to its original footage to the frame. After the print is converted the original footage must be maintained so long as it is booked, and when splices are made replacement film must be inserted to make up for the lost frames. Where it is possible these replacements should always be made from the exact duplicate scenes as those damaged. It is possible for the distributor to have some centralized point, from where the actual desired scenes and footage can be air-mailed to the exchanges when needed, thus effecting no more than a twenty-four hour delay in the transaction.

Where a synchronized disk film is damaged at intervals and replacement parts of the actual scenes damaged are not available, and it is necessary to insert black leader into the footage, the necessary footage should be made up in the fewest practical number of insertions. For example, if there were ten different places in a close sequence where it was necessary to remove two frames each, and there was no definite close-up or dialog in this footage, it would be better to place all twenty frames in at one point than have the ten different black places flashed across the screen. In so doing, though, the inspector must realize in the following inspections of that film that the regularity of the marginal footage numbers will be disturbed throughout this sequence. The method of putting replacement film all in at one place is always desirable in making replacements in the leader between the start-mark and the first action of a reel and is not important on the main title of the first reel. As there is no synchronized dialog or effects during the footage of the main title, there should be no dark spots on the screen whatsoever in the first reel of any subject prior to the first scene of action. Any insertions of black film in the main title to maintain the original correct footage should be ahead of the point where the title fades in on the screen.

After a print has been converted into a synchronized disk print, it must not be booked for showing in a sound track theater, as any black leader that may be in this print will affect the sound reproduction to such an extent that it will either cause dissatisfaction or the projectionist will remove it prior to its screening. This will cause additional work when the print is returned to the exchange and considerable more loss of footage in inserting replacement film again before the print can be used for synchronized disk bookings.

In maintaining disk film in the exchange, every time that a splice is made it should be stamped with an embossing stamp to show that the footage is complete, thereby removing the necessity of a check-up on the footage in following inspections. This materially speeds up following inspections. Contrary to the opinion that prevailed at the beginning of sound, it is not necessary to block out splices made in sound track film, providing these splices are accurately scraped and cut. The splice, however, if improperly scraped will be heard when it passes before the photo-cell.

Under the proper average care the physical life of sound track film is greater than its booking life; and after it is converted into a synchronized disk print, if it receives proper care and an adequate replacement follow-up is observed, the desired condition of having a complete satisfactory print for every account can be realized.

It would not be consistent to make any definite statement concerning the number of times that a sound track print or synchronized disk print is projected before it is in an unfit condition for further screening. At least any number so stated would not fit the two different kinds of film. In practically all cases, projection equipment that reproduces sound from the film is new and is under the care of skilled and competent projectionists. Consequently the minimum amount of damage would result in its screening. The status of equipment which reproduces sound from synchronized disks is usually such that film used in it would have much shorter life than sound track film.

Prior to sound, one could more or less accurately state the projection life of a print, due to the fact that we did not then have to consider deletions and splices which now retire film quicker than any other factors. A few frames, an entire scene, and sometimes a complete sequence removed from a silent print would hardly classify it as unserviceable for some of the smaller accounts so long as the titles were of sufficient length to be read, there was a fade-out at the ending, and the physical condition of the remaining part of the print was fair. Now, however, no theater wired for sound is going to be reconciled to screening sound track film where the dialog continuity is interrupted, or synchronized disk prints that have too much black leader in them or that are out of synchronization with the disk. It behooves the distributor, therefore, to retire film from service now which would have been classified as being in fair physical condition in the days before sound.

A fair average, however, of the number of times a sound track print can be run before the normal wear and tear on it would put it in a questionable condition could be placed at two hundred times. Give the average print two hundred screenings and the damage to it will include warped and buckled film (caused by the loss of moisture from the heat of the projection lamps), dirty and oily surfaces, and surface scratches on both the celluloid and gelatin sides. The average film that has been run two hundred times will show very little strain on the sprocket perforations. Distributors that use the utmost care in their exchange maintenance of film will find that fully seventy-five per cent of the film that is returned to them from the field for final disposition will be in good physical condition so far as sprocket perforations are concerned. This is due to a combination of improved conditions of projection equipment; a better knowledge of the equipment and its operation by the projectionist; a far greater regard for film conditions; increased bookings of multiple date screenings and fewer bookings of the one day runs; a more organized inspection department in the exchange backed by the desire of the exchange manager to have this department functioning as nearly one hundred per cent efficiently as is possible.

From my observations on the effect of repeated screenings on the quality of sound reproduced from the sound track, I would say that there is no apparent tonal difference between the first time a sound track print is screened and the two hundredth time, providing, of course, that the sound track surfaces are entirely free from dirt, oil, or any other foreign substance, that the film is not warped or buckled, that the sprocket perforations are not enlarged, and that there are no scratches or sprocket tooth marks on the sound track surfaces. Any oil, dirt, or other foreign substances that might be on the surfaces of the sound track will cause a decrease in the volume of the sound reproduced therefrom in proportion to the amount of light that is thereby obstructed from reaching the photo-cell pick-up. Also a gathering of dirt, wax, or other foreign substances at the light valve directly between the exciter lamp and the photo-cell pick-up will cause a decrease in volume in the reproduction of the sound in proportion to the amount of light that this obstruction keeps from filtering through from the exciter lamp to the photo-cell pick-up. Dirt or oil on the film or lodged in the sound aperture will have a tendency to affect tonal reproduction to that extent that these agencies might vary the light intensity in the photo-cell pick-up. Warped and buckled film will affect the tonal reproduction of sound only if the film is twisted sufficiently for its smooth passage over the sound aperture to be disturbed. If the sound track weaves to the right or left of its regular tread as it passes over the sound aperture, the volume is decreased in proportion to the amount of the sound modulations that do not pass in a direct line between the exciter lamp and the photo-cell pick-up. There would also be the inclination toward tonal distortion if the film were so badly warped and twisted that the sound modulations were not permitted to ride across the sound aperture at the correct cross angle. This above condition would also prevail where the sprocket perforations are enlarged sufficiently to permit the weaving of the film in its passage over the sound aperture. Minor scratches on the sound track of Western Electric recorded sound do not have any noticeable effect on the sound reproduction. Where the scratch is wide enough and the surface is dark, if there are no abrasions causing the emulsion to be entirely removed from the celluloid, the only effect in the sound reproduction would be a decrease in the volume of sound in proportion to the amount of the area of the sound track that the darkened scratch would cover. Where there are pin point abrasions in the emulsion at intervals in the scratch, there will be a tendency to reproduce a sputtering noise very much like that of radio static; and wherever the light valves of the sound modulations are altered, the tonal reproduction will be affected.

If the scratch is deep and the emulsion is entirely removed over the area of scratch, it will cause a ground noise where the light from the exciter lamp is filtered through the uncovered celluloid onto the photo-cell pick-up. This ground noise would be without tone if the edges of the emulsion are removed with a razor-like precision, but if the edges of the scratch are ragged or irregular, it would reproduce noises other than straight ground noise.

A scratch on the celluloid side of the sound track will not affect the sound reproduction unless it is made in such a manner that it will deflect the light rays from the exciter lamp and change their values in the photo-cell pick-up.

Where the sprocket perforations approach the sound track through faulty printing, or the focus of the exciter lamp is such that its rays are not confined to the width of that sound track, but are spread over the area of the perforations or the frame line between the frames of action in the picture, we shall have a sound reproduced very similar to a motor boat exhaust. This sound is also reproduced by sprocket tooth marks on the sound track where there are abrasions in the emulsion.

The answer to the problem of exchange maintenance of sound film is to make replacement of damaged film with the actual scenes where possible and to withdraw the film from further service when it approaches an unsatisfactory condition because of splices, deletions, warping and buckling, scratches, and a weakened condition.

When film is so withdrawn from service, it is my opinion that the general average will show that that print has about two hundred screenings to its credit.

THE SOVIET CINEMATOGRAPHY

L. I. MONOSSON*

Before speaking about the Soviet cinema and the Soviet cinema industry, I want to say a few words about the cinema of pre-revolutionary Russia.

There were six studios in Moscow, one in Leningrad, two in Yalta, Crimea, and two in Odessa; in other words, the pre-revolutionary film industry of Russia had four producing bases.

The peculiarity of the Soviet film studios, as compared with the pre-revolutionary ones, is the building of the studios in the different National Republics for national cinema production.

The character of the film productions in pre-revolutionary Russia corresponded to that in other countries before 1914. During the war the Russian cinema was utilized in the same manner as in other countries at that time.

Most of the cinema theaters were small but in the larger cities there were especially built cinema theaters, some of them with seating capacities up to 1000. The building of new cinema theaters proceeded very slowly and during the war was discontinued altogether. In the provincial towns the cinema theaters were ill adapted for their purpose, with a limited number of seats and other disadvantages, reminding one of the provincial cinema houses in other countries.

Since it is our aim here to discuss the Soviet cinematography dating from 1917, I shall not dwell any longer on the Russian cinematography prior to that time.

I will attempt first of all to explain briefly the essence of the Soviet cinematography which is in many respects different from the cinematography of other countries, both as to form and content. I will begin with the artistic trends in the Soviet cinematography.

Art Trends in the Soviet Cinema.—Cinematography, like every domain of art, should be considered in its context of cultural, social, and political standards prevalent at the given period. The form and style of a film are closely bound with its subject matter which,

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* Amkino Corp., New York. (Read before the Society at Washington.)

in turn, is determined by the demands of the times. The cinematography of pre-revolutionary Russia conformed both in content and form to the tastes and manners of its public. True, it had no command of the technic that would raise the art of the screen to the formal levels of other arts, yet the screen of that time, too, responded to the influences of esthetic symbolism and nebulous romanticism that held sway over the literature of the period; there were experimenters who sought the proper form that would best give expression to this kind of subject matter.

The early Soviet cinematography, like other arts, could not at first find its proper thematic content nor the clear cut forms to shape the new material. Some guiding principles were arrived at both as to form and subject matter, but it took quite some time before the individual artists, the directors, scenario writers, and actors assimilated the new reality, the new born standards, the new principles of coördination of film and spectator. It was only after the civil war, with the return to peace time reconstruction, that problems of art and culture received their due share of public attention. By that time the artist already began to sense his true relationship to the social organism, and the role of the artist in the multiform process of reconstruction has become more or less clearly defined.

A period of technical experimentation and achievement brought with it also a pretty well crystallized conception of the ideological and artistic fundamentals of the Soviet cinematography. To begin with, the social aspect of life was to receive preference before the individualistic aspect. Man was to be portrayed not in terms of his inner personal moods and emotions but in terms of his social relationships. The drama of the individual in conflict with the individual gave place to the drama of conflict between groups, between social strata, or between individuals representing these socially antagonistic groups.

On its formal side, too, certain basic tenets became crystallized. A maximum of expressiveness, of contact with the spectator was considered as paramount, and to this end the new *regisseurs* bent all of their effort. Not halftones and evanescent shadings, but vivid, sharp sequences, eloquent contrasts, overtones of *montage*, captivating tempo were made the basis of the new cinematic idiom.

The new film actor followed as a corollary to the new film. The actor was emancipated from his enslavement to the "psychological" drama and the screen was emancipated from the overlordship of the actor. No longer was the film regarded as a "vehicle" for the actor, but quite the contrary—the actor took his proper place as a component element of the picture.

The artistic aspect of the Soviet cinema requires a reference to the distinctive styles of some of the outstanding Soviet directors whose fame and artistic influence have gone far beyond the boundaries of their country. One of them is Sergei Eisenstein, an acknowledged world master in the realm of the cinema, the director of *Potemkin*, *Ten Days That Shook the World*, and *Old and New*. Eisenstein bases his pictures not upon individual heroes but on the masses of humanity. Individual characters figure in his films only as episodic material. A brilliant and convincing example of this method is his *Potemkin*, also his *Ten Days*, two films that won not only the admiration but also the close study and emulation of film-masters the world over. The *Eisenstein School* has many followers among the workers in the Soviet cinema. His methods are being widely applied and his style emulated by the new crop of film directors.

Another *regisseur* of creative genius is Vsevolod Pudovkin, director of *The End of St. Petersburg*, *Mother*, and *Storm over Asia*. Unlike Eisenstein, he draws upon fiction for the story of his films, but his fiction is of the stupendous proportion and dynamic sweep of a social drama, and in this *genre* Pudovkin is a great master, indeed. The vivid quality of his emotional methods, his robust realism mark Pudovkin as unique in his art.

The style of both of these master-*regisseurs* has been influenced to an extent by the American masters of the early Griffith and Chaplin period, as well as by some French master innovators.

To the list of serious original and highly talented Soviet *regisseurs* must be added the name of Alexander Dovzhenko, director of *Arsenal*, *Earth*, and other notable films. Dovzhenko is Ukrainian and works in terms of Ukrainian subject matter but along the artistic tenets established by the leading masters of the Soviet cinema.

An interesting group of cinema workers are the so-called Feks (initials for "Factory of Experimental Actors"). They work in the *genre* of expressionist melodrama. Their original taste and sense of style go together with a sound sense of the cinema. One of their best pictures is *The New Babylon*.

In addition to the *regisseurs* and "schools" here mentioned as characteristic of the Soviet cinematography, there are also a number of *regisseurs* excelling in the traditional realistic style not unmixed with modern innovations and influences. Tarich, the director of *Czar Ivan the Terrible*, and Protozanov, director of *Lash of the Czar*, belong to this category.

It may be noted that nearly all of the best products of the Soviet cinematography of recent years have been exhibited in the United States not in the luxurious movie palaces, it is true, but before discriminating and appreciative audiences. The Soviet films shown in the United States received high and merited praise from the American film critics.

Distribution and Exhibition.—The technical, economical, and organizational basis of the Soviet cinema industry have also distinctive features. I will first take up distribution and exhibition:

The potentiality for distribution and exhibition of films in the various republics of the Soviet Union, whose territory is 23,342,872 square kilometers with a population of 147,013,600, is as follows:

Republic	Percentage
Russian Soc. Feder. Soviet Rep.	68.5
Ukrainian Soc. Soviet Rep.	22.0
Trans-Caucasian Soviet Rep.	5.0
Central Asiatic Soviet Rep.	3.9
White Russian Soviet Rep	1.5

The distribution is conducted on the basis of a rigid schedule of rates for the various types of cinema establishments that have a projection apparatus and a more or less permanent exhibition place.

The latest data covering the Russian Socialist Federated Soviet Republic show that on October last this republic, the population of which is upward of one hundred millions, was served by a net of 9693 cinema establishments divided into the following types:

Type of Cinema Establishment	Number of Establishments	Percentage
Cinema theaters (in towns, cities, and urban settlements)	860	8.8
Clubs for workers and state employees	1997	20.6
Schools of all types, children's homes, and colonies	224	2.3
Theater clubs	888	9.2
Cinema theaters in rural settlements	1114	11.4
Traveling outfits for rural service	3873	40.4
Miscellaneous	246	2.6

Thus rural establishments serving the rural population constitute

51.4 per cent of the entire cinema net in the largest republic of the Union. If we added to this the number of establishments serving the workers' clubs, we see that the greatest number of cinema establishments serves the needs of the workers and the peasants.

The urban cinema theaters account for only 8.8 per cent of the total number of cinema establishments. The urban population of RSFSR numbers 15,979,440. The seating capacity of all the urban cinema houses amounts to 349,400, or an average of 400 seats to a theater.

The capacity of the 888 theater clubs is 328,000 seats. The clubs (1997) accounting for 20.6 per cent of the cinema net have 484,800 seats. The 1114 stationary rural establishments, constituting 11.4 per cent of the total number of establishments in the RSFSR have 207,000 seats. Rural traveling outfits, numbering 3873 and amounting to 40.4 per cent of the entire cinema net, have an estimated seating capacity of 387,300—counting 100 seats for every showing.

The urban cinema theaters are open daily, the rural stationary theaters—an average of three times a week, the club establishments—an average of 8 days a month.

The total capacity of the urban cinema establishments is 1,163,700 seats. That of the rural establishments—594,700 seats. The urban population of RSFSR is 15,979,440. The rural population is 85,102,344. Thus in the cities and towns there is a cinema seat for every 14 persons while in the countryside there is one seat for every 143 persons.

In 1928–29 the attendance in the urban cinema establishments was 127,600,000. The rural attendance for the same period was 70,285,000.

The cinema theaters and even the theater clubs and other urban cinema establishments operate on the basis of self support and profit. The rural cinema is also operated on a basis of paying for itself, but this is difficult to accomplish when attendance is small, for the cost of admission to a rural cinema is only 5 cents on the average (from 2.5 to 7.5 cents).

The turnover of rural distribution and exhibition for 1929 amounted to only 17.0 per cent of the gross receipts of the Sovkino for that year (Sovkino is the organization operating in RSFSR). But if the income from the rural cinema establishments is as yet small as compared with the income from urban establishments, at the end of the five year program of cinemafication (which will be discussed presently) the proceeds from rural distribution and exhibition will be greatly increased with the increase in the number of rural "screen-days" (75 per cent of the total), in the number of rural cinema establishments (70 per cent of the total), and in the number of used copies (75 per cent of the total).

The solution of the problem of cinemafying the country—a problem of providing culture, education, and artistic entertainment for the masses of the population of the Soviet Union—is essentially a problem of rural cinemafication, though it goes without saying that the cinemafication of settlements with an industrial population is also one of the principal problems and aims of the general cinemafication program.

I now approach the question of the technical basis of the Soviet cinema.

Technical Basis of the Soviet Cinematography.—At present there are in the Soviet Union eight producing bases in a number of cities (Moscow, Leningrad, Odessa, Kiev, Tiflis, Tashkent, Baku, Erivan, and Yalta). Moscow has six studios, Leningrad three, and the rest of the producing cities one each. It may be noted that new studios have been built in Kiev and Tiflis, and that the new studio now being built in Moscow will be the largest in Europe.

Let us examine in more detail two of the largest producing centers of the Soviet film industry, which undoubtedly will play a large part in the development of the Soviet cinematography within the coming few years—the film studios, or cinema plants as they are called in Soviet Russia, at Moscow and at Kiev.

The Moscow plant, located on the Lenin Hills in a suburb of Moscow, is being built according to the plans of two Russian architects, Voinov and Brokman, whose design won the award in the All-Union contest organized by the Architectural Society of Moscow. Before these plans were finally approved they had been examined by various commissions and discussed at various technical conferences of cinema workers who made a series of changes and improvements in them. The project for the plant was also examined by various high governmental and technical bodies.

The plot set aside for the plant has an area of 56 hectares (138 acres). The main building of the plant, whose volume is 160,000 cubic meters, has a filming, or shooting, area of 4500 square meters calculated for the simultaneous production of 15 full length films, The height of the studio proper is 12 meters and only three units located in the center of the plant attain a height of 17.5 meters. The height and width of the plant are such as to allow a maximum range for the camera.

The form of the plant, resembling that of an airplane, and also the heights and the widths as well as the angles make it possible to do filming not only in different parts of the plant but also permit of large scale filming in several parts simultaneously and in different directions, bringing the width of the sets up to 38 meters. Every "lot" has an area of 300 square meters (25 × 12) needed for the filming group.

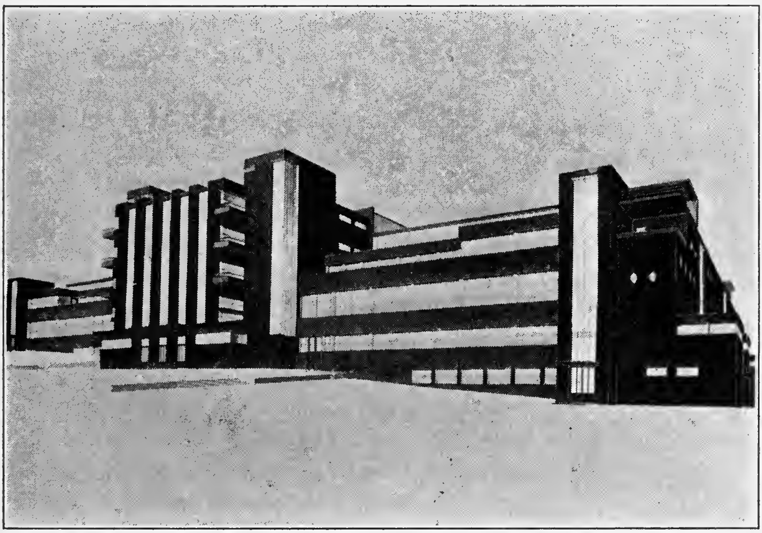

FIG. 1. New studio of Sovkino in Moscow. Front view of the main building.

The entire studio is divided into four independent groups separated by sliding sound-proof walls.

In the studio are three tiers of balconies for filming from above and for lateral and top lighting.

The rear wall of the rear part of the studio has enormous sliding gates, 10 × 12 meters, opening upon an open filming platform of an area of 1200 square meters. At both sides of the platform rising from the ground level are passages for automobiles, cavalry, *etc.*, which are needed in large mob scenes.

The basement located under the floor of the studio has a whole series of light, spacious compartments set aside for keeping furniture and properties. There, too, are located the sculpture shops, all storerooms, two water tanks reaching the level of the studio floor and available for surface as well as under-water filming, and also the mechanism of a revolving platform. All compartments of the basement floor are connected by an 8 meter asphalt corridor where motor carriages are moving continually bringing and carrying away materials. Communication with the studio floor will be achieved by means of a series of passenger and freight elevators besides stairways.

The first floor, with a filming area of 4500 square meters, is served by a number of surrounding compartments containing all the auxiliary workshops for the painting, setting, and electrical departments. There, too, are located all working quarters for the producing staff connected with the immediate work on the "lot," artists, decorators, cameramen, quarters for the make-up and wardrobe men, and rehearsal and projection rooms.

The location of the auxiliary rooms on the first floor makes it possible to supply complete service to every filming unit separately, which will result in a considerable degree of convenience as well as in saving of time and a reduction in the wear and tear on the apparatuses and properties.

On the first floor, too, are located the waiting rooms for actors during recesses.

Like the basement floor, the first floor where the studio is located is pitched so that at one end there is an entrance from the ground for automobiles, horses, *etc.*, while the other end reaches the level of the second floor.

The second floor is assigned exclusively to the personnel and has rooms for directors, make-up men, wardrobe keepers, hair-dressers, halls for extras and actors taking part in mob scenes.

The third and fourth floors are set aside for artist's rooms and projection rooms; there is also a large buffet for the actors.

All the floors are connected by means of ten staircases and a series of elevators.

The material of the structure is of concrete. The roof is made of steel trusses 25 meters long, placed on reënforced concrete frames, and is provided with heat insulating covering. At the enlarged place, the spans are from 25 to 36 meters. Open steel trusses are used for supporting lighting equipment, also for metal bridges, and for floor lights.

Near the studio is being erected a building for the main shops. The building will contain 9717 cubic meters and will be connected with the studio by means of a viaduct through the corridor of which the shops will send their products direct to the studio by means of mechanical carriages moving on rails. The shops will have an electro-mechanical department, with an area of 613 square meters, and carpentry, assembly, and machine departments occupying 1037 square meters. On the second floor will be a drafting room, an office occupying 284 square meters, and a drying room for lumber.

On one part of the plot are located several buildings for inflammable materials, and storerooms for positive and negative films. Already there have been completed two storerooms for copies of films, 3600 cubic meters, each with a storing capacity of 6000 copies, and one for the storing of 900 negatives of full length films.

On an adjacent plot, 26 hectares (40 acres) in area, there are being built living quarters for the personnel of the plant.

The construction and equipment of the main building and the auxiliary structures will be completed in 1930–31, but the partial utilization of the main building for production is already possible.

The problem of using the new plant for a sound studio is now being worked out.

Within the territory of the plant it is also proposed to erect a special building for the production of sound films with the application of the latest achievements in this field, both in the Soviet Union and abroad, particularly in the United States.

The Kiev Cinema Plant.—A distinctive feature in the construction of the WUFKU cinema plant at Kiev (construction begun March, 1927) is the successful solution of the problem of locating the auxiliary establishments that are to serve the main nerve of the plant, the studio proper.

All departments are connected with one another and with the studio by means of a spacious corridor $3^1/_2$ to 6 meters wide. This makes it possible to avoid communication through the yards and superfluous moving about of personnel and equipment. Every department, constituting a distinct unit, is at the same time closely related to other departments serving the studio both in point of location and in coördinating its service with that of other departments.

The studio of the cinema plant is 105 meters long, 36 meters wide, and has an available height of 15 meters.

The iron structure of the studio is really a skeleton upon which are fastened all the necessary means of locomotion, bridges, and galleries. The thickness of the brick wall is that of two halves of standard brick with a filling in between of 250 millimeters of pressed peat.

The movement of the upper lights is regulated by 14 crane ways along which are moved electric carriages capable of lifting or lowering the lighting apparatus and other devices at any point in the studio.

A special transforming station, in which there are for the time being only five aggregates of 1500 kilowatts, transforms the alter-

FIG. 2. New studio of Wufku in Kiev. General view from N.W.

nating current of the central power house of the city into direct current and from this substation the current is supplied to the studio and all other places where it is needed.

The lighting apparatus at any point in the studio receives the needed supply of current from special outlets located along the walls of the studio below and on all the galleries of the cross-bridges.

The heating system of the studio provides, on coldest days, an inner temperature of 65°F.

The territory of the plant measures about 30 hectares (74 acres) with 10 hectares (25 acres) of park which makes it possible for the plant to do most of its productions on the premises and saves the expenses of expeditions and outdoor filming.

Speaking about the Soviet motion picture industry, its technical, economical, and organizational side, one has first of all to consider the five year plan of the motion picture industry.

The Five Year Plan for the Soviet Film Industry.—The five year plan of economic development of the Soviet Union which was set into motion in 1928–29 and which serves as the basis of the reconstruction of the country and for the upbuilding of all branches of industry and agriculture, contains also a schedule for a five year plan of development for the Soviet film industry and cinematography.

This plan provides that at the conclusion of the five year program in 1932–33 the net of cinema establishments will include 65,349 units. The Russian Socialist Federated Soviet Republic alone is to have 50,000 of these, divided into the following types:

Rural cinema theaters	8,400
Rural traveling cinema outfis	20,300
Cinema establishments for schools	16,500
Urban cinema theaters	1,300
Cinema outfits for clubs	3,500

A proportionately similar growth of the cinema is planned also for other republics of the Soviet Union (Ukrainian, Trans-Caucasian, Central Asiatic, and White Russian). The plan provides that all centers of the collectivized regions, all large settlements of the collective and state farms must be provided with cinema facilities or, as the Russians put it, *cinemafied*, that is, equipped with stationary cinema establishments on the basis of one for every settlement of a thousand population or more, to be used for the needs of that settlement and of the adjacent smaller settlements.

The plan provides for the 100 per cent cinemafication of the Workers' Clubs, especially in the settlements of the urban type. This provision will change the geographic map of the urban cinema net.

The tempo of the cinemafication development makes it possible to forecast at the end of the five year program a cinema attendance of 1,610,000,000 people, of which 610 million would be urban and one billion rural.

The cost of rural cinemafication in the course of the five year program is estimated at one hundred million dollars. The income from rural distribution and exhibition for the same period will not cover the expenditures for the rural cinema net. The difference may be regarded as the investment by the city in rural cinemafication.

What are the perspectives of the five year plan in the realm of production? All cinema organizations combined will give in the course of the five years about 1300 feature films. The productions will be progressively increased every year so that in 1932–33, the last year in the five year plan, 350 feature films will be produced.

The number of educational films projected for the same period will exceed 1000.

The largest part of this projected cinema production naturally falls upon the Russian Socialist Federated Soviet Republic (667 feature films and 701 educational) and the Ukrainian Socialist Soviet Republic (241 features and 326 educational).

The production plan provides for special attention to the production of juvenile and particularly school films.

The cost of producing film is also provided for in the five year plan, just as the cost in other branches of industry is estimated in the general economic plans for the period. The cost must be lowered in proportion to the increase in production and toward the end of the five year period the reduction in cost must reach 35 per cent. The decrease in cost must not be attained at the expense of quality, of course.

Also, the time period of production of a feature film must on the average not exceed five months at the end of 1932–33.

The question of developing a qualified personnel for the film industry (directors, scenario writers, laboratory workers, cameramen, mechanics, *etc.*) is taken up and provided for in the five year program. Also the question of establishing cinema schools, higher educational institutions for the industry, is taken care of by the five year plan.

A very serious problem in the Soviet film production is that of subject matter. The subject matter of the Soviet cinematography must be bound up with the main problems of the five year reconstruction program, economic and cultural, of the Soviet Union. This does not mean, of course, that the themes of the Soviet film must be dry and only informative and educational. The pathos of the triumph of man over nature, of utilizing the forces of nature, and creating machines for the emancipation of man from drudgery—in other words—the pathos of the machinization and industrialization of agriculture, of utilizing electric and hydraulic energy, of rationalizing and rendering automatic industrial processes can and undoubtedly will call forth creative artistic forces in the Soviet cinematography; and, translated into cinema language, will evoke strong emotions in the spectator who is an organic part of this newborn collective society.

I would like to add some interesting data and facts that are also provided for in the five year plan for the motion picture industry.

In application of this plan, the Sovkino studios worked out their plan:

The time for production for special full length feature films should be eleven months, for better program features eight and one-half months, and for a regular program feature seven months.

The duration of filming is also foreseen: It should not exceed 80 days in the year 1929–30, which are equally divided between studio and outdoor filming; at the end of the five year plan, that is, in 1932–33, filming in the studio should be increased from 50 to 70 per cent.

The expenditure on negative film for the first negative is determined with a coefficient 1 ÷ 7, and on the second negative 30 per cent less.

The norms for the administrative, technical, and artistic personnel in production of feature films, are fixed as follows: The director should produce, in the second year of the five year plan, at least one and one-half pictures, in the last year, at least two films; the cameraman has to film at least two features a year and the assistant cameraman two films in the year of 1930, in the last year at least three.

Sound Film.—It would be more than strange, in speaking of the cinema in general and in part about the Soviet cinema, not to touch on the subject of the sound film situation in Soviet Russia, inasmuch as in that country also sound receives a good deal of attention, and it is considered that it will greatly influence the future development of the cinema in Soviet Russia.

The sound film in Soviet Russia has already passed the stage of purely theoretical discussions and laboratory research. This does not mean, of course, that there is no more research going on in Soviet Russia in the matter of sound film. Quite the contrary, in this respect Soviet directors and other theorists of the cinema occupy a leading place. Though the silent cinematography is so many years old and the achievements of the Soviet cinematography are so great, yet even now there is much experimenting being conducted in this field and with the same passion and *élan* as during the first year of the Soviet cinematography but with more knowledge of the subject.

The great potentialities of the sound film are recognized in Soviet Russia by all authoritative bodies, governmental, civic, and artistic cinema organizations. The tremendous possibilities of the sound film are particularly recognized with respect to educational activities among the great masses of the population. Its value is also appreciated in recording current events.

Silent film in the Soviet Union is not only for the entertainment of the spectator but also for his education. This must also be true in no smaller measure of the sound film.

The first and most important discovery that put the silent cinema on the path of art was in the opinion of many, particularly the Soviet film directors, the discovery of *montage.*

The individual sequences, or "shots," are only the raw material out of which a picture is to be built or mounted. In the opinion of the masters of Soviet cinematography, mere visual representatives tend to direct the cinematography along the lines of least resistance toward a kind of substitute for the theater.

The sound must be also regarded as a new material for cinematic composition. The impression that the spectator receives is based not upon the sequence of the exhibited scenes but upon their relationships, their contrasts, and conflicts. This was first clearly formulated by Eisenstein, one of the most prominent and talented Soviet cinema directors. This opinion is also shared by another leading Soviet director, Pudovkin.

This is how Pudovkin formulates his idea. With the inclusion of compositional conflict, he says, the work of the director passes the boundary of mere representation or description. Sound makes it possible to communicate to the spectator abstract concepts. If sound will be only a new symptom of the photographed object or person recorded automatically during the filming, this sound will merely add something to the description, but it will have no influence upon the development and the deepening of the cinema language.

Sound introduced as a new element in the construction of a film must not merely accompany the visual images but also be involved in one kind of conflict or another with the visual image with which it is formally united in the *montage.* Let us take a simple instance: the crying of a child heard by the spectator at the same time as he sees on the screen the image of the crying child will give merely a descriptive effect. If the spectator sees on the screen a mother sitting with empty open arms (her grown-up son died recently) and hears a child crying at the same time, he will receive an emotional impact and something of the mother's instinct, of her sensing of her son first of all as a child borne by her—something of this will be communicated to the spectator. This is perhaps an elementary example but it will suffice to reveal the inner conceptual significance that sound may have by being introduced into the picture not by exact synchronizing it with the visual image producing the sound but by artistically evolving a dramatic relationship or conflict between the sound and the visual image.

Coincidence of sound and image may be employed in the opinion of Soviet masters only with the idea of utilizing the greater descriptive effect thus produced. Coincidence of sound and image must be only one of the great number of possibilities of presenting sound and visual images simultaneously.

The cinematic work must also move in the direction of deformation of sound. If sound is not merely an addition to the photographed object but a kind of independent material, it is naturally of interest to discover all possible aspects and varieties of this material.

Technical methods of the silent cinematography such as accelerating and retarding the film, photographing out of focus, fade-ins and fade-outs, distortions obtained by varying the position of the camera, all these methods as applied to the recording of sound surely can give remarkable results.

The introduction of sound in the construction of the film renders greater the possibilities of a more profound cinema language.

This approximately is the substance of the opinions prevalent among the builders of the Soviet film in their discussion of sound films.

The opinions are mentioned here so as to give an idea of the course which the Soviet cinematography will take in creating its own sound films. As yet, these ideas have no opportunity for thorough testing on a large scale. But the most significant films of the best masters of the Russian cinematography now in the course of production have sound scenarios developed along the abstract principles here mentioned.

What is the technical basis for the production of sound film in the Soviet Union and what are the practical results already achieved?

The first work in the realm of sound film, or rather in creating, recording, and reproducing apparatus was begun in 1926. Two

Soviet inventors, one in Moscow and the other in Leningrad, the engineers, Shorin and Tager, independently of each other began their research.

The mechanism for recording of sound in the device of the engineer Shorin is built in the following manner: The current from the microphone is amplified by a special amplifier and runs through a light, thin, movable thread placed between the two poles of a horse-shoe shaped magnet. The poles of the magnet are drilled. The optical system is adjusted so that the image of the line is magnified. On the optical axis between the thread and the film is a cylindrical lens which condenses the light falling on it into an optical line. The length of this line is limited by its diaphragm, so that on the film there is obtained a line of the maximum length of 2.5 mm., but the length of this "light" part depends on the projected line, so that in changing the film there is obtained a variable area record similar to that used in the Photophone system. The absence of the diaphragm opening is a special feature, as the optical line may be obtained as fine as desirable.

For the reproduction of sound by the Shorin device, a form of regular projection machine with the usual form of sound pick-up is used.

The system of Tager is based on different principles. The inside of his sound recording camera contains two film mechanisms working in synchronism. In the left part is a regular camera with an 18 × 22 mm. frame.

In the right side of the camera is the mechanism for the recording of sound. Both mechanisms are united by a roller and work in synchronism. The Tager system employs the Kerr cell principle for photographic recording of the sound.

There is no mass production of sound equipment yet in Soviet Russia, but at the present time there are already in operation five fully equipped stationary sound recording machines in different studios, three movable recording machines, and five recording machines for newsreel—of the Shorin type and three recording machines of the Tager type. A comparatively small number of sound reproducing machines are as yet installed in the capitals of the different Republics in the Union, but the preliminary production program of 1930–31 provides installation in the main cities, and also a number of portable sound reproducing units for the villages, collective farms, and remote workers' centers.

Of course, this is not much in comparison with the output of this apparatus in the United States; however, this number will permit the production of sound and talking films simultaneously in several studios, as well as it will permit the equipping of theaters in the larger centers of the Union. In Leningrad there is already equipped a special studio for sound recording, and the production of sound shorts is under way. In Moscow they are working on sound films in one of the largest studios, a part of which had been given over to sound production.

In the Ukraine, one of the new studios has a special wing for the production of sound and talking pictures.

All these studios are equipped with recording machines of the Shorin system. Besides, within the boundaries of the tremendous motion picture plant now being built in Moscow, of which I previously spoke, there will be a special up-to-date studio for the production of sound films. It is planned to have this studio equipped with the latest and most advanced sound recording machinery.

The production of sound films in Soviet Russia at the present time is still in its infancy, especially in comparison with the production of sound in the United States; there are only short sound films, and even these in reality are still of semi-experimental character. The best educational silent films are being synchronized. A number of outstanding silent full length features which are now in production will also be synchronized.

In order to put the production of sound equipment and sound films and the use of them on a proper basis, they are in Soviet Russia preparing workers for this field.

The largest studios have courses on the theory of sound cinema. Similarly, the Association of the Workers of Revolutionary Cinema (the only cinema social organization in Soviet Russia) has organized courses on sound, in which directors, scenario writers, actors, and cameramen participate. There are also special courses for sound cameramen and sound projectionists in connection with the work that is going on, in the building of sound studios, reëquipment of theaters. It has been decided to establish a permanent contact abroad, in particular with the United States.

For the fall of 1930 is called the first All-Union Production-Technical Conference of the workers of the Soviet sound cinema.

The conference will be attended by over a hundred persons—

directors, engineers, cameramen, operators, laboratory workers, scenario writers, artists, composers, theater managers, representatives of cinema, drama, musical colleges and schools, representatives of societies of writers and playwriters, social organizations connected with the cinema in U.S.S.R., and representatives of the Trade Union of Art Workers.

Among the subjects which will be discussed at the conference, there are: production of Soviet sound apparatus, problems of architectural, electrical, and musical acoustics, scenarios for sound films, laboratory work with sound films, sound film production, and exhibition of sound films.

Results and Possibilities.—The Soviet cinema contributed its part to the world cinema, and in some respects had even certain influence.

We need only remember Eisenstein, the director of *Potemkin*, *Ten Days That Shook the World*, and *Old and New*, and Pudovkin, the director of *Mother*, *The End of St. Petersburg*, and *Storm over Asia*, who is also the author of the well-known book, "Film Technic."

True, the subject matter, the themes in the Soviet cinema differ sharply from the themes in the films in other countries, but this is because of the different social and economic order of that country. Due to the economic basis of the Soviet cinema industry, the Soviet cinema has great possibilities in the seeking of new artistic ways, the application of new artistic methods to the production; hence, the Soviet cinema has so distinctly different "schools" and trends. This same is, by the way, true of the Soviet theater.

Sound in Soviet Russia has found a fertile soil. Using the best creative forces of the Soviet technical thought, as well as the best foreign technical accomplishments in the field of sound, it should develop rapidly toward technical perfection.

The creative thought of the Soviet directors, actors, artists, and musicians will give to the Soviet cinema a form of sound film in line with their *weltanschaung*. The cultural social-economic revolution creating and building at the present time a new life, a new form of social order, will offer a wealth of themes to the Soviet cinema worker, the director, scenario writer, and musician.

The new organizational scheme of the Soviet motion picture industry which consists in combining of all branches of the industry and in centralizing the direction of all the production centers into one executive center, which in itself is a part of the Supreme Council of National Economy, will permit the rationalization of the Soviet motion picture industry.

The Soviet motion picture industry will strengthen its present position and it will assure a steady progress and development.

DISCUSSION

MR. GOLDEN: Am I correct in gathering from your paper that this entire program will be undertaken by the Soviet government; that is, the financial layout for the construction of the theaters and the production of the equipment?

MR. MONOSSON: There are no private motion picture producing companies in Soviet Russia. As in other big industries, the business is conducted by the State Motion Picture Trust on a commercial basis.

MR. GOLDEN: Are you going to develop the equipment in Russia or are you going to the outside world?

MR. MONOSSON: Quite a large portion of the necessary equipment for studios and laboratories, especially for the new studio in Moscow, is bought outside of Russia. This will apply, to a certain extent also, for sound equipment. At the present time, all the necessary raw stock is bought abroad. It is contemplated to build a new plant for the production of raw stock film.

MR. MATTHEWS: I was pleased to hear Mr. Monosson mention the book by Pudovkin. There are few books on motion picture technology written by experts in this field; that is, seldom does a director write about directing, and it is interesting to know that this book has been rated very highly by a number of reviewers. Although written five years ago, it is authoritative on the subject. It is hoped the author will write a book on sound pictures after he has had more experience with them.

Are many American pictures shown in Russia today, and do you know of color processes being worked out in Russia? Brief mention was made of the Tager process for sound recording on 16 mm.

MR. MONOSSON: There is nothing special in color processes worth mentioning as far as I know—as far as I know, Tager is working on 16 mm. recording, but is only in the experimental stage. Of course, there are American pictures shown in Russia. Not all American pictures are suitable for Russia, because we consider that a picture should have not only entertainment value but also educational value.

CONDITIONS UNDER WHICH RESIDUAL SOUND IN REVERBERANT ROOMS MAY HAVE MORE THAN ONE RATE OF DECAY

CARL F. EYRING*

INTRODUCTION

Architectural acoustics was placed on a scientific basis by the late Professor Wallace C. Sabine of Harvard University. Almost his first step was to establish experimentally the facts that "the duration of audibility of the residual sound is nearly the same in all parts of an auditorium;" that it is "nearly independent of the position of the source;" and that "the efficiency of an absorbent in reducing the duration of the residual sound is, under ordinary circumstances, nearly independent of its position."[1] As his statements imply, Sabine certainly did not expect these principles to hold under all conditions. But since he calculated the reverberation time from the time required for the sound to decay from its initial intensity to the threshold intensity his method could not bring to light the presence of more than one rate of decay, and thus he may not have been aware of this added exception to the idealizations he proposed.

In this paper evidence is presented to show that the shifting of the interference pattern during decay may introduce many average rates of decay as the sound dies out. There are also presented reverberation time measurements free from the effect of the shifting interference pattern and made in a small auditorium, in a balcony coupled to an auditorium, and at a position just outside a small "live" room coupled to a much larger very "dead" room and these results show clearly the presence of two rates of decay and hence as explained below two reverberation times. In the small auditorium studied the use of proper diffusing devices were found necessary in order to establish a single reverberation time independent of the position of observation and the location of the sound source.

Suppose the power output of a sound source located in an enclosed

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room is adjusted until there is obtained a sound intensity one million times the minimum audible intensity for the particular frequency used, then according to W. C. Sabine[1] the reverberation time is the duration of the residual sound, measured in seconds and judged by the ear, after the cessation of the source. Thus this definition is restricted to *a particular 60 db. drop in intensity*, and when the reverberation time is experimentally measured no account is taken of the nature of the decay between the two prescribed levels. Under this procedure a room could not have more than one reverberation time, even though the residual sound were to decay at more than one rate.

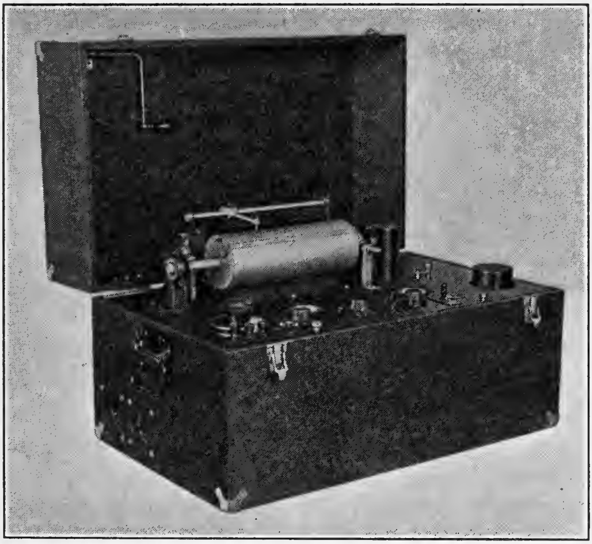

FIG. 1. Reverberation time meter.

Since the time when the original definition was formulated and especially since the advent of instrumental methods of measuring reverberation time which are independent of the ear, there has developed the tendency to define reverberation time as the time it takes the intensity of the residual sound to drop *any* 60 db., the lower or upper limit not being prescribed. This tacitly assumes that the plot between the time and the intensity of the residual sound measured in db. is a straight line, or what is the same thing, that the residual sound thus measured has but one rate of decay, that determined by the slope of the line. If this condition is realized then there is a definite relation between reverberation time, T, (time per 60 db.) and rate of decay, δ (db. per second), such that

$$T = \frac{60}{\delta} \quad \cdots\cdots\cdots\cdots\cdots\cdots (1)$$

It is proposed to redefine reverberation time in terms of rate of decay or damping such that equation (1) may be used even under

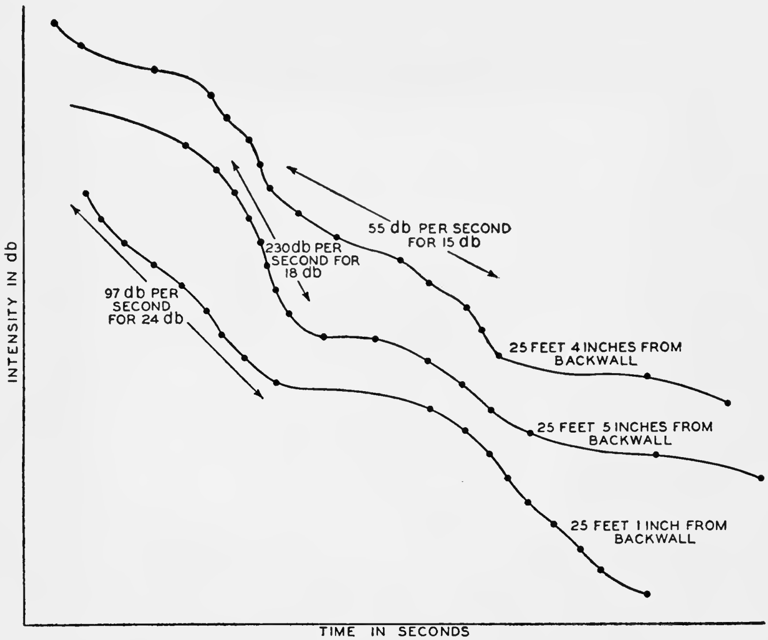

FIG. 2. Decay curves for 500 cycle note.

the condition when the residual sound has more than one rate of decay.

Thus from the slope of the decay curve (Fig. 3) the rate of decay may be obtained and the time, T, for a 60 db. drop in residual sound intensity may be calculated from equation (1) and since the decay curve is straight this will be the reverberation time defined by W. C. Sabine. But for two slope curves, such as illustrated in Fig. 9, neither of the slopes will give Sabine's reverberation time. Each distinct slope, however, gives a definite rate of decay which if substituted in equation (1) gives a definite reverberation time and in this sense a room may have two reverberation times. Since it is the opinion of the author that a rate of decay, δ, is more suggestive than a reverberation time, rates of decay have been emphasized in this paper, but whenever there has seemed to be a need, because of custom, to introduce reverberation times, use has been made of equation (1) rather than the original definition given by Sabine.

The reverberation time measurements were made on a meter similar to that described by the author[2] and also by Wente and Bedell[3]

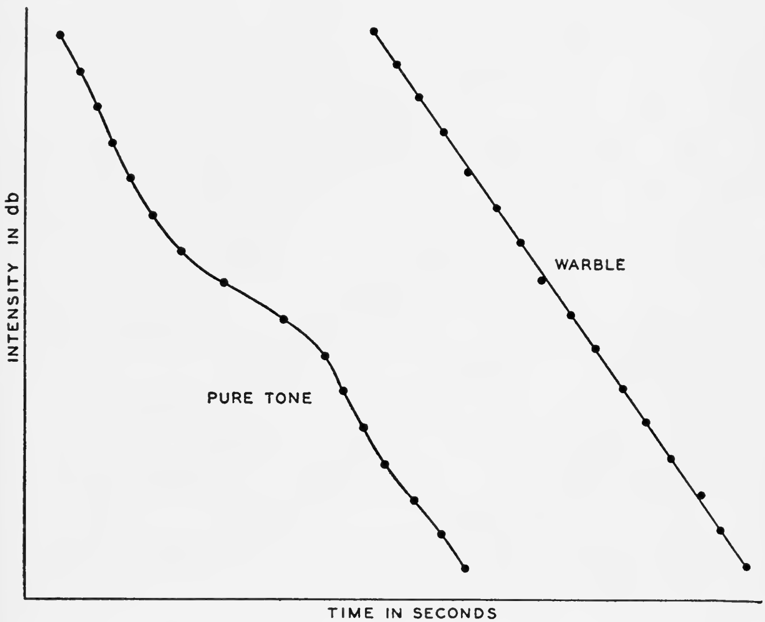

FIG. 3. Decay curves for 500 cycle tone.

in their paper, "Chronographic Method of Measuring Reverberation Time." (See Fig. 1.)

MEASUREMENTS ON RATES OF DECAY

Rates of Decay Due to Shifting Interference Patterns.—When the sound source is cut off there will not only be a decay of sound due to the absorption of the walls, fixtures, *etc.*, but the interference pattern will continually shift causing the actual rate of decay at a point to fluctuate about the rate of decay caused only by absorption. That this fluctuation may be very pronounced and actually changes from point to point in the room is illustrated in Fig. 2. The fluctuations may be minimized as illustrated in Fig. 3 by the use of a warble tone and if necessary by the proper placement of the transmitter. With these precautions, and they are used in all the reverberation time measurements presented in this paper, the effect of interference is greatly reduced. The plot which the meter makes more or less automatically between the intensity of residual sound measured in

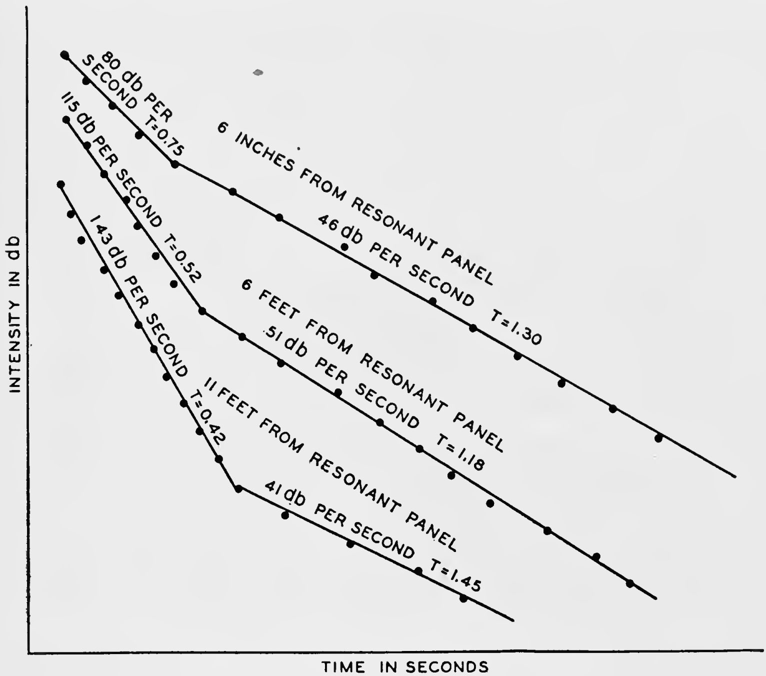

FIG. 4. Effect of resonant panels on decay curves of 500 cycle tone.

db. and the time after cut-off will give a single straight line, unless, as we shall point out below, resonating bodies, coupled rooms with different damping, or parts of the same room with different reverberation times, give rise to more than one rate of decay. (See Figs. 4 and 9.)

A Resonating Panel.—A small room 12 feet wide, 24 feet long, and 12 feet high with open ceiling was built in a large "dead" room. Three walls were made of one inch material, and the fourth was made up of five "flats" constructed out of $^5/_{16}$ inch ply-wood. Reverberation time measurements made in this small room showed two distinct rates of decay for 500 and 1000 cycles (see Fig. 4), the range of the slow rate increasing as the transmitter was moved near the "flats." For all other frequencies only one rate of decay was found. This would seem to indicate that the ply-wood as mounted on the flats is resonant for 500 and 1000 cycles. At 500 cycles and with the transmitter placed 11 feet from the flats, the sound shows a rapid rate of decay for a 33 db. range. This is followed by a slow rate which no doubt is caused by the energy radiated by the panels after the "reverberant" energy has been dissipated. At the panels, on the other hand, the rapid rate lasts only for a 12 db. range.

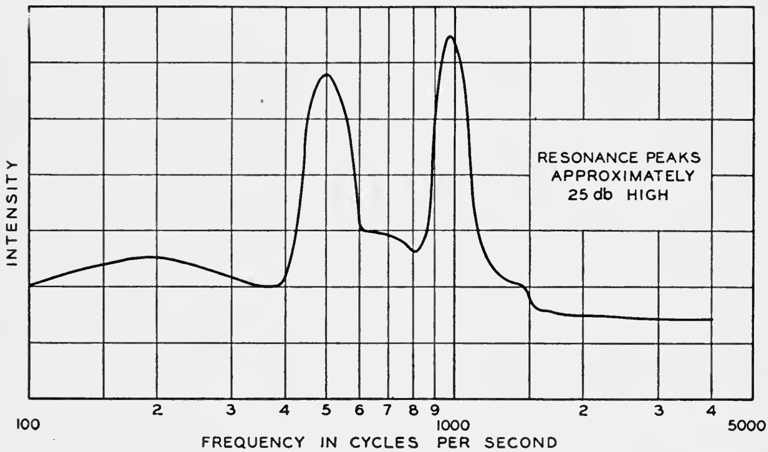

FIG. 5. Curve showing frequencies for which the wall panels are resonant.

The frequencies for which the panels are resonant were found with the aid of the reverberation time meter. First, the amplification of the meter was set so that its relay would trip at an intensity level within the rapid decay range measured at a point 11 feet from the panels, but still within the slow decay range measured at a point 6 inches from them. The time from sound cut-off to relay action was measured through the frequency range, with the transmitter first 6 inches from the resonant panels, and then 11 feet from them. In order to eliminate instrumental and room variations with frequency the last curve was subtracted from the first, and the resonance curve, Fig. 5, is the result. The cause for the two slope curves at

500 and 1000 cycles, but not at the other frequencies, is at once apparent. When the ply-wood was properly nailed to braces at the back, the resonant peaks were eliminated.

A Small "Live" Room Coupled to a Large "Dead" Room.—After eliminating the resonant effect discussed above, reverberation time measurements were made first with the transmitter 6 feet from the floor and then 11 feet above the open ceiling. The results are shown in Fig. 6, in which the two reverberation times found above the open ceiling, are compared with the reverberation times of the coupled rooms. The numbers in parentheses in this and all other figures

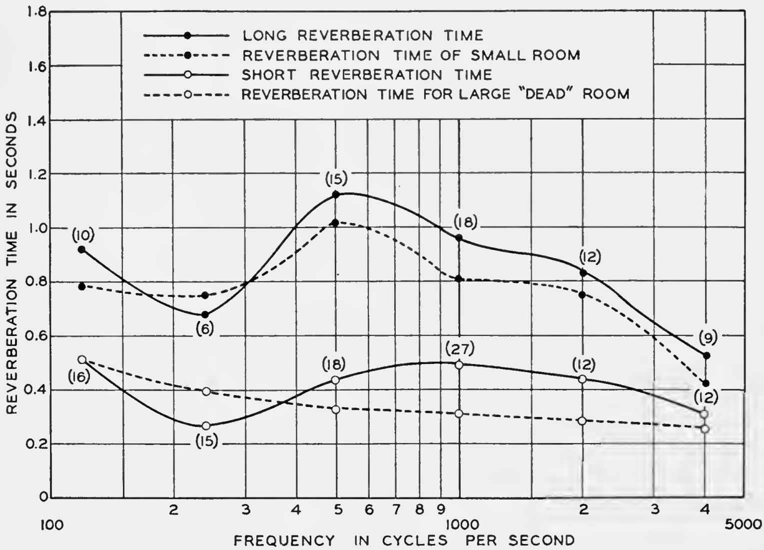

FIG. 6. Comparison of reverberation time-frequency curves.

give the db. range of the decay which takes place at the rate equivalent to the reverberation time indicated. It is clear that immediately following the sound cut-off, the sound energy density above the open ceiling (or what is the same thing, in front of a three-walled set with a closed ceiling located in a sound stage) tends to fall off at a rate determined by the reverberation time of the "dead" room; but since the energy density of the small "live" room does not decay at such a rapid rate, a time will come when the sound intensity at the transmitter will be practically all due to the energy which flows out of the small room or set and hence the measured rate of decay will be nearly the same as the rate of decay of this equivalent sound source. The first rate of decay apparently changes rapidly to the second rate, and this explains why the decay curve shows two regions of distinct slope and therefore two reverberation times. Before the second and longer reverberation time is established some energy returns through the open ceiling from the large "dead" room, but after this,

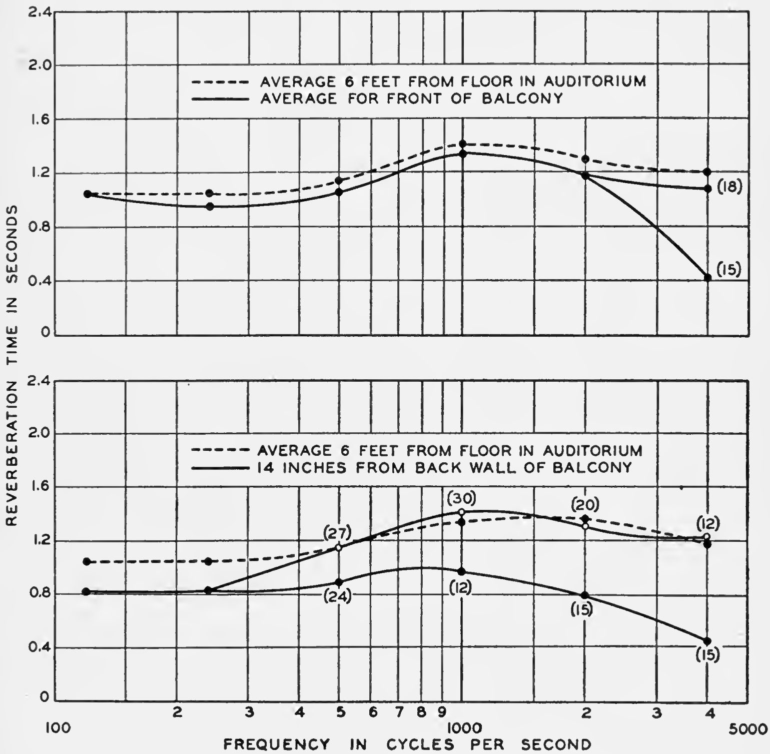

FIG. 7. Reverberation time-frequency curves for the balcony of an auditorium.

the ceiling may be considered as equivalent to an open window. This means that the equivalent coefficient of absorption of the ceiling changes slightly with the time of decay.

A Balcony of an Auditorium.—The balcony is rectangular in shape. It is 27 feet long, 12 feet deep, and 11 feet high. It is coupled to an auditorium having a volume of 37,400 cubic feet by means of a

27 × 11 foot opening. All surfaces of the balcony except the floor are covered with absorbing material. The source of sound is placed in the auditorium. With the transmitter placed 14 inches from the

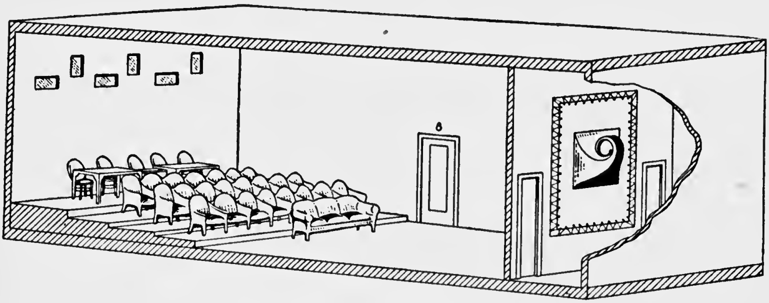

FIG. 8. The small auditorium.

back wall of the balcony, sounds of 500 cycles and above show two distinct rates of decay; when placed 3 feet from the back wall only the 2000 and 4000 cycle sounds show two distinct rates of decay;

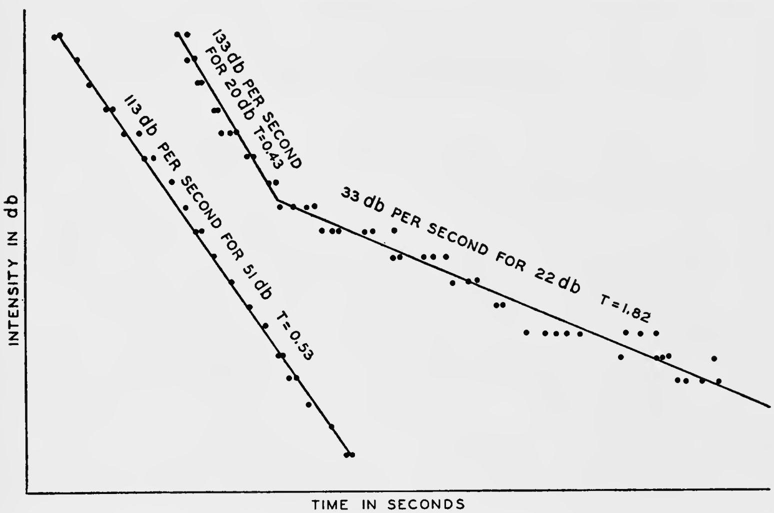

FIG. 9. Decay curves for 1000 cycle note. (Two slope line—before extra surface treatment. One slope line—with diffusing panels staggered about the room.)

and when placed near the front of the balcony (1–3 feet from edge) only the 4000 cycle sound shows two distinct rates of decay. The results are shown in Fig. 7. The longer reverberation times in every case are essentially the same as those found in the auditorium. For sounds of long wave-length (3–10 feet) a balcony of this depth seems to act as if it were a part of the auditorium, but for sounds of short wave-length (0.25–3 feet) it acts like a separate room coupled to the larger room. Making use of the reverberation time formula and the coefficients of absorption of the balcony surfaces, the results obtained for 4000 cycles show that the first reverberation time may

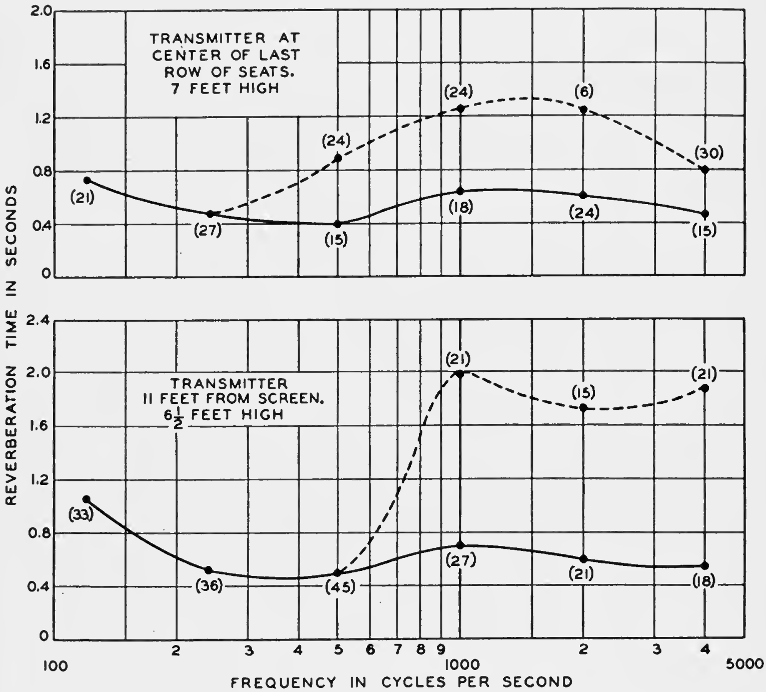

FIG. 10. Reverberation time-frequency curves for small auditorium, no extra surface treatment.

be calculated on the assumption that approximately twice as much energy on the average flows per second through the coupling surface into the balcony than flows out through this surface. The longer reverberation time which is the same as that of the auditorium can only be accounted for by the assumption that during the decay of the residual sound a time is reached when energy flows into the balcony and not out from it. This means that during the first part of the decay the coupling surface acts as a surface having approximately an average coefficient of absorption of 0.5, but that during the last part of the decay it acts as a surface having a coefficient of unity. Thus we are prepared to say that the absorption which a balcony contributes to an auditorium is not only a function of the relation of the wave-length to the depth of the balcony, but is for certain frequencies a function of the time during decay. Obviously the complete solution of the problem is a difficult one.

A Small Auditorium.—The small auditorium has a volume of 10,600 cubic feet. It is 38 feet long, 20 feet wide, and 14 feet high.

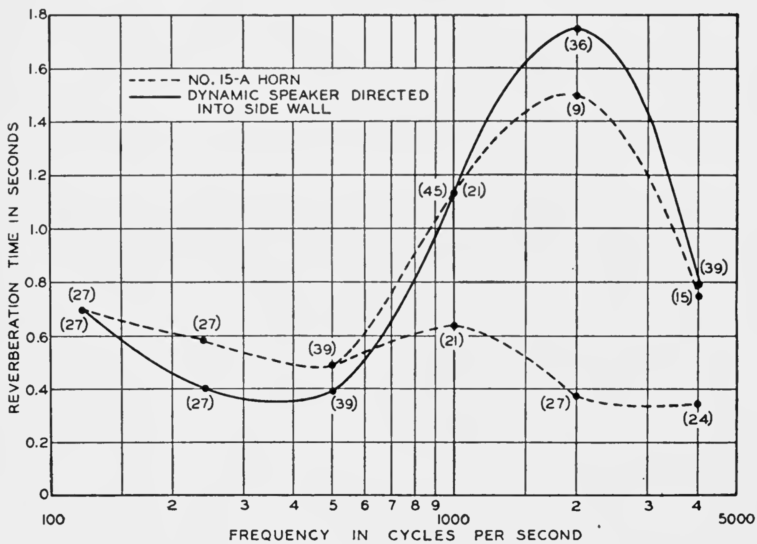

FIG. 11. Reverberation time-frequency curves for a position eleven feet from the screen.

The entire ceiling is treated with absorbing material and the floor is covered with a deep pile carpet mounted on ozite. The screen is mounted at one end of the room and heavy velour curtains, hanging in folds, cover the end surface not occupied by the screen. The surfaces of the two side walls and the end wall opposite the screen are made up of plaster on tile and covered with heavy decorative paper. A 15-A horn is located behind the screen in a small connecting room (6.5 × 14 × 20 ft.). Three rows of upholstered seats (23 in all), a sofa, five upholstered armchairs, and four tables are located as illustrated in Fig. 8. The horn is so mounted that its beam axis if projected would strike the seats. The average observer located in the seat area rates this room as somewhat "dead" but otherwise as a rather desirable place in which to hear reproduced sound. A speaker located at any position between the screen and the seat area notices a decided annoying persistence of high frequency sounds yet the audience is bothered only slightly by such a hangover.

A large number of measurements for various transmitter and sound source positions and for various additional surface treatments, that is, treatments additional to those described above, have been made. The results are summarized as follows:

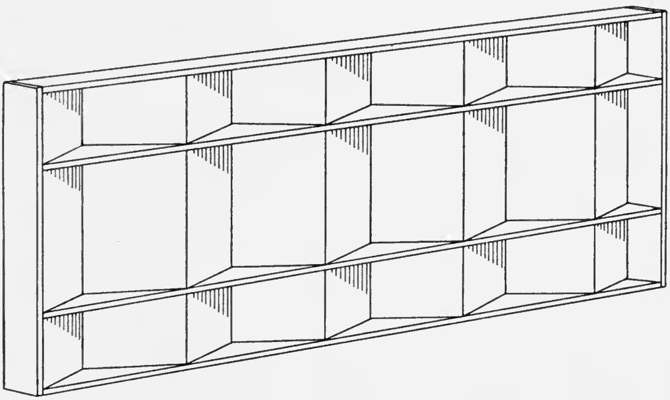

FIG. 12. Diffusing panel, 9 × 4 ft.

Two Distinct Rates of Decay.—A 555-W receiver coupled to a 15-A horn, as illustrated in Fig. 8, was used as a sound source. With no additional wall treatment reverberation time measurements were made with the transmitter located first at the center of the last row of seats seven feet above the floor, and second at a point eleven feet from the screen six and one-half feet high. For certain frequencies the decay curves show two distinct slopes, as illustrated by the broken line in Fig. 9. The reverberation time-frequency curves are shown in Fig. 10, the upper points connected by dotted lines being the second and longer reverberation times calculated from the second slope of the broken decay curves. The shorter reverberation time-frequency curves (the lower curves) are essentially the same for the two positions in the room, but the longer reverberation time-frequency curves (the upper dotted curves) are markedly different for the two positions.

Already it has been shown that a decaying equivalent sound source may be the cause of two distinct rates of decay, and it seems natural to suspect that the two opposite parallel reflecting walls might in this case be such a source. With this as a lead the next experiments were performed.

Cause of More Than One Rate of Decay.—Cotton flannel curtains were hung on the back wall thus reducing the highly reflecting

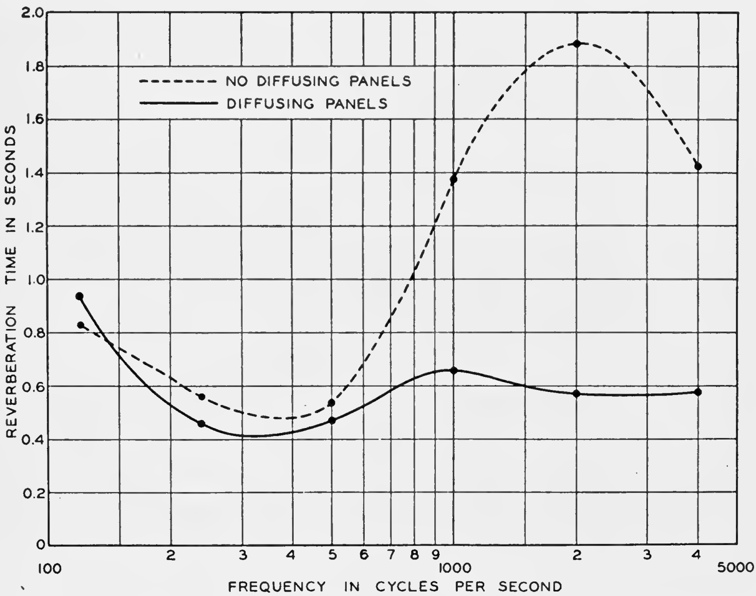

FIG. 13. Reverberation time-frequency curves illustrating effect of diffusing panels.

surfaces to the two parallel side walls. The transmitter was placed midway between the side walls eleven feet from the screen. Two speakers were used, a dynamic speaker placed near one side wall eleven feet from the screen and oriented so the sound beam would be directed toward the opposite wall, and a horn located as described above. Decay curves were obtained, first using the horn, and then the dynamic speaker as a sound source. The results are shown in Fig. 11.

The horn "sends forth a nearly parallel beam of sound radiation."[5]

But the "radiation tends to diverge, ultimately in the form of a cone." Roughly, the time required for the divergence to become the dominating factor varies inversely with the wave-length. This means that the high frequencies will tend to bend from their course to a less degree than the low frequencies, and after a number of reflections at the surfaces of the room, any frequency beam that starts to be reflected back and forth between the two highly reflecting parallel

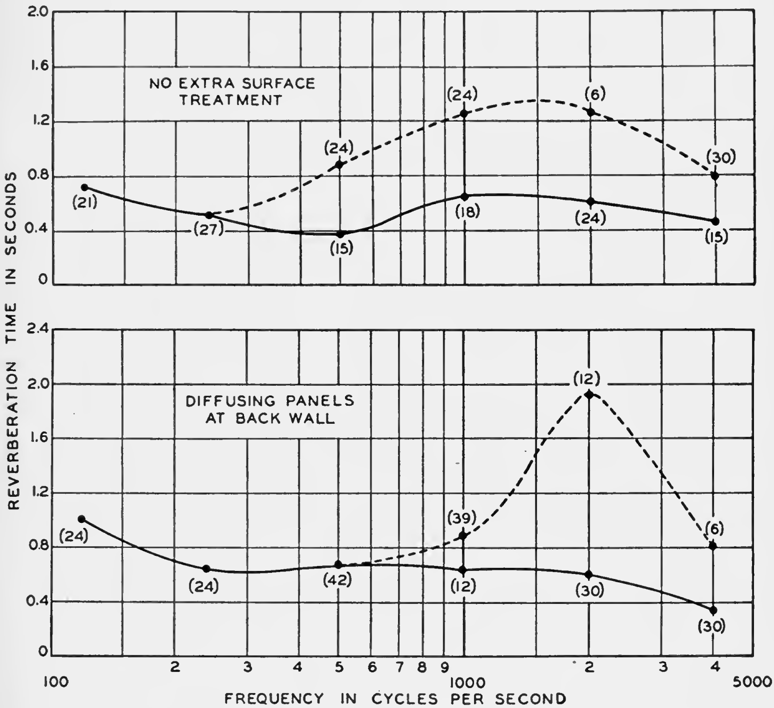

FIG. 14. Reverberation time-frequency curves illustrating effect of diffusing panels at the back wall.

walls will soon be bent into the highly absorbing floor and ceiling if of low frequency; but if of high frequency the back and forth reflection of the beam will tend to persist due to a lack of bending. This means that in a room such as the one under consideration, the low frequency sound beams are diffuse, but the high frequency beams exist roughly in two conditions, a diffuse state and a more or less ordered state. The diffuse state of the low and high frequencies gives rise to the short reverberation times, the lower dotted curve in Fig. 11. The more or less ordered state, the back and forth reflection between the parallel walls, gives rise to the long reverberation times, the upper dotted curve in Fig. 11. Thus the falling off of this upper curve for low frequencies is explained and the falling off at high frequencies may be explained by the fact that the coefficient of absorption of the wall surface increases with frequency.

As has been explained the sound from the dynamic speaker, which is somewhat directional especially for high frequencies, is directed into one of the highly reflecting walls. The curve for the low frequencies is very similar to that obtained using the 15-A horn (Fig. 11), but for the high frequencies the long reverberation times

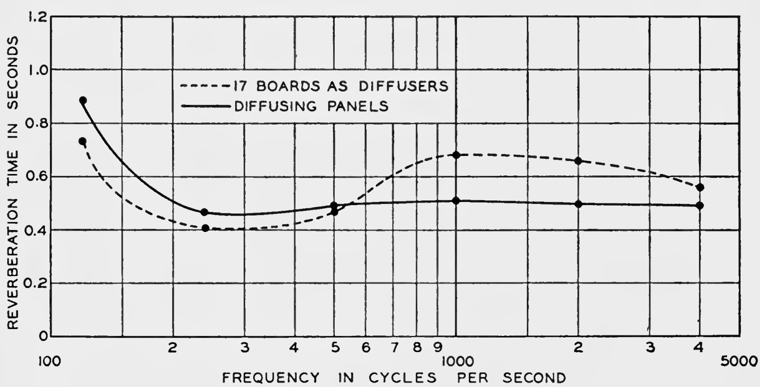

FIG. 15. Reverberation time-frequency curves illustrating effect of nearly vertical diffusing boards.

only are observed, and they are very similar to the long reverberation times observed when the 15-A horn is used. This means that the residual sound, following the cut-off of the dynamic speaker located as indicated above, exists roughly in two conditions, a diffuse state for the low frequencies, and a more or less ordered state, a back and forth reflection between the parallel walls, for the high frequencies. By placing diffusing panels (see Fig. 12) against the wall opposite the speaker with the long dimensions vertical, the residual sound is all reduced to the diffuse state, with the resulting reverberation time-frequency curve shown in Fig. 13.

Improving the Acoustics of the Small Auditorium.—The experimental data definitely show that for frequencies above 500 cycles the small auditorium has two distinct reverberation times, a short time and a long time. The rapid rate of decay (short reverberation time) measured, using the horn as a source and at a position where listening takes place, has an average range of 21 db. before the slow rate of decay begins. (See Figs. 10 and 18.) Since the average listener has not complained of the undue persistence of the high frequencies, the 21 db. drop in intensity during the rapid decay is no doubt sufficient to render the slow rate of decay (long reverberation time) unobjectionable. Probably this may be accounted for as follows. The optimum reverberation time of a room the size of the one under consideration is usually listed as of the order of one second. If the time it takes to say each word in a connected discourse[4] is 0.3

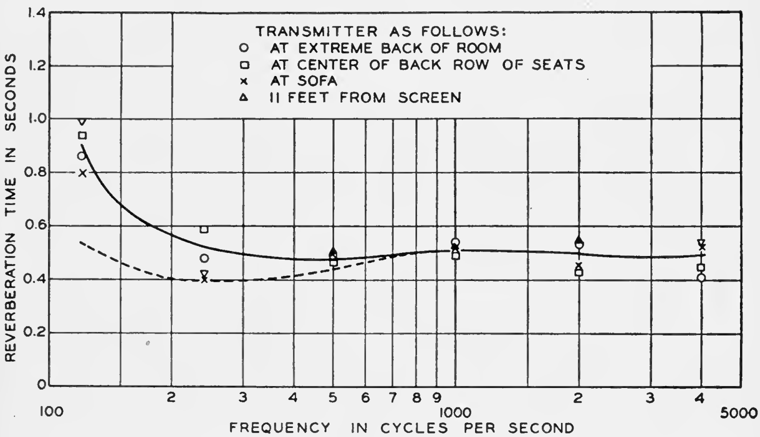

FIG. 16. Reverberation time-frequency curves showing that reverberation time is nearly independent of position if a diffused state is produced.

second and if this is followed by a pause of 0.1 second before another word is started, then the time between successive pauses will be 0.4 second. A reverberation time of one second is equivalent to a decay rate of 60 db. per second, hence the sound intensity due to a given word will have dropped 24 db., before the next succeeding pause is reached. Since listening under such an arrangement is declared satisfactory, it may be that the ear is not much concerned when listening to a connected discourse with residual sounds 20 to 30 db. below the original level.

From what has been said and from a consideration of the short reverberation time-frequency curves shown in Figs. 10 and 18, it is clear why a listener located in the seat area should hear in a rather satisfactory manner the sound reproduced by the horn and this in spite of the second slow rate of decay for the high frequencies.

However, the acoustics of this room would be improved (1) if the range of the rapid decay were increased to at least 30 db. or preferably if the second and slow rate of decay were completely eliminated; (2) if the reverberation time-frequency curves were

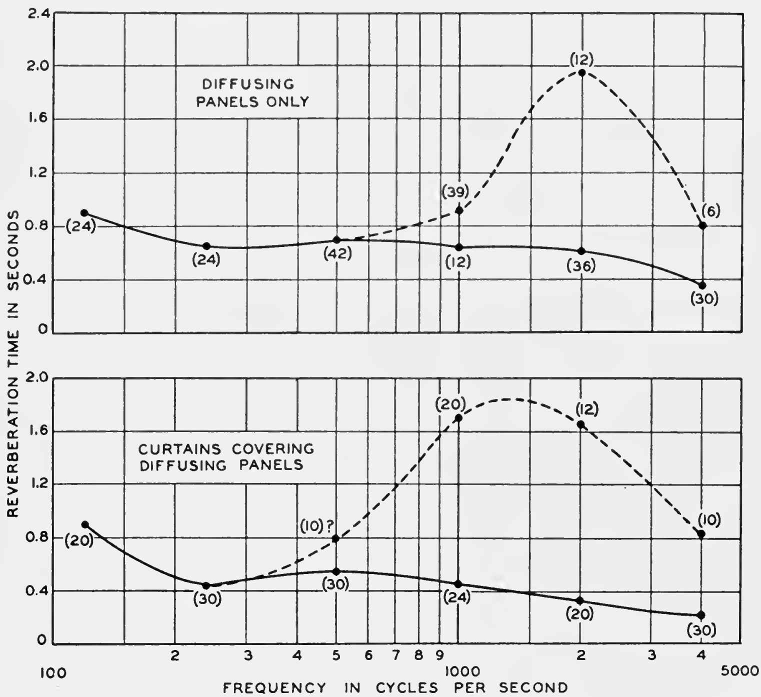

FIG. 17. Reverberation time-frequency curves showing that the effect of absorbing material on the back wall reduces reverberation time for diffuse portion of sound but does not eliminate the longer time for the more or less ordered waves.

smoothed out so as to make the rate of decay of loudness constant for all frequencies; (3) if the room were made somewhat more "live." The first improvement may be achieved by placing four diffusing panels at the back of the room or by placing seventeen boards in a nearly vertical position evenly spaced above the walls, or by staggering five diffusing panels about the walls—two on the back wall, two on one side wall, and one on the other side wall, the excellence of the improvement being in the order listed, the last being best. These facts are shown in Figs. 14, 15, and 16. The second improvement, the proper smoothing out of the reverberation time-frequency curve, is accomplished best by using diffusing panels staggered about the walls. As a matter of fact, for this case the rate of decay of loudness is very nearly constant for all frequencies, the condition probably most to be desired. This is shown by the dotted line in Fig. 16. The use of absorbing material instead of diffusing panels would not solve the problem. Of course, if properly placed,

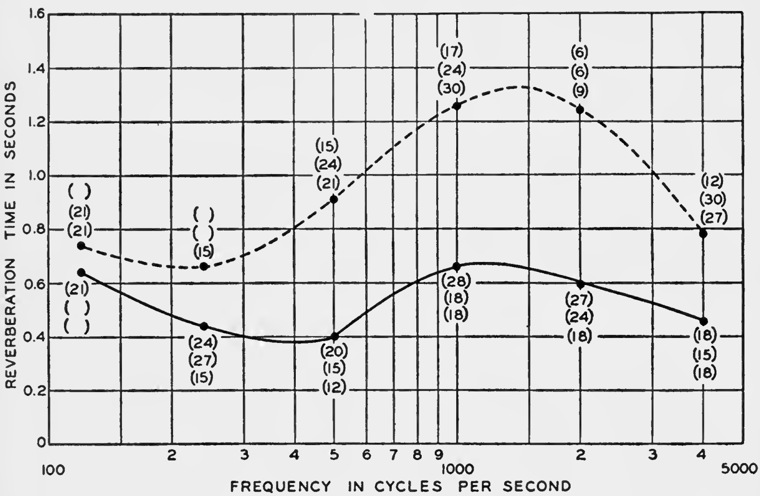

FIG. 18. Reverberation time-frequency curves showing effect of elevating transmitter.

this material would eliminate the second reverberation time found for the high frequencies, but it would also reduce the first reverberation time and the room would become much too "dead." (See Fig. 17.)

Although correcting the other defects a diffusing scheme cannot give the third improvement, making the room more "live," but this may be achieved by removing some of the absorbing material, preferably from the ceiling. This may seem a strange suggestion since already we are bothered with a second reverberation time for high frequencies which is about twice optimum. If because of artistic reasons it is not desirable to remove absorbing material from part of the ceiling and if for the same reasons a diffuse condition of the sound waves cannot be assured by making the side walls irregular, or by building artificial columns as suggested by the "seventeen board" experiment, ideal acoustics if desired could be obtained by covering the ceiling with acoustic plaster and then staggering about the walls in an artistic manner absorbing material edged with a diffusing surface. Certainly large highly absorbing surfaces should not be opposite. Diffusing schemes involving a systematic regular pattern although introducing the desired diffusion may not under certain circumstances adequately correct undesirable effects due to interference.

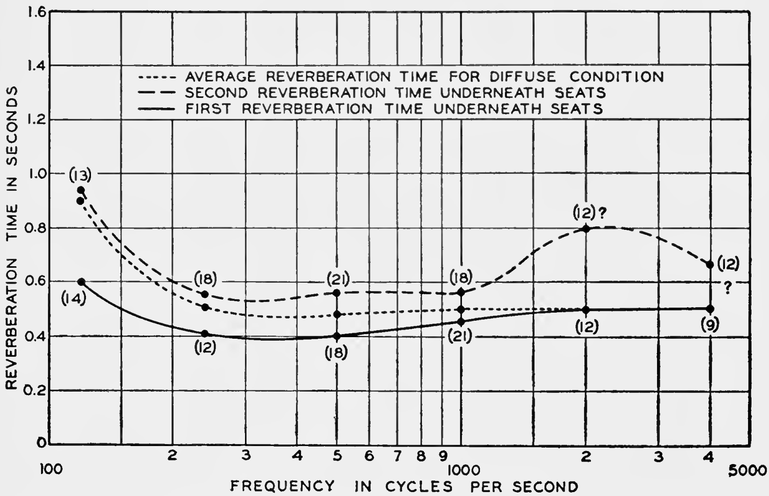

FIG. 19. Reverberation time-frequency curve for a highly absorbing area.

Effect of Location with Reference to a Highly Absorbing Area.—With no extra surface treatment, a non-diffuse condition for a portion of the high frequency waves, and with the transmitter located at the center of the last row of seats, a frequency-reverberation time curve was obtained at each of the following heights of the transmitter, 3 inches, $4^1/_2$ feet, and $7^1/_2$ feet from the top of the seats. Two distinct rates of decay were found for all frequencies above 240 cycles. Generally speaking the rapid decay rate portion (short reverberation time) decreases as the transmitter is elevated from the seats, and the slow rate portion (long reverberation time) increases.

The results interpreted as reverberation times are shown in Fig. 18, the db. range of each portion of the decay curves being noted.

With diffusing panels staggered about the room, a diffuse condition of the sound waves, and with the transmitter located at the center of the last row of seats six inches from the floor the data shown in Fig. 19 were obtained. The results are similar to those found for a position in a "dead" room when coupled to a "live" room. (See Figs. 6 and 7.) They signify that even if a diffuse condition exists among the sound waves, still at a position located well within a highly absorbing area, such as at the ear of a person who slumps down in his seat in a well-filled auditorium, two decay rates will be present, the first rate being greater than that due to the over-all damping of the room.

The concentration of the absorbing material about the audience always carries with it the possibility of a feeding in of the energy from the more highly reflecting portions of the room during the last stages of the decay, and the establishing of two reverberation times, which may or may not be undesirable, and also the possibility of making the listening area too "dead." This is clearly brought out by the measurements reported in this paper.

Application of Reverberation Time Formula.—It is further important to realize that the reverberation time as calculated by the formula[2]

$$T = \frac{0.05\ V}{-S \log_e (1 - a_a)} \quad \ldots\ldots\ldots\ldots\ldots (2)$$

can only agree with the observed value provided a diffuse condition of the sound waves is established. Assigning coefficients of absorption to the surfaces and fixtures as shown in the table, a reverberation time of 0.47 second is calculated, agreeing very favorably with the average measured value of 0.49 second for 500 cycles, and 0.51 second for 1000 cycles obtained with the diffusing panels staggered about the room. This agreement is significant.

Table Showing Sound Absorption Coefficients

Ceiling treatment[2]	0.8
Carpet[6]	0.25
Curtains and screen (av.)[6]	0.25
Wall paper[6]	0.03
Chairs[6]	2.0 units per chair
Sofa[6]	6.0 units per sofa

SUMMARY

The residual sound following the cut-off of a sound source will show a number of average rates of decay (and hence equivalent reverberation times) due to the shifting of the interference pattern as the sound dies out. Even after the elimination of the effect of interference at least two distinct rates of decay will exist (1) in coupled rooms of different natural reverberation times; (2) in a single room with non-uniformly distributed absorption and no sound diffusing scheme; (3) at a position well within an area of concentrated absorption; (4) in a room containing resonant bodies. The "live" portion acts as an equivalent decaying sound source for the "dead" portion.

Thus if an auditorium is to have a single optimum reverberation time it should not only be free from echoes and have the proper amount of damping, but the absorbing material should be fairly uniformly distributed, resonating bodies should be eliminated, and a diffuse condition of the sound should be further assured by proper diffusing schemes. Such precautions will also reduce to a minimum the undesirable effects due to interference.

Acknowledgment is extended to Mr. Frank A. Goss for his efficient help in obtaining all the data used in this paper.

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[1] SABINE, WALLACE C.: "Collected Papers," pp. 18, 104.

[2] EYRING, CARL F.: *J. Acoustical Soc. Amer.*, I (January, 1930), No. 2, p. 236.

[3] WENTE AND BEDELL: "Chronographic Method of Measuring Reverberation Time," *J. Acoustical Soc. Amer.*, I (April, 1930), No. 3, p. 422.

[4] WATSON, F. R.: *J. Acoustical Soc. Amer.*, I, No. 1, p. 48.

[5] CRANDALL: "Theory of Vibrating Systems and Sound," pp. 138, 174.

[6] WATSON, F. R.: "Acoustics of Buildings."

DISCUSSION

MR. HUNT: The results which have just been described required the making of a large number of very precise determinations of rates of decay of sound. This was possible with the precision reverberation meter which was recently developed at the Bell Telephone Laboratories. It is worth noting that the results are not only significant in themselves, but the method used is an advance in the technic of reverberation measurements.

MR. TAYLOR: I should like to have Mr. Eyring say a word about the source of sound in these measurements. Where the reverberation is as long as shown here—a second or a second and a half—the source cuts little figure, but I had an opportunity to question this in rooms where the reverberation was of the order of a tenth of a second.

MR. EYRING: The source of the sound in most cases was a 555-W receiver connected to a 15-A horn. In one case we used a dynamic cone speaker. We took the precaution of not only opening the oscillator circuit but also of shorting the oscillator and the receiver. The thing that convinces me that the two rates of decay were present in the room and not due to the horn is that by the use of the diffusing scheme we could completely eliminate the two slopes and obtain a single straight line.

MR. KELLOGG: I should like to add a word to what Mr. Eyring said about the cessation of the original source of sound. It is undoubtedly applicable to the horn type of speaker and the commercial baffle type, for the tests I shall speak of were tried on both types. We set up a condenser microphone in a room and ran its amplified output through one vibrator or an oscillograph, and the loud speaker coil current through another vibrator. At the beginning and the end of the tone, the sound coming directly from the speaker could be easily distinguished from the echoes. In all cases the sound appeared to start and stop about as suddenly as the coil current itself.

MR. WOLF: It is certainly a relief and a source of much satisfaction to acoustic men to learn that we have at our disposal instruments with which to measure acoustic quantities which have so long defied quantitative analysis. Out of some 2000 theaters we have analyzed, we have had some suspicion of the acoustic factors which Mr. Eyring has called our attention to, but heretofore it has been impossible to measure or judge the magnitude of their importance. With instruments such as Mr. Eyring has been using, acoustic treatment can be made more exact and more economical which is so important in the reproduction of sound.

REPORT OF PROJECTION AND SOUND REPRODUCTION COMMITTEE*

Two meetings of the committee were held previous to the convention, one on March 18, 1930, and the other on April 8, 1930. It was planned to hold one more meeting but this was found to be impossible. Both meetings were attended by the following members of the committee who live in or near New York City.

F. H. RICHARDSON, *Past Proj. Committee Chairman*	
HERBERT GRIFFIN	Int. Proj. Corp.
TREVOR FAULKNER	Par. Pub. Corp.
S. K. WOLF	E. R. P. I.
G. C. EDWARDS	A. P. S.
W. A. MACNAIR	Bell Tel. Lab.
D. F. WHITING	Fox Hearst Corp.
J. H. GOLDBERG	Par. Pub. Corp.
P. H. EVANS	Warner Bros.
LEWIS M. TOWNSEND, *Chairman*	Par. Pub. Corp.

Other members who were unable to attend but were reached by mail were:

W. B. RAYTON	B. &. L., Rochester, N. Y.
CHAUNCEY GREEN	Projectionist, Minneapolis, Minn.
RUDOLPH MEIHLING	Philadelphia, Pa.
EMERY HUSE	E. K. Co., Hollywood, Calif.
R. H. MCCULLOUGH	Fox West Coast Theaters, Los Angeles, Calif.
W. C. BATSEL	RCA Photophone Corp., N. Y.

The following report on "Screens and Their Properties," by S. K. Wolf, has been accepted by the committee for incorporation in this report:

SCREENS

The success of a sound picture installation today may be seriously affected by the characteristics of the projection screen. The requirements of a screen may be divided into two classes—optical and

* This report was presented in abstract before the Society at Washington and in full before the New York Section, June 12, 1930.

acoustical. The optical requirements must be such that it will give the least possible visual fatigue to the audience. The acoustical requirements must be such that sound will be transmitted through the screen without a discernible loss in quality. There are a limited number of sound installations, however, where the source of sound is placed beside the screen and likewise is not transmitted through the screen itself. In these limited cases there are no acoustical requirements.

In papers by L. A. Jones and M. F. Fillius[1] and by L. A. Jones and Clifton Tuttle,[2] the optical characteristics and requirements for

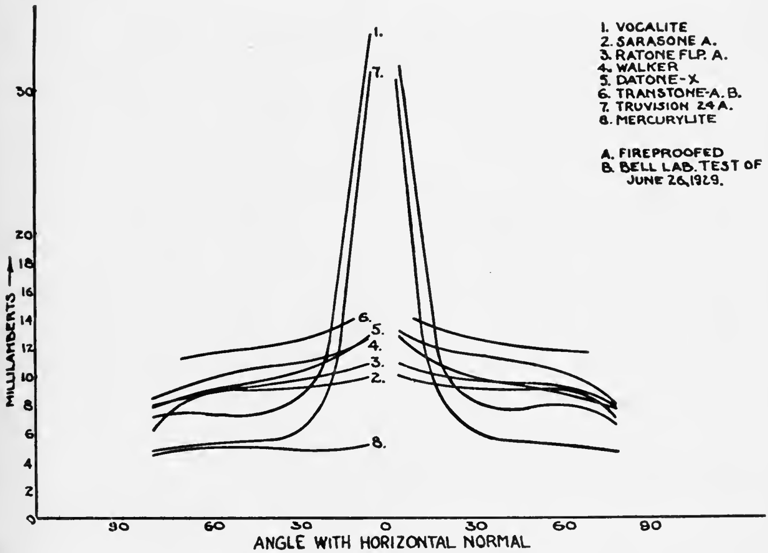

FIG. 1. Light reflecting characteristics of several commercial sound screens.

visual projection are covered in considerable detail and therefore need not be repeated in this report, except to cover such modifications as may be affected by the introduction of sound.

Optical Characteristics.—From an optical standpoint, sound screens having a high and uniform sound transmission coefficient, which is generally obtained by perforating the screen, suffer a uniform loss

[1] JONES, LOYD A., AND FILLIUS, MILTON F.: "Reflection Characteristics of Projection Screens," *Trans. Soc. Mot. Pict. Eng.* (1920), No. 11, p. 59.

[2] JONES, LOYD A., AND TUTTLE, CLIFTON: "Reflection Characteristics of Projection Screens," *Trans. Soc. Mot. Pict. Eng.*, X (1927), No. 28, p. 183.

over the entire viewing angle of less than 10 per cent light intensity and a correspondingly less physiological loss in light sensibility. Fig. 1 shows the light reflecting characteristics of most of the important commercial sound screens. These curves give the relative reflecting characteristics of the screens listed as taken by laboratory photometric measurements and it should be borne in mind that theater conditions should be considered in their interpretation. To determine the absolute optical characteristics it will be necessary to make photometric measurements in theaters. All screens listed in Fig. 1 have substantially the same acoustic characteristics.

Color Requirements.—With the advent of color it is necessary that

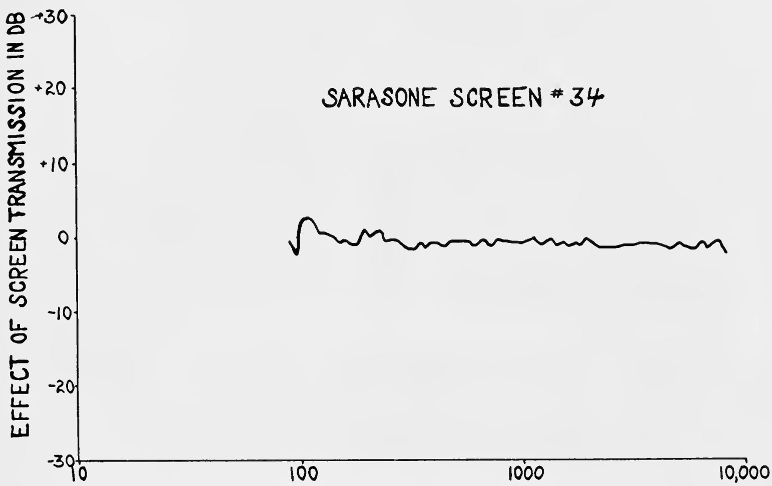

FIG. 2. Typical acoustical characteristic of a sound screen.

the reflecting characteristics of screens be given serious consideration. A white matte surface will reflect all colors in proportion to the intensity of the various colors falling on the screen. The silver and quartz screen shows by spectrum analysis a deficiency between 410 and 500 mμ or in the blue end of the spectrum. Of course, with tinted films the spectrum of the light reaching the screen is very much distorted. It is anticipated that considerable study will be given to color reflection in the future.

Acoustical Characteristics.—In order that a screen be satisfactory acoustically for reproducing systems where the sound source is placed immediately behind the screen, it must transmit sound uniformly over the entire sound spectrum in use at the present time, that is, from 50 cycles to 6000 cycles with a maximum allowable variation of 3 decibels. Fig. 2 shows a typical acoustical characteristic of a sound screen. This curve was made by placing the screen to be tested between a source of sound and a pick-up apparatus in the form of a condenser microphone and volume indicator, and relative levels are measured over the sound spectrum in question.

Deterioration.—Screens deteriorate rapidly and frequent attention should be given them. Atmospheric conditions surrounding the stage in most theaters contain considerable dust and dirt and the fresh white surface of a screen under most theater conditions has a very short life. Screens should be inspected and carefully examined several times a year. In addition to the reduced light reflection which dust collecting on the screen will cause, the collection of such dust and dirt may seriously affect the sound transmission characteristics. Considerable difficulty has been experienced in an effort to clean screens. At the present time the most satisfactory method of reclaiming screens is by resurfacing.

The Academy Projection Committee wishes to recommend that a more exhaustive study be made of the life and deterioration of screen surfaces from both an optical and acoustical standpoint.

The desirability of establishing a standard of desirable screen brightness in relation to size of screen including wide film and magnascope reproduction is recognized by the committee, but lack of time compelled us to leave this subject for more complete attention at the fall meeting.

In connection with the above subject the necessity for portable photo-cell apparatus for measuring screen intensities presents itself. The following excerpt from a letter from Mr. L. A. Jones* covers the requirements of such apparatus quite thoroughly. "In order to use a photo-electric cell as a means of measuring illumination, it is of course necessary in some way to make a correction for the difference between the spectral sensitivity of the cell and the spectral sensitivity of the human eye. This can be done by placing between the photo-electric cell and the light source in question a selectively absorbing filter so adjusted that the effective sensitivity (obtained by multiplying wave-length by wave-length the spectral sensitivity of the photo-electric cell by the spectral transmission of the filter in question)

* Research Laboratory, Eastman Kodak Co.

is equivalent to that of the human eye. Photo-electric cells which are of the same type and supposed to be identical show differences in spectral sensitivity. We have in the past manufactured selectively absorbing filters to fit the spectral sensitivity of certain particular photo-electric cells. The special filter mentioned above was developed at the request of Mr. C. Deshler* to fit a caesium cell type PJ-15. Cells made under this designation do not vary enormously in spectral sensitivity and hence one of these filters with such a cell should give a response approximately proportional to the visual intensity of the radiation."

To date no such instrument is available for commercial use. The committee feels that to make a standard of screen brightness effective such an instrument should be developed in order that each theater or group of theaters might use one to check from time to time against whatever standard may be decided upon. Mr. Herbert Griffin and Mr. Rudolph Miehling both contributed material regarding the use of the photo-voltaic cell for this purpose, but the same is true of the use of this cell. They have been used in laboratories but have not yet been developed for commercial use.

The subject of grading lenses to give a per cent increase in picture size received considerable attention. A proposal was made to try to get the companies who record on disk exclusively to reduce their film image to the size which has become standard for projection of film recorded subjects. This did not meet the approval of the producers of disk recordings nor of the committee. The various lens manufacturers meet this problem in different ways. The Projection Optics Co. and the Illex Optical Co. each make bifocal objective lenses by which it is possible to change the focal length just enough to enable the projectionist to fit either the standard aperture or the proportional aperture for film recordings to the same screen. The Ross people feel that their present method of supplying lenses varying in $^1/_4$ in. steps is adequate. Mr. W. B. Rayton proposes in a paper presented at this convention to meet the situation in another way. Instead of supplying lenses which differ by a constant interval of $^1/_4$ in., he recommends two series of lenses, each second or third member of which will give an 11 per cent difference in magnification. This solution would enable a choice of either the second or third size above or below a given size to match the two different apertures

* General Electric Co., Harrison, N. J.

to exact size on the screen. This proposal received the unqualified endorsement of the committee.

The following reports on "Methods of Fire Prevention" by Mr. G. C. Edwards, A. P. S., and Mr. Herbert Griffin received the approval of the committee.

METHODS FOR FIRE PREVENTION

Due to the extreme heat found in the concentrated light ray necessary for projection combined with the inflammability of the nitrate film there is always present in the theater a danger of fire in the projection room.

If, however, the film can be kept moving at ordinary projection speed in the projector, fire from this source is very rare.

A survey of 480 fires in the City of New York during the period from May, 1926, to September, 1929, showed that they were caused as follows:

Loose splices and torn film	84 per cent
Mechanical stoppage caused by poor mechanical condition of projectors	7 per cent
Improper methods of storing and handling	6 per cent
Electrical short circuits	3 per cent

Loose Splices and Torn Film.—These figures show conclusively that the greatest danger and fire hazard by far is due to the inefficient system of inspection by film exchanges. Where splicing machines are used, they are permitted to get out of adjustment. Film cement of poor quality or that which has been exposed to the air until most of its volatile constituent has evaporated is commonly used. Patches made in a hurry and not allowed to properly weld before removing from the splicer, failure to see that the scraped edge is dry before cement is applied, manual inspection by inspectors wearing gloves, and the speeding up of inspection until the film actually parted in the hands of the inspector, are the faults existing in exchanges.

In many cases it was found that laboratories sending out first run prints necessitated the remaking of practically every splice before projection could be undertaken. The alibi of the exchange in this matter is that the splices are made by unskilled workers in the theater, reel boys and such, but the fact remains that, due to their failure in catching and correcting these faults, they are directly responsible for the very large percentage of fires caused during that period.

Projector Faults.—Seven per cent of the fires were traced directly to poor mechanical condition of equipment. Faulty take-ups caused by excess oil getting to the friction disk, which, due to its position on the projector, is practically unavoidable in projectors which have been subjected to much wear, failure of mechanical safeguards to function due to wear, and emergency repairs made in the theater which, due to the lack of proper materials and tools, prevented the proper functioning of mechanical safeguards, are the principal projection room faults.

Carelessness in Handling and Storing.—The proper storage of film is a difficult problem in many small theaters. The expense of installing proper cabinets has in many cases lead to the managements depending on all kinds of substitutes. Shipping cases, bread cans, and even reel cans are being used. Cheap cans with light flimsy doors which would not, even when new, close properly were frequently found. Loose film on benches and in open boxes and ends and trailers wrapped in the reel bands and placed on nails and in pigeon holes were discovered. These things acted as fuses to carry the fire all over the room when trouble occurred. In one case, a serious fire was caused by the projectionist placing the used reel on the floor while threading up, while a very short reel was running in the other projector, and inadvertently dropping a hot carbon butt on to it when retrimming his lamp.

Electrical Short Circuits and Blowing Fuses.—Three per cent of the fires were caused from this source.

Asbestos leads burned off in one case and came in contact with bottom of the lamp house burning large holes in it with a resultant shower of sparks. A boy was passing with a reel in his hands and attempted to pull the switch. The reel was fired in his hands. The arc from a blowing fuse in another case resulted in hot metal getting to the reel on the rewinder. Failure of insulation due to chafing, switches working loose and shorting on switch boxes, grounding due to copper deposit from carbons bridging insulation, were all found causes of fire under this classification.

Remedies.—(1) A complete revision of the method of inspection in film exchanges.

(2) A daily test of the adjustment of splicing apparatus in exchanges and laboratories and projection rooms including cement.

(3) The education of the managements of theaters to the necessity of maintaining equipment in good working order and proper provision for storing film in the theaters.

(4) The abolition of open link fuses.

(5) The education of men handling film in the correct methods for safety in the theater.

A METHOD FOR PREVENTION OF FIRE, FILM BUCKLE, AND ELIMINATION OF POOR DEFINITION IN PROJECTED PICTURES

With the advent of sound and the installation of sound screens it became necessary to greatly increase the illumination at the aperture in order to overcome the lack of brilliancy caused by the porous screens. When this was done buckling, lack of definition in the projected picture, fire hazard, and distortion of the sound track immediately became apparent and a general problem. One successful method of eliminating these difficulties has been accomplished by the introduction of the Super Simplex mechanism for new installations and the rear shutter assembly for existing installations of old types of Simplex mechanisms. By placing a properly designed shutter in the rear of the projector the heat was, of course, immediately reduced by fifty per cent and by applying scientific principles to the shutter construction it has been possible to reduce the heat still further. This method has been productive of highly desirable results. In connection with sound-on-film, if there is no buckling of the sound track the reproduction from it will be far superior to that brought about from a sound track distorted from the terrific heat which was heretofore incident on the film.

A report, furnished by Mr. D. F. Whiting covering "Analysis of Quality Losses," was very comprehensive and received very favorable comment by a majority of the committee. However, as this report only covers film reproduction on one type of equipment, it was decided to hold this report and to add to it by getting similar reports to cover other types of apparatus, also disk reproduction and to present a complete report on all of this at the fall convention.

This subject of adjustment of volume levels and remote control created by far the most intense interest of all subjects on our schedule. After much discussion it was unanimously decided by members present at the meeting to recommend and endorse the addition to all existing sound installations and to all new installations a remote volume control to be located in a logical place in the auditorium. This apparatus is adaptable to practically all equipments. It can be arranged so as not to interfere with the changeovers or operation of the present faders or volume controls. The following paper by Mr. Whiting covers the subject as applied to W. E. equipment, in some instances.

ADJUSTMENT OF VOLUME LEVELS AND REMOTE CONTROL

The adjustment of volume levels has been found by practical experience to be best accomplished by the use of a remote control device located in as near an average position in the house as is practicable. By means of such a device, variations in volume level may be made or compensated for which would be difficult to bring about with the usual cueing method now most universally used. A competent observer, having such a device under his control and being located in a strategic position from a sound standpoint, can produce a fairly satisfactory showing from a rather poorly recorded film or can get an excellent showing from a film having good recording. Effects which it has been practically impossible for the projectionists to accomplish by the cueing method or by the use of the usual buzzer signal method, owing to the difficult observing position in the former case and the time lag in the latter case, can be brought about through the use of this remote control device to accomplish results which are impossible to obtain in any other way at the present time, due to the limitations imposed by recording and reproducing processes. Such effects include the momentary increase of volume level to bring about more natural effects during the firing of a cannon, the slamming of a door, or other sudden temporary noises which cannot be recorded and reproduced at the desired levels by the ordinary process. A good example of such a case occurs in the picture *Sunrise* in which the whinny of a horse occurs in the middle of a long suspended, tense, and otherwise silent period. The effect upon the audience of this whinny is somewhat startling even as recorded and reproduced by normal methods; but by the use of a remote control device such as described, the whinny of the horse can cause the audience to freeze in their seats and cause some members to cry out in alarm. It has been found impractical to expect to accomplish this result by the use of the usual fader located in the booth. It requires close watching on the part of the observer but with a little experience the result is almost perfect. The volume must be increased suddenly just at the instant immediately preceding the first sound and it must decrease as rapidly immediately following the sound. If the volume is increased prior to the sound the ground noise noticeable during the quiet period will increase and forewarn the audience and the result desired will not be achieved. There are other times also when certain extraneous noises have entered into the recording and, through the use of this remote control device, the disagreeable effects caused by these undesirable sounds can be wholly or partially removed. The remote control may also be made use of by an observer to compensate for the effect of the audience's reaction, such as laughter, hand clapping, and the like. It has been observed many times that applause or laughter interfered with sounds which occurred during this period, which sounds, if reproduced at sufficient volume to override such noise, and thereby be heard by the audience, would provoke even more uproarious demonstration on the part of the same. Thus the effect of many of the best recorded witticisms are lost and it is only possible to get them over to the audience by the control of an observer situated where he can hear the interference. It has been suggested that the necessary volume under such conditions should be anticipated at the time of recording, but this would be ridiculous because of the ever-changing response of different audiences which may not respond at all in the manner anticipated.

In addition to the advantages described above, better volume control of the more usual nature can be obtained through this remote control device than can be expected with the usual practice. The device may be operated following a cue sheet, and dispose of the volume control in the projection room, or it may be made auxiliary to the control afforded by the projectionists. The former seems the more preferable arrangement in most cases.

One remote control device, which has been used with considerable success at the opening and during the first few showings of many feature pictures and during the entire showing of one of the same, consists simply of a suitable potentiometer connected in circuit between the output terminals of the fader and the input terminals of the projection amplifier. This potentiometer has been equipped with means whereby the impedance presented to the amplifier is constant for all positions of the dial switch, and of the proper value to suit the amplifier. As constructed, it affords a range of 20 db. divided into steps of 2 db. each which are designated from minus 10 to plus 10, there being 11 positions in number.

In Fig. 3 is shown a schematic drawing of the potentiometer, and a sketch showing the appearance as viewed from the top. Fig. 4 is a diagram of its location in the circuit. It should be noted that the control knob is of such a shape that the position of the brush can be determined easily in the dark and, for a similar reason, each position is designated by a round stud which may be easily felt with the finger and the position of the pointer determined whenever desired by counting from the zero or middle, which is of a different shape from the others. While in many cases it is unnecessary to determine actually the position of the pointer, this type of construction has been found to be a convenient form. The minimum loss imposed by this type of potentiometer need not be great, the loss due to the type described being exactly 2.5 db. The device may be connected in the

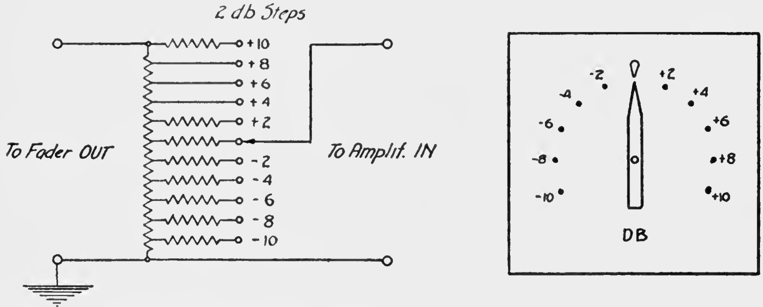

FIG. 3. Diagram of remote control device circuit and top view of device.

circuit merely by running two pairs of shielded wires from the projection room to the selected position, and making the necessary electrical connections at their terminals. There may possibly be cases where a greater range than that afforded by the device as described can be used to advantage and, if this is the case, the device can easily be constructed to cover any range desired. Also it is optional what value should be used for each step. It appears likely that the steps should not exceed 3 db. each. It seems unnecessary that they be closer than 2 db. each.

Auxiliary to the device as described and supplementing its operation could be the use of two signal lights, say red and white, indicating the projection machine running at any given time. These lights should be operated all the time that the machines associated with them are running, and this may be accomplished by arranging the lights to be operated by the projection motor switch. Through the use of these lights, the observer will be able to tell which machine is operating and, what is more important, he will be able to receive warning that a changeover is imminent and prepare to compensate for irregularities occurring during that period. It should be understood that just before the changeover occurs, the lamp previously out will light and the two lamps will be burning simultaneously for a short time.

It also appears that some improvement could be made in the now prevalent method of communicating with the projectionists by means of a telephone set. Under present practice, this result may be accomplished only by the projectionist leaving his machine to answer the telephone. A more desirable method would appear to be that of loud speaker communication from the observer to the projectionist.

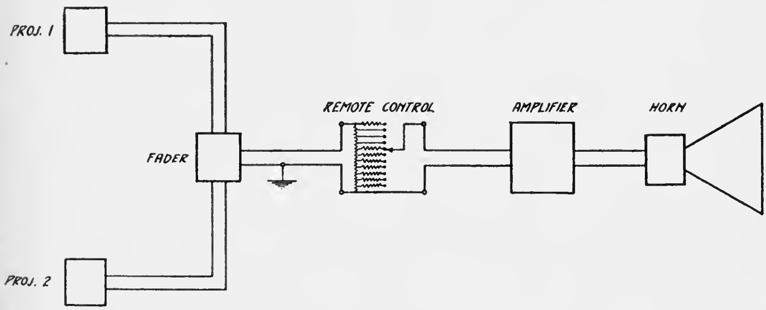

FIG. 4. Diagram of location of remote control in circuit.

In case the projectionist desired to reply to these instructions or in case a question were asked, the projectionist could speak into a transmitter located adjacent to the port hole through which he observes the screen. Such an arrangement has been in use in one of the reviewing rooms for some time, and it appears quite satisfactory for both this and theater use. No buzzers will be necessary with this system since the projectionist can be spoken to directly without any action on his part and, if the remote control device described is used, the buzzer becomes unnecessary for volume control purposes.

The problems connected with the personnel necessary to operate such a remote control device as that described above will probably be more difficult than that of the design and installation of the device itself. While a large motion picture house could well afford to pay for the services of a man well trained for this purpose, the fact that they have been getting along without his services to date is an obstacle to overcome when considering the introduction of such a device. Undoubtedly the smaller houses cannot afford to pay for a man of this type and it is doubtful if they would consider the use of any such device if it would entail the exclusive services of any person.

There appears to be no organized group at the present time whose members are exactly qualified for this work. It demands a man having some musical training and a fine appreciation of the effect of crescendos and pianissimos and the knowledge of where they should occur in the music normally encountered. The man should have some understanding of the limitations encountered in our present-day recording, in order that he may be able to intelligently compensate with the best of his ability for somewhat undesirable effects introduced during the recording process. The man should also have a working knowledge of the sound equipment installed in the theater and the function of the various parts, in order that he may be able to detect faults when they occur and to take the necessary steps for their removal. In spite of the above, the man need have no knowledge of how to play a musical instrument and he need not be a musician; he need not be qualified to do recording or to do the installation or servicing work on sound equipments in theaters, and he need not have any knowledge or experience in operating projection machines. Above all things, however, the man should be a showman. He should be able to take the film as received, consider it his raw material with which to work and make out of it something better than it is in itself. He should be observing of audience reaction and take whatever advantage his control offers to make that reaction as favorable as possible. In other words, he should be a qualified production man having a fine sense of the things which will please his audience, and he preferably should be connected in some capacity with the house management. Since the functions of this man do not start until the showing itself starts, and since they end immediately upon completion of the showing, there appears to be no good reason why this man could not perform dual functions in small houses, and thereby enable such small houses to install such control devices. Naturally the requirements of a man to handle a small house need not be as high as those desirable for a larger house, and a man under the control of the manager whose services are not necessary for other purposes when the audience is seated, could be trained to perform this function.

RCA REMOTE VOLUME CONTROL

Another method which is being used to some extent by RCA is to connect a Selsyn motor mechanically to the volume control or fader in the projection room and to connect another to a dummy fader in the rear of the auditorium. The two Selsyn motors are electrically connected and when either the fader or dummy are operated, the other one moves in synchronism. This allows the fader to be operated from either place at any time desired.

ACOUSTICS OF THEATERS

The problem of treating a theater to make its acoustic properties ideal or even satisfactory is one which has gained much consideration by the industry. The exhibitors have manifested a keen interest with the obvious purpose of improving the sound reproduction in houses for which they are responsible. The more technical groups are becoming increasingly concerned with the measurement and control of the acoustical conditions in auditoriums which are intended primarily for sound reproduction.

The committee recognizes the importance of these developments and is studying them and will be prepared to report in the future on advancements in this field.

USEFUL LIFE OF FILM

Questions of the level at which ground noise becomes objectionable, preparation and repair of film for disk reproduction, the effect of splices on film reproduction, and 1000 *vs.* 2000 ft. reels have been reported to the committee by Mr. Trevor Faulkner. These same questions have been completely treated by Mr. Faulkner in his paper which appears on page 501 of this issue of the JOURNAL.

DISCUSSION

MR. TOWNSEND: The President of the Society asked in particular that the committee take some action, or at least give their opinions, regarding wide film. I have brought this before the committee, and it was their unanimous opinion that the Projection Committee at this time would rather not enter into the discussion.

MR. LITTLE: In the papers on screen measurements referred to in the report. the tests were made with the light incident on the screen normally while in practice it is incident at from 5 to 25 degrees. We have tested our screens in a similar manner but we feel that such tests do not tell the whole story.

Another point in regard to screen brightness measurements in the theater, at the present time it seems that the cheap visual instruments on the market are better adapted to brightness measurements than the photo-cell.

MR. TUTTLE: (Communicated) Data on the reflection characteristics of screens obtained with normally incident light are directly applicable to conditions in the theater where the light is incident at an angle. The reflection factor measured as a function of angle away from the direction of regular reflection varies but little with the angle of incidence when the incident angle does not exceed 10 or 15 degrees on such material as motion picture screens.

MR. NICHOLSON: I'd like to make a few remarks on Mr. Townsend's comments on the availability of the piece of apparatus for measuring the reflection of the light from the screen. The same problem was tackled in measuring the intensity of flashing lamps for recording purposes. That problem also is concerned with filtering the light so that the response of the photo-electric cell will be the same as the response of the emulsion to be used. This can be accomplished but I'd like to agree with the former speaker that after using photo-electric cells for such measurements and also for the purpose of measuring transmission of film, we found that the different photo-electric cells would not give the same measurements. We had quite a bit of trouble, so that when we came to the problem of measuring the light reflected from the screen we first used the Leeds and Northrup illuminometer. Measurements of light of different color can be accomplished by inserting between the standard and the photometric field a filter which will cause the comparison light to be of the same color as that reflected by the screen.

MR. TOWNSEND: A portable apparatus for measuring screen intensities would be very advantageous to the industry. This need not necessarily be a photo-cell apparatus. Any device which could be considered standard would be suitable.

MR. RICHARDSON: The subject of volume control is very vital at this particular time. That suggested in the report is one particular way of handling that problem. Putting the control in the hands of the individual picked up at random is open to some objection and the method of controlling the volume in the sound track at the time of manufacture offers the better solution.

ABSTRACTS

The Editorial Office will welcome contributions of abstracts and book reviews from members and subscribers. Contributors to this section are urged to give correct and complete details regarding the reference. Items which should be included in abstracts are:

Title of article
Name of author as it appears on the article
Name of periodical and volume number
Date and number of issue
Page on which the reference is to be found

In book reviews, the following data should be given:

Title of book
Name of author as it appears on the title page
Name of publishing company
Date of publication
Edition
Number of pages and number of illustrations

The customary practice of initialing abstracts and reviews will be followed. Contributors to this issue are as follows: George P. Silberstein, and the Monthly Abstract Bulletin of the Kodak Research Laboratories.

Children's Theater and Children's Films. *Intern. Rev. Ed. Cinemat.*, **2**, April, 1930, p. 435. A report of the International Institute to the Child Welfare Committee considers the problem of production of special films for children and their presentation. An investigation discovered that children do not care for special films, produced usually with an erroneous idea of their mentality. Special children's shows have usually failed in the various countries. The adults in charge of the children will not attend these shows. The production of these films calls for the coöperation of the psychologist, artist, and producer.—*Kodak Abstr. Bull.*

The Picture and Education. T. Ramsaye. *Ed. Screen*, **9**, May, 1930, p. 134. An address before the Visual Instruction Section of the Ohio State University Educational Conference. Motion pictures are more adapted to mass education than textbooks. The present motion picture industry is purely an amusement industry and must not be looked to for the development of visual educational technic.—*Kodak Abstr. Bull.*

Talking Film of Surgical Dissection Made in Sixteen Millimeter. *Ex. Herald World*, **99**, May 24, 1930, p. 41. A dissection requiring six weeks to complete was photographed on two reels of amateur standard film, after which a synchronized sound record was made on a disk.—*Kodak Abstr. Bull.*

Scholastic Films in Austria. E. Schober. *Intern. Rev. Ed. Cinemat.*, **2**, April, 1930, p. 417. There are 14 permanent theaters devoted to scholastic motion pictures in Vienna and 46 throughout Austria. The Scholastic Cinematographic Guild is an organization of schoolmasters, whose subsidiary, the Scholastic Cinematographic League, is producing various experimental films. The Cinematographic Seminary (1928) is undertaking a study of the principles of teaching by films. The Austrian Cinematographic Archive is gradually accumulating scholastic films for rental.—*Kodak Abstr. Bull.*

Movie Camera: An Aid in Search for the "One Best" Method. A. H. MOGENSEN. *Factory,* **79,** June, 1930, p. 1310. With the development of fast lenses and panchromatic film for amateur standard cameras, motion pictures of time study work or "micromotion studies" have been used to a great extent in industrial plants. Time recording is accomplished in one of two ways: (1) photographing a rapidly moving clock of microchronometer simultaneously with the operation; and (2) using a constant speed camera. In the latter method film is run through at 1000 frames per minute so that each picture is made 0.001 minutes later than the preceding one. In addition to motion analysis, this method may also be used in teaching old operators or training new ones.—*Kodak Abstr. Bull.*

Modern Laboratory. *Cinematography,* **1,** April, 1930, p. 13. This article describes a new, modern film processing laboratory located in New York City. Interior walls are finished throughout in white tile. The building is heated by oil burners and is equipped with a refrigeration plant. Air is filtered before entering the workrooms and is automatically kept at constant humidity. The developing rooms are equipped with machines for both negative and positive processing. The laboratory has been equipped for sensitometric work and has a projection room, fitted with sound reproducing apparatus. A number of illustrations of the new plant are shown.—*Kodak Abstr. Bull.*

World's Biggest Auditorium: Atlantic City Auditorium. *Kinemat. Weekly,* **159,** May 15, 1930, p. 67. The large ballroom of the Atlantic City auditorium has recently been equipped by Western Electric to show talking pictures. This auditorium, which covers nearly five acres, has a public address system installed comprising four sets of horns. These are arranged as follows: one set on the stage with six horns with twenty units, which are ordinarily connected to five amplifiers; one set in each of two gondolas, attached to the ceiling, each with twenty-five speaker units; and another set on the projectolier. The reproducing of sound has been planned so that a relay switching arrangement allows any set of horns to be used.—*Kodak Abstr. Bull.*

RCA's Sound Studio on Wheels Permits High Speed Shooting. *Ex. Herald World,* **99,** May 24, 1930, p. 42. This sound recording and camera equipment is housed completely within two trucks, one containing the power supply and the other the recording apparatus. The recording equipment is identical with that used in the studios and all parts can be removed from the truck for installation if so desired. Two complete recording units of 1000 feet of film capacity are provided, permitting synchronization with a maximum of six cameras. A film conditioning cabinet is provided having a capacity of 16,000 feet of film.—*Kodak Abstr. Bull.*

New Color Firm to Start Operations. *Film Daily,* **52,** June 1, 1930, p. 1. A color process is announced, called Supercolor, which is stated to be a revival of the old Kinema-color process.—*Kodak Abstr. Bull.*

French Engineers Invent Outdoor Daylight Screen. *Film Daily,* **52,** June 22, 1930, p. 12. The device consists of an ordinary opaque or transparent screen in front of which is placed a frame holding rows of very thin, bright metal blades arranged perpendicularly to the screen surface. The blades, not visible to the spectator, catch light obliquely, and cast shadows on the screen.—*Kodak Abstr. Bull.*

Obtaining Relief in Cinematography. J. DE LASSUS. *Bull. soc. franc. phot.*, **16**, December, 1929, p. 315. One of the most successful artifices adopted for imparting a stereoscopic effect to motion pictures is to move the camera while the optical axis is made to pass through the central point of interest in space. This article announces a device by which the optical axis is directed automatically, whatever the displacement of the camera. The apparatus is not described.—*Kodak Abstr. Bull.*

New Cameras for Sixteen Millimeter Film. *Phot. Dealer*, **44**, March, 1930, p. 132. A description is given of the new models C and D of the Ciné Nizo amateur cameras. Both models have four speed motor control and may be hand cranked as well as motor driven. The motor runs off 35 feet at one winding. The model C is fitted with a locking device which may be used either as a safety catch or for fixing the motor for continuous pictures. A single claw pull-down is used. An interchangeable lens mount on both models permits the use of lenses other than the $f/3$ fixed focus lens regularly supplied.—*Kodak Abstr. Bull.*

Spools and Film Threading. *Amat. Phot.*, **69**, May 28, 1930, p. 490. Various types of 16 mm. projection spools are described. An aid to threading is the Hayden "self-threading finger," a V-shaped piece of metal which is fixed to the end of the film, and is easily threaded into the spool slot.—*Kodak Abstr. Bull.*

Keeping the Light Mask Free from Dust. *Cinema*, **34**, May 7, 1930, p. xxvii. The difficulty of keeping the light slit free from dust and film scrapings during the reproduction of sound film is overcome (according to a recently patented method) by forming the aperture by the tangential approach of the circumferences of two rings. The rings are rotated in opposite directions so that the portions not actually forming the aperture can be wiped by mechanical means.—*Kodak Abstr. Bull.*

New Shutters for Old: Rear Shutter for the Older Model of Simplex. F. H. RICHARDSON. *Ex. Herald World*, **98**, Feb. 22, 1930, p. 41. The author gives a description of a rear shutter for older model Simplex projectors with directions for its installation. It is claimed that the rear shutter will decrease heat on the film gate by 75 per cent, thus lowering the danger of fire.—*Kodak Abstr. Bull.*

Variable Focus Lens. *Ex. Herald World*, **98**, Section 2, Jan. 18, 1930, p. 37. This lens eliminates the necessity of changing lenses or shifting the projector when changing from silent to sound film. A ring on the lens mount is turned to enlarge the image and bring it over to the same part of the screen occupied by the silent image.—*Kodak Abstr. Bull.*

Silent Worm Drive. M. C. MARSH. *J. Sci. Instr.*, **7**, May, 1930, p. 171. The use of an ebonite worm driving a metal wheel reduces noise considerably at high speeds. Water lubrication is employed.—*Kodak Abstr. Bull.*

Latest Developments in Wide Film Pictures. E. I. SPONABLE. *Electronics*, **1**, May, 1930, p. 65. A thorough study is made of the advantages of several proposed sizes of wide film over the present standard size. A discussion of the change in sound recording technic made possible by the use of wider sound tracks is also included in the article. G. P. S.

Cost of Wide Film Change. *Bioscope* (*Mod. Cinema Technique*), **83**, May 14, 1930, p. i. It is estimated that it would cost about £6,000,000 for the motion picture industry to change to wider films, of which sum two-thirds would be expended in changing theater equipment.—*Kodak Abstr. Bull.*

Theater for Wide Films Built at RKO Studios. *Ex. Herald World*, **98**, Section 1, Jan. 18, 1930, p. 35. A theater one story high has been constructed at the RKO studios for showing wide film pictures by the Spoor-Bergren process on a screen $22^1/_2$ by 46 feet. The theater is 45 by 115 feet in size. A new structure housing four sound stages is being completed which is 500 feet long, 150 feet wide, and five stories high. The theater and stage will occupy an entire end of this large building.—*Kodak Abstr. Bull.*

A British "Re-Sync-er." *Bioscope* (*Mod. Cinema Technique*), **83**, April 30, 1930, p. viii. This resynchronizing device for motion picture projection using sound-on-disk system consists of a footage counter and a dial graduated into 16 sections, each of which corresponds to a frame. The device is attached to the 90 foot per minute spindle of the projector by means of a flexible drive shaft. The footage counter is set to correspond with the edge number on the film before the projector is started, and thereafter the exact frame and foot passing the aperture can be detected at once. The equipment can be used for quick resynchronization following a film break, for change overs, and for signaling the orchestra leader if "play in" music is desired.—*Kodak Abstr. Bull.*

Care in Handling Sound Film. *Kinemat. Weekly*, **159**, May 29, 1930, p. 69; *Ex. Herald World*, **99**, May 24, 1930, p. 40. Stringent rules enforced in the Exchange Maintenance Dept. of Metro-Goldwyn-Mayer to ensure the careful handling of motion picture film are reprinted in full. White cotton gloves are provided and must be worn on both hands while film is being inspected. Rings on the fingers are prohibited, regardless of whether they are covered with gloves. The film is to be held for inspection between the thumb and first finger, with the hand under the film palm upward. Every splice made in the department must be stamped with the Metro-Goldwyn-Mayer embossing machine. Detailed rules are given for the splicing of sound film.—*Kodak Abstr. Bull.*

Messterphon-Messtronom-Chronomesster. O. MESSTER. *Kinotechnik*, **11**, Nov. 20, 1929, p. 592. After a description of some early motion picture-with-sound equipment devised by the author, he leads up in a brief manner to the situation existing at the date of publication in Germany, finally describing the equipment figuring in the title. The Messterphon is a sound record disk turntable with a differential drive gear for resynchronization. The author praises the simplicity of the use of disk records and equipment utilizing disks. The Messtronom is a synchronized rewind device for paper ribbon music notes for the orchestra director. The Chronomesster is a chronometer for synchronization at distant points of radio speeches with film exhibitions and the like.—*Kodak Abstr. Bull.*

The Problems of Printing. A. YOUNG. *Cinematography*, **1**, April, 1930, p. 14. A short historical review prefaces an account of the development of combined sound record and picture printers. Both positive stock and negative film are handled in light-tight heads, thus permitting use of the printer in daylight. Speed control, reverse motion, and dissolve mechanism are included as features of the printer.—*Kodak Abstr. Bull.*

New Disk May Soon Eliminate Complaint of Express Costs. D. FOX. *Ex. Herald World*, **99**, May 24, 1930, p. 17. A 16 inch record containing several hundred grooves to the inch will play for 72 minutes. It is called the Micro Disc record. Another type of phonograph record is being marketed for 15 cents and consists of a composition substance called "durium" mounted on a paper back. The author suggests that the problem of shipping disk records now used for sound-on-disk motion pictures would be greatly simplified if micro disk records could then be packed directly in the can with the film or mailed separately in envelopes.—*Kodak Abstr. Bull.*

Recording the Sound Pictures. T. E. SHEA. *Bell Lab. Record*, **8**, April, 1930, p. 356. A detailed but popular article dealing with the equipment, personnel, and technic of recording a sound picture by the Western Electric system.—*Kodak Abstr. Bull.*

Acoustics of the Sound Film Studio. C. W. GLOVER. *Kinemat. Weekly*, **159**, May 22, 1930, p. 51. A description of a method is given whereby a studio (British Filmcraft Production, Ltd.), originally designed for silent films, was converted into one suited for the taking of sound pictures, despite the fact that the original construction of the building prevented the use of massive structures to provide sound insulation. A description of the construction of a new sound studio (Associated Sound Film Industries, Ltd.), including a method of building an effective sound trap in the roof is also given. G. P. S.

Calculating Reverberation (Correspondence). C. W. GLOVER. *Kinemat. Weekly*, **159**, May 8, 1930, p. 67. A comparison is given of the results obtained when the reverberation formula of Morris and Eyring (*Kinemat. Weekly*, **158**, April 10, 1930, p. 62), and two formulas due to P. E. Sabine were applied to such varied buildings as a church, a concert hall, and a highly damped studio. A curve whose use minimizes the calculation involved in applying Sabine's formulas is also given. G. P. S.

Seats as an Aid to Uniform Acoustical Conditions in Theaters. W. K. FRIEND. *Ex. Herald World*, Section 2, **98**, Feb. 15, 1930, p. 29. Seats should be made of materials which absorb nearly as much sound as a person. Three types of seats are analyzed according to their absorption characteristics using the Sabine mathematical equation. Reverberation data for each type are included.—*Kodak Abstr. Bull.*

Real Images in Pictures without Film Perform at Television Show. *Ex. Herald World*, **99**, Section 1, May 31, 1930, p. 102. A group of actors going through their act at the General Electric Studio were "televised" to a theater half a mile away and their images projected upon a six foot screen before an audience. The voices and sounds were transmitted by radio. It is stated that the images swayed slightly during projection. The process is that developed under the direction of V. F. W. Alexanderson and the larger screen presentation was made possible through the use of a light valve.—*Kodak Abstr. Bull.*

BOOK REVIEWS

Motion Picture Almanac, 1930. *Quigley Publishing Company,* Chicago, 1930, 247 pp. $1.25. According to the editors the purpose of this almanac is to "supply information that is reliable, and facts that are accurate to the end of making better known and consequently better understood, the entertainment that the motion picture industry produces, and the personalities whose genius and effort create this entertainment." Included in the book are lists of players, directors, writers, producers, and other executives, advertising and publicity writers, press writers, editors. A glossary of studio terms is published. Various other lists and short articles on sound, the short feature, world theaters, and exports conclude the book.—*Kodak Abstr. Bull.*

Deutscher Kamera Almanach, 1930. K. Weiss, editor. Vol. 20. *Union Deutsche Verlagsgesellschaft Zweigniederlassung,* Berlin, 1929, 251 pp., $1.25. The articles in this volume cover a wide range. They deal with modern expression and angles in photography; photographing children in the nude, hands in artistic photography; the photography of animals and birds; photography as a medium for advertising; present color photographic methods (Autochrome, Jos-Pe, and Colorsnap); stereo photography; progress in the manufacture of high speed and color sensitive materials; bromoil and bromoil transfer; and photography with artificial light. A short history of the first expedition to photograph the Alps in July, 1861, with wet plates is given. For the motion picture amateur there are articles on the small film camera and the film amateur as his own director.—*Kodak Abstr. Bull.*

Photoelectric Cells: Their Properties, Use, and Application. N. R. Campbell and Dorothy Ritchie. *Isaac Pitman & Sons, Ltd.,* London, 1929, 209 pp., $4.50. The subject material is treated in such a manner as to render it useful not only to the initiated but to those practically unfamiliar with photo-electric phenomena. The first part deals with theoretical considerations as they affect the use of photo-electric cells. The construction of several types of cells is dealt with in this part. The second part deals systematically with the proper choice of a photo-electric cell to fit the need at hand and with its proper use and handling. Methods of measuring photo-electric current and several means used for its amplification are also given. The last part of the work is devoted to the application of photo-electric cells to such uses as photometry of lamps, measurement of illumination, color matching, absorption, and several others. The book contains a large number of references to the literature on the subject. G. P. S

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SOCIETY NOTES

The Fall Meeting.—The Arrangements Program prepared by Chairman W. C. Kunzmann is printed elsewhere in this issue.

At the suggestion of several members, a boat trip has been arranged for Wednesday afternoon, October 22nd, which will permit of informal get-togethers.

All members are urged to stay over until Thursday morning to witness the two-way television demonstration at the Bell Telephone Laboratories, Inc. The demonstration involves considerable expense and this exceptional opportunity should not be missed.

Authors are urged to forward short abstracts of their papers to the chairman of the Papers Committee, Mr. J. W. Coffman, Audio-Cinema, Inc., 2826–34 Decatur Avenue, Bronx, N. Y. These abstracts are urgently needed by the Publicity Committee.

Authors are warned that they must adhere rigidly to the time allotted for presentation which will usually not exceed 20 minutes. Remember that in this time it is not possible to present more than seven pages of double-spaced typewritten material on the usual $8^1/_2$ in. by 11 in. page. Also remember that even the most experienced orators rehearse their speeches beforehand. Authors should rehearse and re-rehearse their material so as to make an efficient presentation.

If motion pictures are to be presented, the authors should make preliminary arrangements with Mr. H. Griffin, International Projector Corporation, 90 Gold Street, New York, N. Y., who will have charge of projection arrangements.

Your president will award a prize to the author who makes the most effective and efficient paper presentation.

The Ballot.—The following names appeared on the ballot for new officers.

President:	J. I. CRABTREE, Research Chemist, Eastman Kodak Co.
	F. A. BENFORD, Research Physicist, General Electric Company
Vice-President:	E. I. SPONABLE, Technical Director, Fox Film Corp.
	W. C. HUBBARD, Sales Agent, General Electric Vapor Lamp Company

Secretary:	J. H. KURLANDER, Commercial Engineer, Westinghouse Lamp Company
	E. R. GEIB Assistant to Manager, Carbon Sales Division, National Carbon Co.
Treasurer:	H. T. COWLING, Motion Picture Engineer, Eastman Kodak Company
	W. H. CARSON, Vice-President, Agfa-Ansco Corp.
Governors:	W. C. KUNZMANN, Sales Engineer, National Carbon Co.
	F. C. BADGLEY, Director, Canadian Government M. P. Bureau
	O. M. GLUNT, Assistant Apparatus Development Engineer, Bell Telephone Laboratories, Inc.
	M. C. BATSEL, Chief Engineer, RCA Photophone, Inc.

The officers whose terms expire September 30, 1930, are as follows:

President	J. I. CRABTREE
Vice-President	H. P. GAGE
Secretary	J. H. KURLANDER
Treasurer	W. C. HUBBARD
Governor	W. C. KUNSMANN
Governor	H. T. COWLING

The Editor Manager.—The committee under the chairmanship of Mr. L. A. Jones appointed to report on the applicants for the position of editor-manager is in process of interviewing prospective applicants and will make recommendations to the Board of Governors at their meeting on September 22, 1930.

Historical Committee.—Your president has discharged the previously existing Historical Committee and has appointed a new one under the chairmanship of Mr. C. L. Gregory. The personnel of the committee is as follows:

C. L. GREGORY, *Chairman*

E. W. ADAMS	G. E. MATTHEWS
M. CRAWFORD	T. RAMSAYE
C. F. JENKINS	F. J. WILSTACH

FALL MEETING OF THE SOCIETY, HOTEL PENNSYLVANIA, NEW YORK

(October 20th to 23rd, inclusive)

The following committees and individuals will officiate during the convention.

Reception

W. C. KUNZMANN
J. W. COFFMAN
O. M. GLUNT
P. H. EVANS
W. C. HUBBARD
H. T. COWLING
S. R. BURNS
A. S. DICKINSON
M. W. PALMER
W. WHITMORE
A. N. GOLDSMITH
N. M. LAPORTE

Convention Registrars

W. C. KUNZMANN
S. RENWICK
K. C. D. HICKMANN
E. R. GEIB

Hostess to Convention

MRS. E. I. SPONABLE, assisted by
MRS. W. M. PALMER
MRS. H. GRIFFIN
MISS DOROTHY P. HUBBARD

Banquet Arrangements

WILLIAM C. HUBBARD

Note.—Make your table reservations with Mr. Hubbard or at the Registration desk.

Tables for 8, 10, or 12 persons.

When making table reservations, kindly list the guests to be seated at your table which will greatly help our Banquet Committee in their seating arrangements.

Banquet Master of Ceremonies

To be announced in Final Program

Supervisors of Projection Equipment

CHARLES EICHORN, Local No. 306, New York M. P. M. O.
H. GRIFFIN, International Projector Corp.
HARRY RUBIN, Publix Theatres Corp.
A. L. RAVEN, Raven Screen Corp.
H. B. SANTEE, Electrical Research Products, Inc.
E. I. SPONABLE, Fox Film Corp.

Entertainment and Amusements

M. C. BATSEL, RCA Photophone, Inc.
LESTER B. ISAACS, Loew's, Inc.
J. S. MACLEOD, Metro-Goldwyn-Mayer Pictures

M. W. PALMER, Paramount Famous Lasky Corp.
J. H. SPRAY, Warner Bros. Pictures, Inc.
E. I. SPONABLE, Fox Film Corp.

Press and Publicity

W. WHITMORE (Chairman, S. M. P. E. Publicity Committee) Electrical Research Products, Inc.
G. E. MATTHEWS, Eastman Kodak Company
J. R. CAMERON, Cameron Publishing Company
F. C. ELLIS, Eastman Kodak Company

Note.—This Committee together with Mr. H. T. Cowling, Chairman of the Membership and Subscription Committee will have headquarters in the Registration Room.

Transportation, Bulletins, Reservations, and Announcements

W. C. KUNZMANN H. T. COWLING N. D. GOLDEN

Official Photographers

CARL GREGORY, Cameraman, New York
F. C. ZUCKER, Cameraman, New York

Note.—Meeting Headquarters will be in the Salle Moderne on the roof of the Hotel Pennsylvania.

Registration Headquarters will be located on the foyer at the entrance of the Salle Moderne. Look for direction cards on your arrival at the Roof Garden.

Ladies' Headquarters will be located on the roof of the Hotel Pennsylvania, with Mrs. E. I. Sponable the hostess.

Garage accommodations will be available for members and guests motoring to New York at a $1.50 rate per night, and a $9.00 weekly rate. Day and night attendants.

Golfing privileges have been arranged at several country clubs in the vicinity of New York, and hotel guest cards can be obtained at the registration desk, by those who wish to play golf; the usual club course fee will be charged.

Tentative Program

MONDAY, OCTOBER 20th

8:30 to 10:00 A.M. Convention Registration, Roof Garden foyer, entrance to the Salle Moderne

10:00 A.M. Convention called to order, Salle Moderne
Address of Welcome—Major Edward J. Bowes, Managing Director, Loew's Capitol Theatre, New York
Response by President, J. I. Crabtree
Report of the Secretary, J. H. Kurlander
Report of the Treasurer, W. C. Hubbard
Report of Convention Committee, W. C. Kunzmann, *Chairman*

Presentation of Papers

12:30 to 1:30 P.M. Luncheon

2:00 P.M. Meeting, Salle Moderne

Presentation of Papers

7:30 P.M. Monday Evening, October 20th

Get-together party of members and guests in Salle Moderne, admittance by your identification card. An exhibition of a selected film program of unusual interest.

TUESDAY, OCTOBER 21st

8:30 to 9:30 A.M. Registration

9:30 A.M. Meeting, Salle Moderne

Presentation of Papers

12:30 to 1:30 P.M. Luncheon

2:00 P.M. Meeting, Salle Moderne

Presentation of Papers

TUESDAY EVENING, OCTOBER 21st

Open night for members' own recreation. A film program exhibition in the Salle Moderne is under consideration for those who prefer remaining at the hotel.

WEDNESDAY, OCTOBER 22nd

8:30 to 9:30 A.M. Registration

9:30 A.M. Meeting, Salle Moderne

Election of Officers and Presentation of Papers

12:30 to 1:30 P.M. Luncheon

This is the open afternoon of the Convention, and your convention committee has under consideration a boat trip around Manhattan Island. Announcements of the program for this afternoon's recreation will appear in the final program.

7:00 P. M. WEDNESDAY EVENING, OCTOBER 22nd

S. M. P. E. Semi-Annual Banquet, Grand Ballroom, Hotel Pennsylvania.

Speakers, Dancing, and Entertainment

Note.—Procure your banquet tickets early at the Registration desk, also make your table reservations, listing your guests. Tables for 8, 10, or 12 persons. Banquet tickets will be collected at the tables.

The Banquet Master of Ceremonies and the speakers for the evening will be announced in the final program.

THURSDAY, OCTOBER 23rd

9:30 A.M. Meeting, Salle Moderne
Presentation of Papers

12:30 to 1:30 P.M. Luncheon

2:00 P.M. Meeting, Salle Moderne
Presentation of Papers
Open Forum
Discussion of location and plans for the 1931 Spring meeting.
Adjournment

Note.—The Papers Committee will have the fall meeting papers program ready for distribution to members early in October.

Convention Committee

J. W. COFFMAN
W. C. HUBBARD
M. W. PALMER
W. C. KUNZMANN, *Chairman*

OBITUARY

JOHN J. LYNG

John J. Lyng, late Vice-President of Electrical Research Products, gave up his life on August 9, 1930, in trying to save his sister-in-law from drowning. His age was fifty-three years.

His business career was a lifetime of service in the Bell System that started in 1905 when he joined the New York Telephone Company as switchboard installer.

Two years later he was transferred to the Western Electric Company's engineering department, now known as Bell Telephone Labora-

J. J. LYNG

tories. There Mr. Lyng was engaged in designing and testing apparatus for the Bell System.

As his special abilities received recognition he was placed in charge of a large group of engineers and technicians who comprised what became known as the Apparatus Development Department, organized to develop communication equipment that would be both economical to manufacture and convenient to use. Much of the present-day convenience and adaptability of telephone equipment can be laid to the work of that department.

Under Mr. Lyng's direction the Bell Telephone Laboratories developed the first commercially successful equipment for producing and reproducing talking motion pictures, including devices for recording on both wax disks and films; amplifying, controlling, and projecting sound in connection with motion pictures and for the complete synchronization of sound with sight as applied to pictures.

In October, 1928, he was appointed Vice-President of Electrical Research Products, in charge of engineering and technical development, the subsidiary organized by the Western Electric Company for the distribution and servicing of its talking picture sound system. In carrying out the duties of this office Mr. Lyng sponsored, as an addition to the Bell Telephone Laboratories, the first laboratories in the world devoted exclusively to development and research work on sound pictures. He was also the moving spirit behind the inauguration of Electrical Research Products' testing laboratory in Hollywood.

The esteem in which he was held by all his associates is perhaps best expressed in the following extract from the tribute paid him by John E. Otterson, President of Electrical Research Products:

"John Lyng was a man's man. A hard worker himself, he inspired others to work hard, and yet he loved to play. Unselfish, big hearted, genial, endowed with a keen sense of humor—he was beloved and respected by all. Underneath these qualities was a rugged honesty and fearlessness which dominated his character. It was typical of the man that he should meet his heroic death in saving the life of another."

SUSTAINING MEMBERS

Agfa-Ansco Corporation
Audio-Cinema, Inc.
Bausch & Lomb Optical Co.
Bell & Howell Co.
Bell Telephone Laboratories, Inc.
Case Research Laboratory
Consolidated Film Industries
DuPont-Pathé Film Manufacturing Corp.
Eastman Kodak Co.
Electrical Research Products, Inc.
General Theatres Equipment Co.
Mole-Richardson, Inc.
National Carbon Co.
Pacent Reproducer Corp.
Paramount-Famous-Lasky Corp.
RCA Photophone, Inc.
Technicolor Motion Picture Corp.

Transactions of the S. M. P. E.

A limited number of most of the issues of the *Transactions* is still available. These will be sold at the prices listed below.

Please note that nos. 1, 2, 5, 6, 8, and 9 are out of print.

Orders should be addressed direct to the *Secretary*, J. H. Kurlander, Westinghouse Lamp Co., Bloomfield, N. J.

No.	Price	No.	Price	No.	Price
3	$0.25	18	$2.00	29	$1.25
4	0.25	19	1.25	30	1.25
7	0.25	20	1.25	31	1.25
10	1.00	21	1.25	32	1.25
11	1.00	22	1.25	33	2.50
12	1.00	23	1.25	34	2.50
13	1.00	24	1.25	35	2.50
14	1.00	25	1.25	36	2.50
15	1.00	26	1.25	37	3.00
16	2.00	27	1.25	38	3.00
17	2.00	28	1.25		

JOURNAL

OF THE SOCIETY OF

MOTION PICTURE ENGINEERS

LOYD A. JONES, EDITOR *pro tem.*

Volume XV **NOVEMBER, 1930** **Number 5**

CONTENTS

JOURNAL
OF THE SOCIETY OF
MOTION PICTURE ENGINEERS

LOYD A. JONES, EDITOR *pro tem.*

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Entered as second class matter January 15, 1930, at the Post Office at Easton, Pa., under the Act of March 3, 1879.

A SEMI-AUTOMATIC TIMING DEVICE FOR MOTION PICTURE NEGATIVES*

J. I. CRABTREE, C. E. IVES, AND FORDYCE TUTTLE

A motion picture sensitometer, commonly called a "timer," is a device for making a series of single picture frame trial exposures through a motion picture negative which exposures correspond to those given by the various steps on the printer. The exposed film is then developed and the correctly exposed picture frame selected by judgment. The exposure which this frame received indicates the correct exposure to be used in the printer.

A sensitometer which is entirely automatic in its action and likewise a non-automatic model have been described in earlier communications.[1,2] Further experience with these instruments indicated that it was desirable that at least the exposure timing should be automatic and a very simple apparatus making this possible was devised.[3] Since the publication of the first paper referred to, other devices have become available commercially, one particularly having the timing shutter operated by means of a spring.[4]

A satisfactory timing mechanism must fulfill the following conditions:

(1) The intensity of the exposing light must be approximately equal to that existing in the motion picture printer.
(2) The instrument must be capable of rapid operation and permit of easy control.
(3) The mechanism should be of rugged construction.

The exposures should be equivalent, however, to those given by the printer in the following respects:

(1) The various exposures should be exactly equal in magnitude to the several light settings of the printer.
(2) The exposures should be exactly reproducible.
(3) The exposure level should be capable of slight adjustment so as to compensate for aging of the lamps, *etc.*

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* Communication No. 436 from the Kodak Research Laboratories. (Read before the Society at Washington.)

(4) The intensity level used should be equal to that used in the printer.
(5) The same factor in exposure (intensity or time) should be varied between the steps in the sensitometer as in the printer. Usually the intensity is varied and not the time.

The first three of these considerations have been treated in the

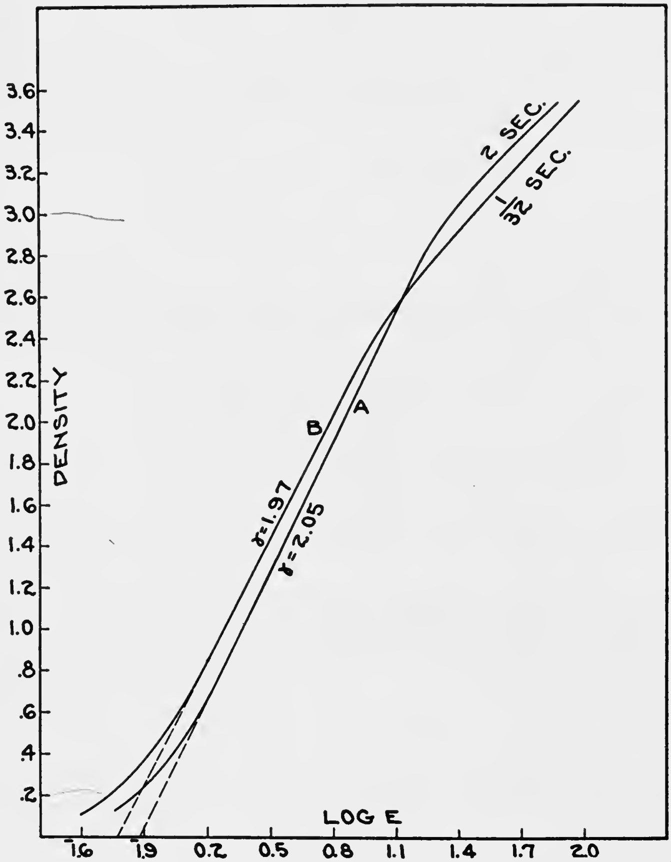

FIG. 1. Curves showing effect of exposure intensity on contrast of motion picture positive film.

papers referred to above. If the test exposures are to produce results which are indistinguishable with respect to photographic quality from those obtained in the motion picture printer then it is necessary that the exposure intensity and therefore the exposure time should be equal in both cases for corresponding exposure steps. This requirement is imposed by that characteristic of photographic sensitive emulsions which manifests itself as a variation in efficiency of response to exposures of constant magnitudes when the intensity factor of exposure is varied. This effect is exemplified in the H & D curves for an average degree of development of motion picture positive film shown in Fig. 1. In the cases represented by the two curves the same series of exposures and the same degree of development were given but the exposing light intensities used for curve *A* were 64 times as great as the intensities for the respective exposures in the case of curve *B*. The time of exposure of curve *A* was $^1/_{32}$ of a second and for curve *B*, 2 seconds, this difference in time of exposure giving for corresponding steps, equal values for exposure in the equation,

$$\text{Exposure} = \text{Intensity} \times \text{Time}.$$

If a sensitometer is employed which gives an exposure of, say, 2 seconds and in which the general intensity level is only $^1/_{64}$ of that in the printer, it will be found impossible to make a satisfactory match between the prints. It will be possible to adjust the two instruments so that the shadow densities are equal at all corresponding steps but then the highlight and shadow densities cannot be matched simultaneously for any one step. The resulting print made on the sensitometer will be more contrasty than that made on the printer. The curves in Fig. 1, representing a moderate degree of development, indicate that a density difference of about 0.1 would be found in the half-tones of the two prints when the shadow portions are equal at a density of 2.0. With a greater degree of development of positive film the effect is still more pronounced. These and other effects of the so-called "failure of the reciprocity law" have been treated very thoroughly in a series of papers by L. A. Jones and his associates.[5]

It is evident that the ideal condition exists when the intensity used in the sensitometer is precisely equal to that used in the printer, but if it differs by a factor of three or four, no discordance in results will, as a rule, be detectable on visual inspection.

The effects mentioned above will produce a lack of correlation between the sensitometer and printer if in one instrument the control of exposure is accomplished by a variation of the intensity while the time is held constant, and in the other by a variation of the time with the intensity remaining constant, unless the range of exposure variation is small. In the present paper only those printing machines in which the control of exposure is obtained by variation in light intensity will be considered.

The sensitometer should produce good contact between the negative and positive and permit of safe handling of the film, while there should also be a visible indication when the exposure is taking place.

The exposure should also be capable of being started at any time and it should go to completion without any possibility of interruption.

Design of Sensitometer.—A sensitometer with an automatic exposure timing mechanism has been constructed following a design which meets the requirements stated above. A timing switch was considered unsatisfactory for controlling the short exposures of high intensity required to simulate the conditions existing in the average printer when the exposure time ranges from about $^1/_5$ to $^1/_{40}$ second.

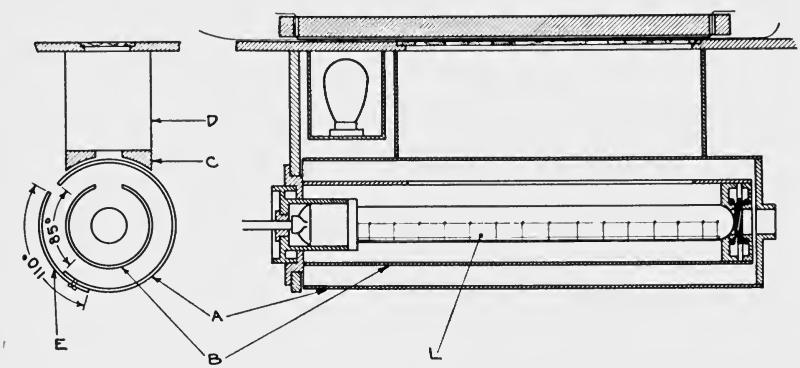

FIG. 2. Schematic sectional view of shutter assembly.

The type of lamp otherwise suitable for use in a sensitometer is not well adapted for switching on and off quickly. Moreover, it is desirable to eliminate the many electrical contact points existing with this type of control. Accordingly, a shutter was chosen for performing the timing operation. This has the further advantage that the lamp current is easier to supervise because the lamp is burned continuously.

The timing device consists of a cylindrical shutter which intercepts the light path and is propelled by an alternating current induction type motor. Such a motor will run at a sufficiently constant speed when fed with current from any large central station supply unless the motor is heavily loaded. By means of a positive engaging single revolution clutch, the cylinder is picked up by a continuously moving gear and carried through one complete revolution.

A sensitometer tablet is used to control the light reaching several frames of the negative being tested. The tablet is designed to transmit increasing quantities of light from frame to frame so that each frame receives an exposure equivalent to that given by one of the printer light change steps.

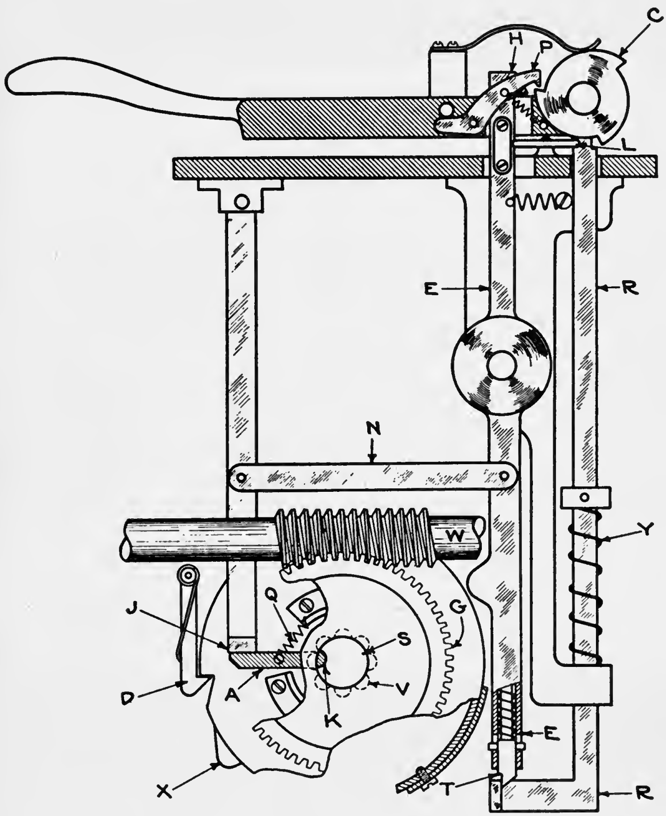

FIG. 3. Detail of clutch and release mechanism.

The preparation of a tablet to suit any particular printer has been described in one of the papers referred to above,[1] and in a later paper when a trial and error method was used.[6]

Arrangement of Shutter Parts.—The essential features of the exposure timing mechanism are shown in Figs. 2, 3, and 4. In Fig. 2

the shutter is shown surrounding the lamp. The rotating cylinder is seen at A. Inside this is another cylinder, B, which remains stationary. Above the cylinder, A, is a light shield, C, which forms the bottom of the light tunnel, D, leading to the sensitometer tablet and printing station. E represents a movable segment which is used to vary the width of the aperture in A. The lamp is shown at L. Light reaches the printing station by passing through the opening in the fixed cylinder, B, through the opening in the rotating shutter, A,

FIG. 4. Photograph of sensitometer mounted in table.

and then into the aperture in the light shield, C. When the opening in shutter A is not in line with the other two openings, no light reaches the printing station. To assist in preventing leakage of light around the shields all of the shutter and mask parts are covered with a dull black coating.

The exposure takes place with the shutter rotating at a speed of one complete revolution in one and one-half seconds. The maximum shutter opening is 85 degrees so that the maximum exposure time is somewhat less than 0.4 second. The movable segment, *E*, can be set so as to make shorter exposures as required.

The Timing Mechanism.—It is desirable that the cylinder should start its revolution very shortly after the platen is brought down, thereby pressing the positive and negative film in contact over the sensitometer tablet. For this purpose, a type of clutch sometimes used on punch presses was chosen. In Fig. 3 the clutch and release mechanism are shown at the completion of the exposure cycle. In the foreground is seen the worm gear, *G*, driven continuously by the worm, *W*, attached by a flexible coupling to the motor shaft. The worm gear revolves continuously about a shaft, *S*, at its center which is picked up by the gear and carried through one revolution when the clutch key, *K*, is made to enter the working position.

The clutch key acts as follows: When in idle position, as shown in the drawing, the key forms a segment of the shaft and lies in full contact with the surface of the keyway in the shaft. The keyway has the form of part of a circle, the center of which lies in the surface of the shaft outline formed by the outer surface of the key itself at this point. Surrounding the shaft and key is the worm wheel, *G*, in which are cut eight keyways, *V*, also of circular outline. When the key is revolved on its own axis in the keyway by the movement of the lever arm, *A*, it enters one of the keyways in the worm wheel. Thus it is in engagement with both the worm wheel and the shaft and the shaft is driven by the rotating worm wheel.

Cycle of Operation.—When the platen is raised to its resting position and then brought down in contact with the films lying on the sensitometer tablet, the cam, *C*, is caused to rotate by the pawl, *P*, attached to the platen. The push rod, *R*, held against the cam by the spring, *Y*, descends, releasing the lock arm, *E*, which rotates through a small angle in a clockwise direction, performing three operations:

(1) The platen is locked in contact with the film by the hook, *H*.
(2) The lever, *L*, is driven against the vertical face of the cam, *C*, completing the motion of the cam to allow the push rod, *R*, to rise again.
(3) By means of the link, *N*, the clutch lever stop, *J*, is swung to the left, thus releasing the clutch lever, *A*.

The clutch lever, *A*, drawn by the spring, *Q*, moves upward rotating the clutch key, *K*, as described above. The key thus engages the keyway in the worm wheel. With the clutch parts in this position the shaft and shutter cylinder are carried around with the worm wheel. When the cam surface, *X*, attached to the shutter cylinder passes the boss on lock arm, *E*, it pushes the lock arm to its original position where it is held by the engagement of a spring catch, *T*, with the extension from the lower end of push rod, *R*. The stop, *J*, is, of course, returned at the same time to its original position. When the rotating shutter assembly brings the clutch lever arm, *A*, to the stop, *J*, it is held back, causing the clutch key to be rotated on its own axis. As soon as the clutch key has been rotated to a position where it lies entirely within the shaft profile and, therefore, no longer engages the keyway in the worm wheel, the shaft comes to rest. In order to prevent the force of the now taut spring, *Q*, from causing the cylinder to go backward to the point where the clutch key engages, the detent pin, *D*, is made to engage a depression in the surface of the cylinder, holding it in the position where it has come to rest.

Thus it can be seen that the timing device operates automatically after the platen is pressed down. It is not necessary to delay the operation of the platen for an opportune moment in the cycle of rotation of the timing gear because the release mechanism becomes preset and the platen locked as soon as the platen reaches the position where it is to remain until the exposure has been made. The exposure cycle is completed without any danger of interruption and is not repeated until the platen has been lifted and returned to its rest position.

The Optical System.—The intensity of the exposing light must be made equal (approximately) to that in the printer. If the time of exposure in the sensitometer and the printer are equal, then the intensities for each exposure step will be equal when adjusted to produce equal printing effects, provided similar light sources are used. It is necessary, therefore, when designing the instrument, to provide for the correct time of exposure and to make certain that sufficient illumination is available.

The intensity of illumination attainable depends upon the light source available and the optical system employed in distributing the light. The most simple and convenient method of obtaining the illumination intensity required is by the use of a 12-inch tubular showcase lamp. This lamp has a line filament about 10 inches long and can be mounted within the cylindrical shutter. The most powerful lamp of this type available is rated at 40 watts, but the manufacturer (National Lamp Co., Cleveland, Ohio) will, on special order, supply a 60 watt lamp giving sufficient illumination for the purpose. If possible, this lamp, and in fact any printer lamp, should be burned

5 or 10 per cent below its rated voltage so that its life will be prolonged and the change in intensity with age will be less rapid.

Perfectly uniform illumination over the sensitometer tablet is also necessary. Only by a long trial and error method is it possible to construct a sensitometer tablet to be used in an aperture which is not uniformly illuminated and even then the efficiency is low. The illumination must be uniform if the sensitometric method described by Jones and Crabtree[1] is to be followed in preparing the tablet. The best way to test the uniformity of exposure is to make flash exposures on a strip of motion picture positive film held against a glass plate placed in the aperture while the shutter is operated. The lamp current should be regulated so that a density of 0.5 to 1.0 is produced at a gamma of at least 1.0.

When a tablet $1^3/_8$ inches wide by 7 or more inches long is illuminated by a lamp of this type placed at a distance of 5 to 9 inches, the illumination is generally uniform except for a slight shading off at the ends. The usual method of overcoming non-uniformity in a case like this is to interpose, between the lamp and the aperture to be illuminated, a strongly diffusing body such as one or more sheets of ground or opal glass. This usually results in considerable loss of light. A better method of overcoming the lack of illumination at the ends of the tablet is to place glass mirrors (silvered on the back) in the narrow vertical ends of the tunnel. If the illumination at the ends of the tablet becomes too high as a result, it can be diminished by grinding the surface of the glass with a little fine emery powder, using as a tool a small disk of glass held flat against the surface to be ground. Thus the illumination is made uniform by increasing the intensity where it has been low rather than by decreasing it generally.

The time of exposure may be from $^1/_8$ to $^1/_{40}$ second with different printers in common use, but it will be sufficient if the time of exposure in the sensitometer is within a factor of 3 or 4 times that of the printer with which it is to be used. If the lamp is placed at a distance of 4 or 5 inches from the tablet, the light intensity can be made equal to that required in a printer in which the exposure time is 0.05 to 0.1 second.

Auxiliary Equipment.—Fig. 4 shows a photograph of the sensitometer mounted on a table of convenient design for carrying the auxiliary equipment necessary for handling the film, controlling the lamp current, and so on. The schematic top view in Fig. 5 shows the relative positions of the equipment. On the left are the film roll holders for negative, *N*, and positive film, *P*.

The negative film passes from the roll holder through the roller guide, *G*, over the safelight at *L*, over the sensitometric tablet, *T*, to the clip, *C*, where two perforations are engaged for bringing the negative in frame with the tablet with the assistance of the guide line on the safelight, *L*. When the clip is open the negative is free and can be drawn through the footage meter, *M*, to the rewind, *R*. The positive film goes directly from the roll holder to the platen, *Y*, where it is held flat on the pressure pad by friction against the plush lining in the two channels through which it is threaded at either end of the platen. At the back of the table is an upright carrying the ammeter or voltmeter, *V*, a safelight, and the switches controlling the lamp

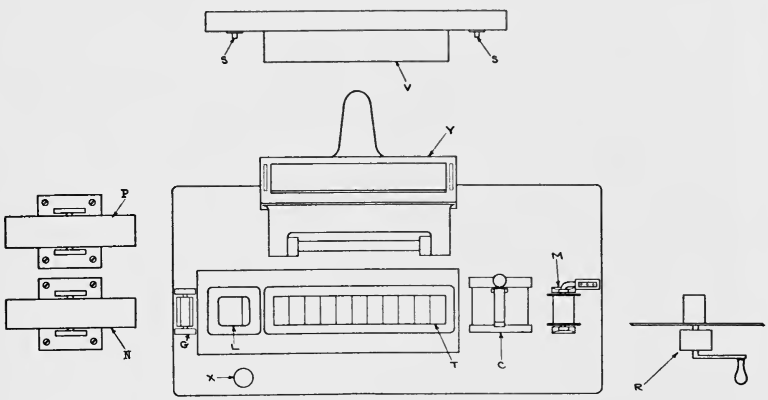

FIG. 5. Schematic top view of sensitometer with auxiliary apparatus.

and motor circuits. In the photograph (Fig. 4) the handle of the screw controlled rheostat can be seen at the lower right.

Good contact between the films held under the platen is assured by the springs backing up the pressure plate on which a felt pressure pad is mounted. The felt pads are covered by a strip of black velvet to avoid reflection effects.

Light is permitted to reach the edge of the film so that edge numbering is printed on the positive film. These marks are of assistance in identifying the scenes when the tests are viewed.

Considerable experience with this sensitometer has proved the value of the various features and the advantage of correct photographic quality rendering.

SUMMARY

(1) The dependence of photographic quality on the intensity of the exposing light in a motion picture sensitometer is discussed.

(2) The design of a simple semi-automatic sensitometer in which the exposure intensity is equal to that in the motion picture printer is described.

The authors are indebted to Mr. A. J. Miller for assistance in the construction of this instrument.

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DISCUSSION

MR. R. C. HUBBARD: Is there a variation in lamps when the tubular type is used?

MR. IVES: We have not experienced this difficulty. There is, however, some difficulty in the first adjustment of the optical system.

A NEW SIXTEEN MILLIMETER PROJECTOR

A. SHAPIRO*

An analysis of the requirements for maximum efficiency in 16 mm. projection reveals a number of interesting problems. As we are here considering an instrument suitable for business, educational, and entertainment purposes and not merely a plaything for amateur cinemists, satisfactory projection must give a good account of itself with respect to the following major operating factors, *viz.*, illumination, good projection, and ease of operation.

In addition to these major operating factors, the designer should incorporate such features as will allow the greatest possible usefulness of his projector with a minimum of effort and attention on the part of the user. To this end, the instrument should be light in weight, compact, and easy to set up. Bearing in mind that the user in the field of 16 mm. projection is very often not mechanically adept, such adjustments as are necessary should be of the simplest, and their use made as foolproof as possible.

And finally, when all the mechanical requirements have been fulfilled, good design will take into consideration the appearance of the product. The 16 mm. projector is seldom hidden away in a projection booth. It is generally exposed near the audience, and very often the subject of as much attention as the film being run. We are a mechanically minded generation, and we like to see the wheels go around. So the problem of 16 mm. projector design is not really fully answered until we can say that the result is attractive to the eye, of a harmonious finish, and generally well balanced as to line.

It is the purpose of this paper to describe in a brief way the manner in which the Ampro, a new portable 16 mm. projector, has attempted to meet these various problems.

The question of screen illumination has always had a large share of attention on the part of projection engineers, not only in the 16 mm.

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* The Ampro Corporation, Chicago, Illinois. (Read before the Society at Washington.)

field, but in the wider film widths as well. In the 16 mm. projector, it is desirable generally to use incandescent lamps for our source of light. In most cases these have a light source spread larger than the very small aperture, and a great deal of light is lost which even the most effective condensing system cannot direct through this small aperture. Consequently the light efficiency of the projector depends to a very large degree upon the mechanical action involving the movement of film and shutter.

To gain this mechanical light efficiency, the Ampro projector uses a double claw movement, acting on two horizontal sprocket holes simultaneously, and moving the film in an interval of 0.006 second per picture. This means that the film moves less than one-tenth the period of any cycle, and is stationary the remainder of that period. To accomplish this extremely rapid movement without undue strain on the film, a special pressure shoe was worked out having a pair of double pressure pads, one pair operating directly at the aperture, and the other pair operating below the aperture. By distributing the pressure in this manner over a fairly long pressure pad, the film resistance per unit area is unusually low and reduces film noise to a minimum.

In conjunction with the fast intermittent movement, a special type of cylindrical shutter having two blades was worked out giving a quick cut-off at the aperture in a horizontal plane. The action of this cylindrical shutter is further improved by the double cut-off obtained by its two blades closing the aperture simultaneously from top and bottom, thus enabling the cut-off blades to be narrower than would otherwise be possible. This gives a shutter light efficiency appreciably greater than is possible with the usual disk shutter of similar size and speed.

Good Illumination.— Good illumination of itself would not be justified if the quality of projection did not measure up to it, and in the Ampro special attention was given to this factor. It was found by practical tests that with the usual 48 interruptions per second flicker did not entirely disappear at normal film speed. The high speed intermittent and cylindrical shutter were particularly adaptable to more frequent interruptions, and in its present design, the Ampro has 64 interruptions per second, giving a flickerless screen even at less than normal film speeds.

A very interesting development in the Ampro is the means used to maintain steady projection. One of the principal causes of what we call jumping pictures in claw feeding mechanisms is the scraping of the claw teeth in the film sprocket holes when the teeth withdraw from the holes. To insure complete freedom from this cause, a special movement was developed which lifts the claw from the film before it withdraws. The claw teeth enter the film holes slightly above the bottom edges of the holes. The speed of movement downward is acquired gradually, finding its maximum speed somewhere near the middle of the stroke, and decelerates toward the end of the stroke. The claw teeth then move slightly upward before withdrawing, being in contact with the film only during the time of actual passage downward.

Ease of Operation.—To make the Ampro easy to operate has been one of the prime considerations in Ampro design. All controls are centralized on the right hand side of the projector normally facing the operator. The starting and stopping switch, the speed control, and the reversing and rewinding switch are mounted on a panel in the base of the projector. For quick and easy regulation of the position of the picture on the screen or wall, an adjusting knob rotates the entire mechanism about the motor.

Just above this adjusting knob is the "Still Button," a turn of which allows the projection of still pictures without injury to the film. This is accomplished by interposing a special heat resistant lens between the condensers and the aperture. This action is automatic upon rotating the "Still Button," as the heat resistant lens is centrifugally controlled to come into play whenever the mechanism has stopped and the film has ceased moving. This is a safety feature preventing the scorching of film should the motor stop and the light remain burning.

A distinctive feature is the method used for rewinding film. No hand crank is provided as the mechanical rewind is very simple to operate and preferable. To rewind, the machine is thrown into reverse, and a rewind button in the back cover of the projector is depressed. Immediately the rewind speed is increased. A 400 ft. reel of 16 mm. film can be rewound in forty seconds. Here again a safety feature has been incorporated whereby the rewind button is automatically thrown out of engagement when the projector switch is thrown into forward speed. The rewind button cannot be operated at forward, but can be engaged only in reverse. This eliminates all possibility of tearing film by the projector attempting to rewind at forward speed, and pulling the film in opposite directions.

General Appearance and General Considerations.—In the matter of appearance it is only possible to generalize in a paper of this character. Much attention has been given in the Ampro to obtain pleasing lines. The workmanship and finish are of a quality consistent with a precision device. For portability, the reel arms collapse, and the whole is contained in a suitable case with space for reels, *etc.* The lamps used are standard prefocused projection lamps, and are interchangeable. The lamp as well as the intermittent and shutter mechanism are easily accessible.

Superlite Model.—To take full advantage of the new 20 volt projection lamp recently developed by the National Lamp Works of Cleveland, Ohio, an Ampro Superlite model has been developed. This contains a transformer in the base and is usable on 60 cycle a.c. only. The illumination obtained in this model has been very gratifying and has served to extend the usefulness of 16 mm. projection for longer distances than has hitherto been possible, and for larger pictures. In the 20 volt lamp, the source of light has not only been increased in intensity, but the area of the source has been considerably reduced, thus making it possible to obtain much higher efficiencies in 16 mm. projection.

I will conclude this paper with a short reel picturing some of the features of this new projector. This reel, incidently, is an example of the use of motion pictures for sales purposes. It has proved a very satisfactory substitute for personal salesmanship in order to reach dealers and camera shops located in towns not conveniently visited by salesmen. In spite of the many technical features involved in demonstrating a projector, this silent film has actually proved to be a very competent salesman. With the addition of sound, it would seem that the traveling salesman has a formidable competitor rapidly developing.

The reel is being shown on an Ampro Superlite, and, as you will note, the picture almost completely fills the fourteen foot screen on the stage at a distance of about seventy feet from projector to screen. A standard 2 inch projection lens is used and the current is drawn from the house line at 110 volts, for a 250 watt lamp.

While the illumination does not measure up to professional projection, you will note that the little brother of the 35 mm. projector is keeping pace in this fast moving industry, to the cry of better and larger pictures.

A NEW POWER AMPLIFIER SYSTEM

LINCOLN THOMPSON*

The two characteristics of the thermionic amplifier tube which have given it unique supremacy over any other amplifying device have been its ability, first, to amplify signals without appreciable distortion, and, second, to amplify signals without requiring any appreciable energy from the signal source. The latter feature is due to the ability of the grid to control the flow of electron current from the filament to the plate without taking any material current itself. When the grid potential is more negative than that of the filament, no electron current flows into the grid, but when the grid potential is positive, part of the electron stream enters the grid. Consequently, in order that no appreciable energy shall be consumed in the grid circuit, amplifier tubes have usually been operated with their grids more negative than the filaments.

When operated under these conditions, the input impedance of well-evacuated power tubes is of the order of many millions of ohms at the audio frequencies to be considered, but with the grid positive, the input impedance drops to the order of several thousands of ohms. It is obvious that such a tremendous change in input impedance would usually seriously distort any signal swinging from the negative grid region into the positive region and, consequently, the signal swings have been entirely confined to the negative region in conventional amplifiers. Conventional tube design has therefore been directed toward obtaining the optimum characteristics for distortionless amplification in this region. One of the main considerations involved has been the maintenance of a linear relation between the magnitude of the input signal and the amplified output signal. This requires a straight line relation between the grid voltage and plate current and the familiar grid voltage-plate current characteristic of practically any good amplifier tube exhibits some portion which very closely approaches a straight line. The class of tubes of lower amplification

* Wm. H. Bristol Talking Picture Corp., Waterbury, Conn. (Read before the Society at Washington.)

constant have this straight line portion in the negative grid region, while with tubes of higher amplification constant this portion is usually displaced toward the positive grid region. Consequently, power tubes designed for use in conventional amplifiers are of the low amplification constant type, because they are expected to furnish maximum possible undistorted output, this being only attained when full usage is made of this straight line portion of the grid voltage-plate current characteristic.

It is obvious that tubes of higher amplification constant make just as good power amplifiers as those of lower amplification constant, as far as the straight line portion of this characteristic is concerned, provided they can be operated either with less negative bias or even with positive bias. In the system to be described, tubes of relatively very high amplification constant are used as power tubes and they are operated at zero or positive biases.

These tubes of high amplification constant have two advantages: first, that of greater gain, and, second, that of a higher output impedance. In order to illustrate these facts, the conventional 250 tube will be compared with a tube of the same mechanical size used in this new system and designated as the 530. The main difference between these tubes is that the 530 has a finer grid structure and, consequently, a higher amplification constant.

At zero grid and 450 volts on the plate, the plate current of the 530 is about 55 milliamperes, the same as the 250 at 84 volts negative. The amplification constant of the 530 is 19, while that of the 250 is 3.8 and the plate impedance of the 530 is 6000 ohms at zero grid and 450 volts on the plate against 1800 ohms for the 250 at normal bias and a plate voltage of 450. The mutual conductance of the 530 is 3200, while that of the 250 is only 2100, due to the fact that the plate impedance of the 530 at zero grid is lower than if it were biased. The grid voltage-plate current characteristics of the two tubes are shown in Fig. 1. Due to its higher mutual conductance, the 530 is steeper than the 250, but otherwise the curves are exactly similar, excepting that the 530 is displaced toward the positive grid region.

The available plate current swing of the 250 in either direction is the same as the 530, namely, 55 milliamperes. Therefore, it is evident that, with the same plate current swing available from each tube, the available power output from the plate circuit will be in the ratio of their output impedances, or about $3^1/_3$ times greater with the 530, other factors being equal.

However, if any tube is operated at zero grid, it is obvious that, unless some special system of operation is devised, distortion will occur. When the signal swings positive, grid current will flow, tending to reduce the signal voltage, while, when the grid swings negative, no grid current will flow and the signal voltage will be unaffected.

This distortion practically amounts to rectification and is extremely unpleasant to the ear.

However, by interconnecting two matched tubes, according to Fig. 2, it is obvious that, when an applied signal swings positive,

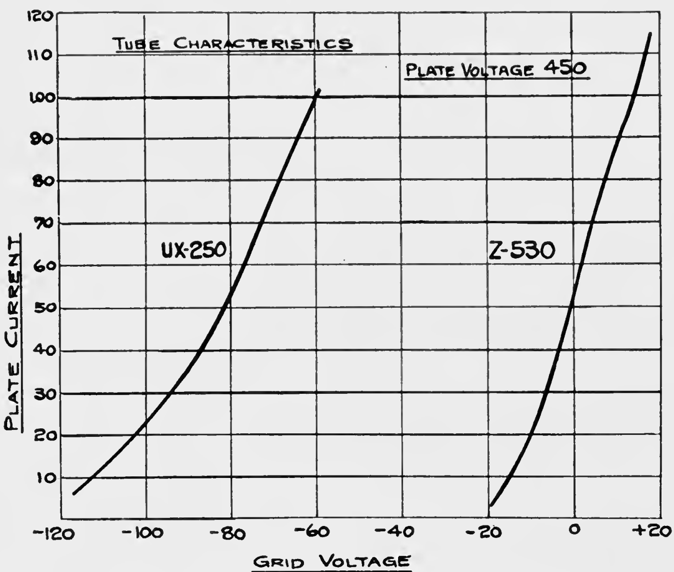

FIG. 1. Grid voltage-plate current characteristics of UX-250 and Z-530 tubes.

current flows in the grid circuit of tube *A*, since the grid is positive with respect to the filament, but not in the grid circuit of tube *B*, since the grid is negative with respect to its filament; but when the signal swings negative, current flows in the grid circuit of tube *B* and not in that of tube *A*. If the grid current-grid voltage characteristics of the two tubes are matched, equal positive and negative swings of the signal will produce equal flows of current in each grid circuit, and the reflected load on the signal source for the positive pulsation will be equal to that for the negative pulsation. Consequently, the positive and negative half cycles of the signal are subjected to equal conditions.

If the grid voltage-grid current characteristics for each tube were a straight line starting from zero, it is evident that the combined grid circuits would function like a pure resistance. In other words, equal positive and negative pulsations would not only cause equal flows of grid current, but a linear relation would exist between the amplitude of the signal voltage and the grid current produced by it.

In the design of the tubes for this system, it was therefore neces-

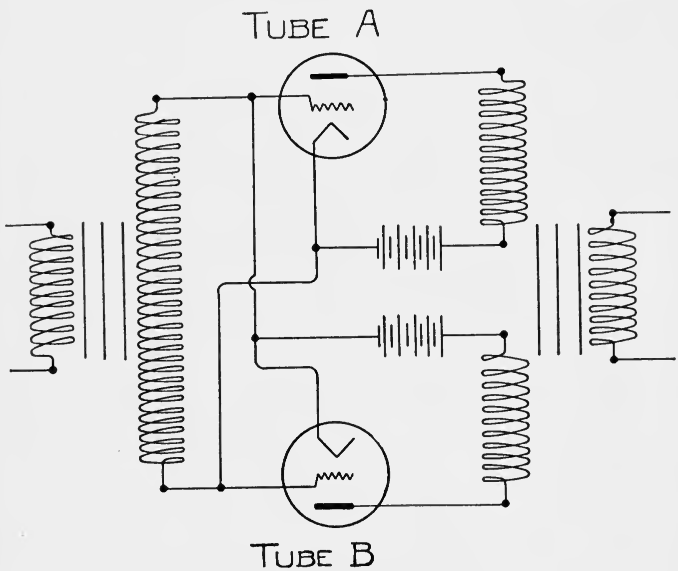

FIG. 2. Circuit containing two matched tubes.

sary to produce as nearly a straight line grid voltage-grid current characteristic as possible.

The structural constants of the tube, such as plate-to-grid spacing, grid-to-filament spacing, grid surface, and grid material, affect the shape of this curve due to their effect on secondary emission from the grid. When secondary emission occurs, secondary electrons are being ejected from the grid by the primary electrons from the filament. If this velocity of ejection is sufficiently great to project them into the region where the electrostatic field of the plate is stronger than that of the grid, they add to the stream of electrons entering the plate. The net grid current under these conditions is represented by the difference between the primary electrons entering the grid and the secondary electrons which join the stream to the plate. Consequently, secondary emission influences the net grid current considerably and is a powerful factor in determining the shape of the grid voltage-grid current curve. Excessive secondary emission may produce a curve like that of curve *A* in Fig. 3, which shows a point where the rapid increase in secondary electrons causes the net grid current

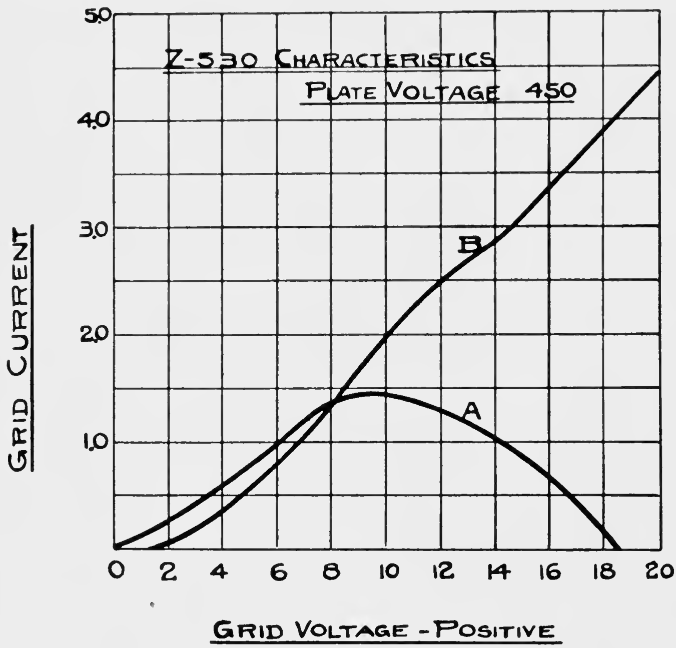

FIG. 3. Grid current-grid voltage relation for Z-530 tube.

to decrease as the potential is increased and, finally, the secondary electron current equals and exceeds the primary electron current, reversing the direction of the net current. Curve *B* shows a standard 530 and it will be noted that the curve is quite straight except for a slight hump. Tubes with no secondary emission from the grid tend to give curved characteristics following something between the classic 3/2 power law and a square law, but carefully controlled secondary emission from the grid serves to straighten the characteristic. Another important factor in the lower part of the curve toward zero grid is the filament voltage, a lowered filament voltage causing a straighter curve. Since zero grid is referred to the negative end of the filament, the grid will not be positive with respect to every part of the filament until its potential exceeds the voltage drop across the filament terminals. This produces a long curved portion in the grid voltage-grid current characteristic which is shortened by decreased filament voltage.

As a result the standard 530 has a 3.5 volt, 2.5 ampere filament instead of the 7.5 volt, 1.25 ampere filament of the 250. Further experimental work will probably lead to tubes with even better straight line characteristics.

It is obvious that this "pure resistance" characteristic can deviate some from the ideal, but feeding from a lower impedance signal source will make the deviations negligible. The average grid impedance of the combined circuit of the tubes mentioned is about 4000 ohms, and the tubes of the order of the 201A or 112A will feed it nicely, although the coupling transformer should step down instead of stepping up.

In view of the fact that the coupling transformer steps down instead of up, the high gain in the output tubes themselves a little more than makes up for the step-up which is usually obtained with a negatively biased tube in a conventional amplifier. However, the advantage of the greatly increased power output is still maintained.

It is also evident that the same inherent advantages obtained in push-pull are obtained, such as balancing out of the even distortion harmonics, balancing out of plate currents in the output transformer, *etc.* Also it will be noted by referring to Fig. 1 that the useful straight line portion of the grid voltage-plate current characteristic extends far into the positive region, and even though the negative pulsation reaches sufficient amplitude to be cut off in the one tube, at this same instant this same pulsation may still not exceed the limits of the straight line portion on the positive side of the other tube, thus allowing for a kind of semi-distortion for extremely large signals beyond the allowable undistorted output.

It is usually desired to use two matched tubes for this system, but it would be possible to substitute for one of the tubes a unilateral device whose voltage-current characteristic matches that of the grid voltage-grid current characteristic of the tube. The combined input circuit would then function just as with two matched tubes, but the output would only be that of the one tube, the unilateral device only serving to give the desired "pure resistance" characteristic to the input circuit. Since there are many obvious advantages to using a pair of matched tubes, the development of this phase of the system has received little attention.

There have been many interesting problems involved in the development of this system, and experiments indicate that the fullest possibilities of the system have not as yet been realized. However, complete commercial systems involving the amplification of sound with this system as a nucleus have been developed. Systems for recording and reproducing both on disk and film have been put into practical use, and public-address systems, announcing systems, sound-distribution systems, and the like, have been designed.

DISCUSSION

PRESIDENT CRABTREE: Where are the tubes available?

MR. THOMPSON: They are made specially for us, and we, of course, market them ourselves. We have marketed them with the amplifier only.

PRESIDENT CRABTREE: How many tubes are used in the amplifier?

MR. THOMPSON: This one has three leading stages not operated according to this system but without any negative bias between the grid and filament. The final power stage operates according to this system, there being five amplifier tubes in all.

MR. TAYLOR: I am interested to know what the weight of the apparatus is that you have here and to what degree is it portable? How many pieces constitute this demonstration and about what do they weigh?

MR. THOMPSON: The pieces that constitute the apparatus described in Mr. Bristol's paper are: first, the projector which weighs 30 lbs. in its carrying case; second, the synchronizer attachment to the projector which weighs 10 lbs. and is carried in the turntable carrying case; third, the turntable which weighs 40 lbs.; fourth, the amplifier whose weight depends on the output required, the one demonstrated weighing 90 lbs., but having sufficient output even for large theaters; fifth, the horn whose weight also depends on the auditorium to be filled with sound, the one demonstrated weighing 70 lbs.

PRESIDENT CRABTREE: What is the maximum output?

MR. THOMPSON: The one here has an output of about 10 watts, but the limiting factor has been the last tube of the leading stages. A special tube designed for the requirements of this system is being built for this stage to overcome this, so as to exceed this output considerably.

MR. PALMER: I should like to ask Mr. Thompson whether this is all a.c. operated.

MR. THOMPSON: It is a.c. operated.

MR. ROSS: In view of the phenomenal additional amplification obtained, what is the comparative life of this new form of tube compared with the regular?

MR. THOMPSON: That is difficult to answer. We have had tubes in service for 500 hours and some for only 50 hours. The main difficulty at first was in getting tubes that were right to start with. Gas in the tubes was the main difficulty. With good tubes to start with, there is no reason why the life should not be the same as the corresponding tubes in conventional use.

MR. ROSS: Due to the requirement of matching the tubes does the change in the characteristics of any element of a tube introduce distortion of the signal during amplifying?

MR. THOMPSON: The characteristics we are most interested in are the grid voltage-grid current curve. Tubes can vary within very wide limits in other respects, but the grid current-grid voltage remains very constant.

SCANNING LOSSES IN REPRODUCTION

N. R. STRYKER*

In the photographic reproduction of sound there are unavoidable losses related to the speed with which the film is moved. For high quality reproduction, these losses must be reduced to within tolerable limits. In the first place, it is not possible to lay down on the sound track a line of light which is infinitely narrow. Furthermore, it is difficult to adjust the line of light so that it is normal to the direction of travel of the film. The first of these losses results from what may be called the *image width effect* and the second the *azimuth effect*. The following discussion chiefly concerns the variable density method. It also applies to the variable area method so far as the image width effect is concerned, but does not apply strictly as regards the azimuth effect.

Both theoretical and experimental curves are presented showing the magnitude of these two effects and the influence of combined image width and azimuth effects under what correspond to normal operating conditions are discussed. It is shown that for the image width normally employed for the reproduction of sound from film the quality of reproduction need not be affected appreciably and that if the azimuth error is kept within reasonable limits only a negligible loss in quality results. It is also shown that if optical systems of proper design are employed, the losses which are indicated theoretically correspond very closely with those obtained in practice. From this the deduction may be drawn that optical systems need not contribute appreciably to loss of reproduced quality. The experiments, for which data are given, were made on standard Western Electric apparatus.

The image width effect is one which under various forms is fairly well known. It is essentially what is known in television and telephotographic systems as the aperture effect. The derivation of a formula indicating the departure from linearity due to the image width effect is relatively simple. Briefly, the image width effect results

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in a loss of reproduction which increases in magnitude as the frequency is raised until complete extinction of the reproduced wave occurs. At higher frequencies transmission again occurs to a moderate degree. The loss of efficiency at any particular frequency, f, may be expressed in terms of the ratio of that frequency to the extinction frequency, f_o, and consequently the latter must be kept high. The extinction frequency is obtained by dividing the velocity of travel of the film by the width of the reproducing image. For standard practice this would correspond to 18 inches per second divided by 0.001 inch which gives 18,000 cycles per second. The amplitude distortion is mathematically described by a factor equal to $\frac{\sin x}{x}$ where $x = \pi \frac{f}{f_o}$.

The optical system referred to is shown in Fig. 1, and consists of

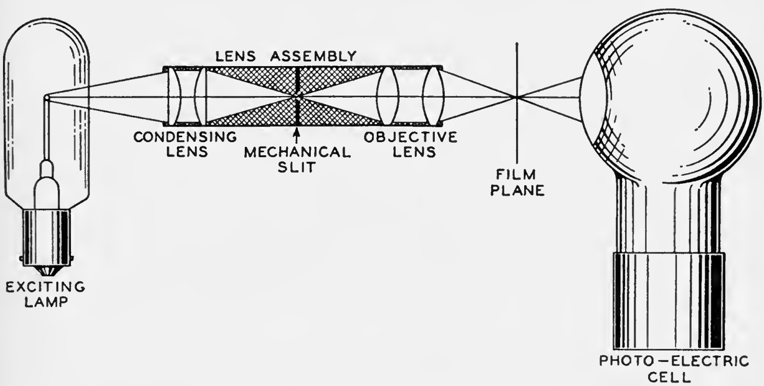

FIG. 1. Diagram of optical system for sound reproduction.

a lamp, condensing lens, mechanical slit, objective lens, the film, and a photo-electric cell.

The theoretical loss due to the image width effect is shown in Fig. 2. A decrease in amplitude progressively with increasing frequency is to be noted. When converted into decibels the loss, as shown, increases with increasing frequency at first slowly and then more rapidly.

Fig. 3 shows the image width effect for various widths of image from 0.000 inch to 0.005 inch. Attention should be centered, of course, on the curves for image widths of 0.002 inch or less, since for these image widths the losses in the commercially important high frequency range are not excessive.

The azimuth effect can practically never occur without some accompanying image width effect. However, where the image width employed is made relatively small but the image not normal to the direction of film travel, the azimuth effect would be controlling and may therefore be considered separately. It will then be shown that the total loss in decibels resulting from the simultaneous presence of these two effects is the sum of the two losses in decibels.

When the reproducing image is tilted so that at one side of the sound track it lies a certain distance above its position at the other side of the sound track, a resulting loss which will occur at high frequencies will be due to the fact that the image extends a finite amount in the direction of travel of the film. The loss of efficiency at high frequencies will be exactly the same as if no azimuth deviation existed

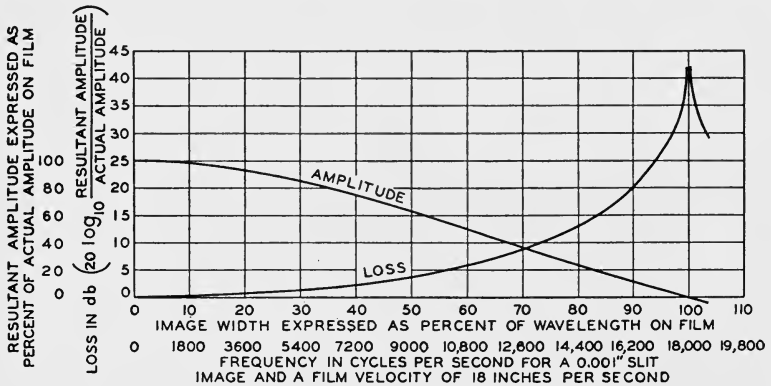

FIG. 2. Losses due to image width.

but the reproducing image had a width equal to the displacement of the image at one side of the sound track above its position at the other side of the sound track. The same charts and formulas which are used for computing image width effects may be used for computing azimuth effects, provided that for a given azimuth deviation across the entire sound track a loss be used corresponding to that for an image width of the same value. To prove this, refer to Fig. 4 where a narrow image, *A-B*, laid down obliquely is divided into smaller images, *a*, *b*, *c*, *d*, *e*, *etc.*, successively. Since the striations across the sound track are of uniform density, the current generated in the photo-electric cell by any one of these elementary images (for example, elementary image *a*) will be exactly the same as if this image were expanded so that its height (in the direction of the travel of the film) remained the same but its width became the entire width of the sound track as shown by the dotted lines. This assumes, of course, that the total illumination represented by image *a* before and after expansion remains the same. Proceeding in this manner, with all of the elementary images into which the sound track might be divided, the total current in the photo-electric cell will be that corresponding to an image covering uniformly the area, *A-B-C-D*, and having a total amount of illumination equal to that which the oblique image, *A-B*, possesses. The loss at various frequencies, due to azimuth deviations, must then be equal to that which would correspond to an equal width of the image if no azimuth variation were present. To illustrate, refer to

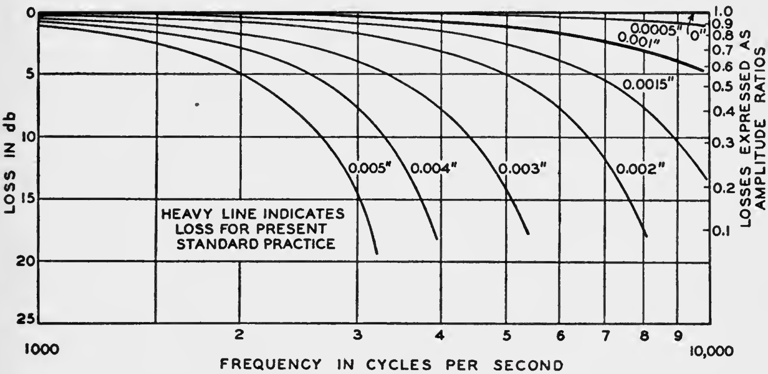

FIG. 3. Losses for various image width or azimuth deviations.

Fig. 3, where the loss at 6500 cycles due to a one mil image width is equal to 2 db. An image which has a total azimuth deviation of one mil but which is infinitely thin will also result in a loss of 2 db. at 6500 cycles relative to the volume of reproduction at very low frequencies. Mathematical proof is given in the appendix for the effect of azimuth variations and it is found to be of the form $\frac{\sin y}{y}$.

It has been stated that where both the image width effect and the azimuth effect occur simultaneously, as they must in fact do in practice, the loss of reproduction due to the two of them jointly will be the sum of the individual losses produced by each separately. This may be proved in the following manner: If an oblique image of appreciable width is divided up into a large number of successive oblique images each of very small width, the reproduction which results from each of these very narrow oblique images will be that which would result from a normal image of the same width modified by the factor which takes into account the loss due to the azimuth effect. The same process may be followed for each of the very narrow oblique images. The total reproduction obtained for the oblique image of appreciable width will be the sum of those obtained from the elementary images. The result is that the total loss due to an oblique image of appreciable width is that due to a normal image of the same width, modified by a factor which takes care of the loss due to azi-

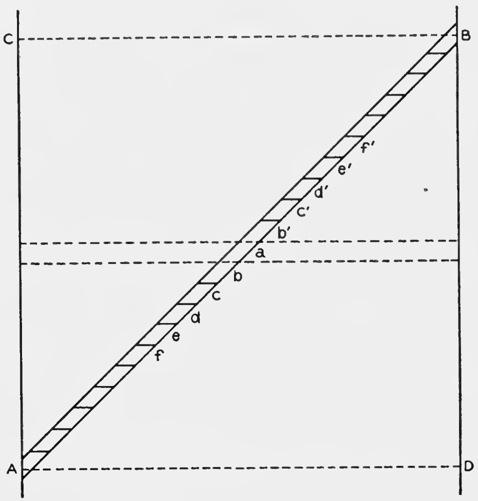

FIG. 4. Scanning image having negligible width and an azimuth deviation.

muth deviation. Hence the loss due to an oblique image of appreciable width is the sum of the losses due to the image width effect and that due to the azimuth effect. Mathematical proof given in the appendix indicates the total loss to be of the form, $\frac{\sin x}{x} \cdot \frac{\sin y}{y}$.

Figs. 5 and 6 indicate the loss resulting from azimuth deviations of from 0.000 inch to 0.002 inch for image widths of 0.0005 inch and 0.001 inch, respectively.

Experimental determinations of the losses introduced by the effect of image width have been carried out. Response measurements have been made from constant frequency films for image widths of various values ranging from 0.00025 inch to 0.0018 inch. Assuming a zero error in the adjustment of the optical system with respect to azimuth, Fig. 7 shows graphically both measured and theoretical values of loss for the various image widths employed in the test. The low fre-

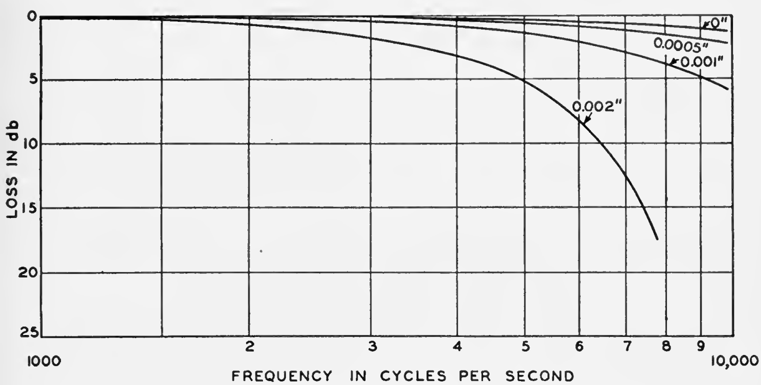

FIG. 5. Losses for various azimuth deviations for a 0.5 mil image.

quency response obtained with the use of a one mil image has been assumed to represent the reference level and the losses produced by the use of other optical systems, all having different image widths, are

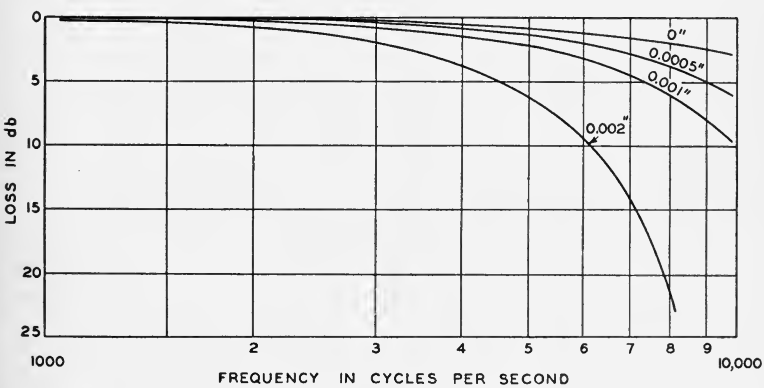

FIG. 6. Losses for various azimuth deviations for a 1 mil image.

plotted relative to the reference level. The probable error in the measurement of any image width is of the order of ±0.05 mil. It will be noted that the discrepancies between theoretical and actual losses are very small except in the case of the measurements for the

1.8 mil image width. In general the deviations are attributable to experimental errors from various sources. In the case of the larger discrepancy for a 1.8 image the difference is not assignable to any defect in lens systems because of the fact that the high frequency losses are smaller than theory would indicate. This discrepancy may be due either to the non-uniformity of the illumination across the width of the slit, thereby resulting in a smaller effective image width than that measured by the microscope or to the probable error in the measurement of the image width. It will be noted how rapidly the high frequency loss decreases as the image width is decreased.

In the same manner we have made experimental determinations of losses introduced by various assigned values of azimuth for a 0.001

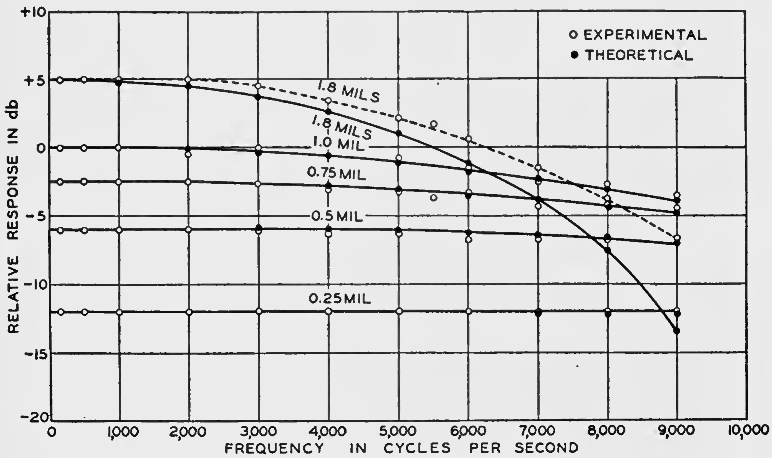

FIG. 7. Comparison of experimental and theoretical loss characteristics for various image widths.

inch image width as indicated in Fig. 8. The curves presented indicate losses introduced solely by azimuth deviations of amounts as indicated. It will be noted that experimentally determined values of loss agree very closely with those that would be expected from a purely theoretical consideration.

Fig. 9 indicates experimentally determined values of loss introduced by the effects of both image width and azimuth for a 0.001 inch image. These values are presented for various values of azimuth as indicated. It may be noted that the measured values of losses under these conditions of test agree very closely with those which might be expected from theoretical considerations.

In interpreting the above data a number of points are worthy of mention. In the first place, the signal strength is reduced by a reduction of the image width. It is therefore relatively more im-

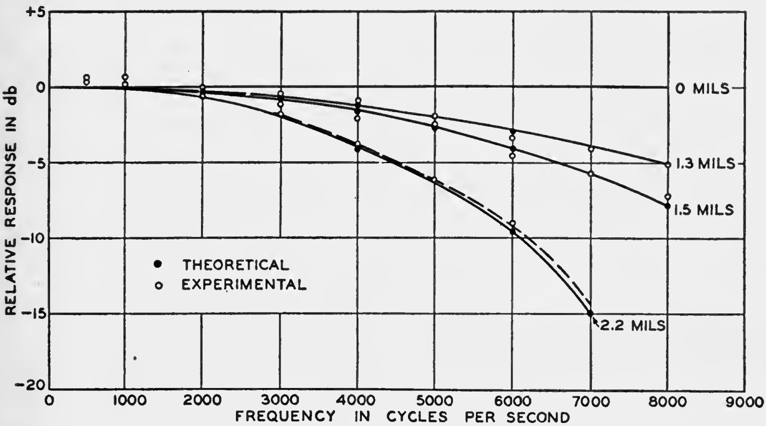

FIG. 8. Comparison of experimental and theoretical loss characteristics for various azimuth deviations.

portant with narrow image widths to have either a more brilliant light source, a more highly efficient optical system, or a more sensitive photo-electric cell. To a certain extent a loss of volume occurring at

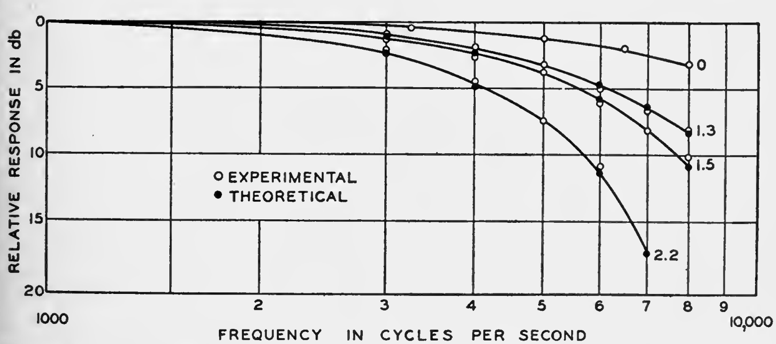

FIG. 9. Comparison of experimental and theoretical losses for combined effects of image width and azimuth (0.001″ image width).

one of these points in the system may be made up by altering another portion of the system, provided that in doing so the ratio of signal to noise is not reduced.

It should also be noted that the azimuth effect does not depend on the width of the sound track but upon the azimuth deviation. The azimuth effect for wide sound track is the same as for narrow sound track for a given disparity in the location of the two ends of the image in the direction of travel of the film. With a wide sound track, of course, a given angular deviation will produce a larger azimuth effect.

It should be noted that errors of azimuth adjustment in a recorder must be considered in relation to any existing error of azimuth in the reproducer. If an azimuth error should exist in the recorder of the same degree and direction as that present in the reproducer, its influence wil be canceled. If, however, the azimuth error recorded varies from that present in the reproducer, we have to deal with the summation or difference of these two errors.

SUMMARY

Experimental measurements of scanning losses under various conditions of test have indicated excellent agreement with those which would be anticipated from a theoretical study. Methods are given for computing the magnitude of the losses due to the image width effect and the azimuth effect. Charts showing such losses are also given. It is shown that for the width of image used in practice, the loss due to image width effect is relatively small; and that if azimuth deviations are kept within bounds which are reasonable, the loss due to the azimuth effect is small.

Finally, considering the unavoidable character of the losses resulting from the use of a finite image width, the conclusion is drawn that with proper design and adjustment, optical systems need not be responsible for an appreciable loss of efficiency at the higher frequencies within the range at present used for reproduction.

APPENDIX

Derivation of Formulas for Losses Introduced by Image Width and Azimuth

The width of the image may be defined as the geometrical image width or the width that is effective in producing definite frequency losses. If the image is uniformly illuminated, as in the case of the experiments described in this paper, the two definitions are synonymous. If, however, the image is not uniformly illuminated, it is of importance to know that portion of the image width which is effective in producing definite losses at particular frequencies. Therefore, the image width shall be defined as the width of the band of light at the film that is effective in producing a definite loss at a particular frequency. In practice, the effective image width is generally expressed in mils.

The azimuth is defined as the position of the axis of the image at the film plane with respect to a perpendicular to the direction of the film motion. When the image is correctly positioned the azimuth is zero. Azimuth may be expressed in degrees but it is more conveniently expressed as a deviation in mils.

The ratio of the amplitude of the light variation received by the photo-electric cell to the amplitude of the transmission of the film is the scanning loss. This loss is generally expressed in decibels, in which case it is 20 $\log_{10}$ of this ratio. The scanning loss depends upon the image width, the azimuth of the image, and the film velocity. We shall consider the effect of each separately.

1. *Effect of Image Width for Zero Azimuth.*—Fig. 1 graphically represents pure sinusoidal light transmission for a film having a constant amplitude, $O'D'$, at all frequencies, and traveling at a constant velocity in the illuminated image plane, $AA'BB'$.

The problem is to determine the ratio of the transmitted amplitude of the light incident upon the photo-electric cell to the amplitude of the film transmission.

For simplicity, the origin is chosen at the maximum amplitude of the cosine wave of film transmission.

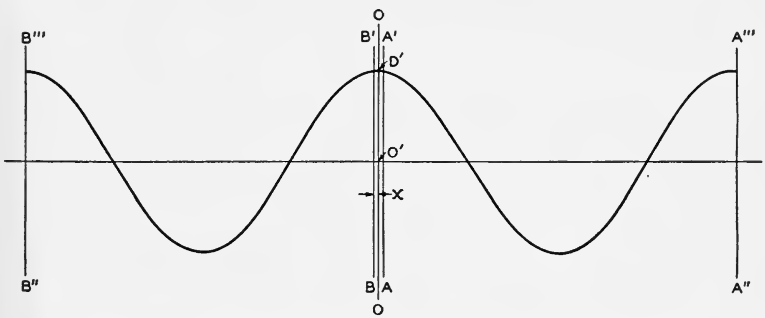

FIG. 1. Analysis of scanning loss effect of change in slit image width for zero azimuth.

$$Tr_f = K + Y_{max} \cos x \qquad (1)$$

in which Tr_f is the film transmission, Y_{max} is $O'D'$, the maximum amplitude, and K is a constant. Only the variable factor of equation (1) need be considered.

The image width is represented by the limits, AA' and BB', which vary from 0 to 2π and 0 to -2π, respectively, thereby covering two wave-lengths.

The average ordinate of an integrated area of a cosine wave is

$$Y_{av} = \frac{Y_{max}}{B-A} \int_A^B \cos x \, dx \qquad (2)$$

If $Y_{max} = 1$ and $B = -A = X$, then only one-half the wave need be considered and equation (2) becomes

$$Y_{av} = \frac{\sin X}{X} \qquad (3)$$

in which

$$X = \frac{2\pi f\beta}{v} \text{ and}$$

2β = image width
f = frequency
v = film velocity

Equation (3) then may be more conveniently expressed as:

$$Y_{av} = \frac{\sin \pi \dfrac{f}{f_o}}{\pi \dfrac{f}{f_o}}$$

$$f_o = \frac{\text{film velocity in inches}}{\text{image width in inches}}$$

in which f_o is the cut-off frequency and f any particular frequency. This equation holds for any particular image width and film velocity.

The reduction in the original amplitude in decibels is obtained from:

$$\text{Scanning loss in db.} = 20 \log_{10} Y_{av} \quad \ldots\ldots\ldots\ldots \quad (4)$$

Two interesting facts resulting from this analysis are that (1) the transmitted amplitude shifts 180 degrees in phase between each multiple of the wave-length at which infinite attenuation results; and (2) there is no change in the wave shape; or, in other words, no frequency distortion results.

2. Effect of a Change in Azimuth for a Fixed Image Width and Combined Effect of Image Width and Azimuth.—The method of analysis employed is illustrated by reference to Fig. 2, on which $AA'BB'$ is the area of the sound track of a theoretically perfect film of width, $2l$, traveling at a constant velocity past an image, $EE'DD'$, of width, 2β, having an azimuth, α.

Again the problem is to obtain the relative reduction of the transmitted amplitude of the light to the photo-electric cell, with respect to the amplitude of the film transmission.

The variable factor of the film transmission may be represented by

$$Tr_f = Y_{max} \cos px \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (5)$$

in which Y_{max} is the maximum amplitude, x the distance along the film and

$$p = \frac{2\pi f}{v}$$

in which v is the film velocity and f the frequency.

The procedure for determining the average ordinate of the transmitted light is to divide the expression for the total light transmitted by the film over that portion of the sound track exposed by the area of the image.

The total light transmitted through the film over the slit area is

$$Tr_t = Y_{max} \int_{-l}^{+l} \int_{x - \beta \sec \alpha}^{x + \beta \sec \alpha} \cos (x + y \tan \alpha) dxdy \quad \ldots\ldots \quad (6)$$

since $DD' = EE' = 2\beta \sec \alpha$ and $FD = y \tan \alpha$. x in the integrand of equation (6) is measured from a moving origin whose locus is the middle of the oblique image shown in Fig. 2.

Then upon the first integration,

$$Tr_t = \frac{2Y_{max}}{p} \int_{-l}^{+l} \sin (p\beta \sec \alpha) \cos p(x + y \tan \alpha) dy \quad \ldots\ldots \quad (7)$$

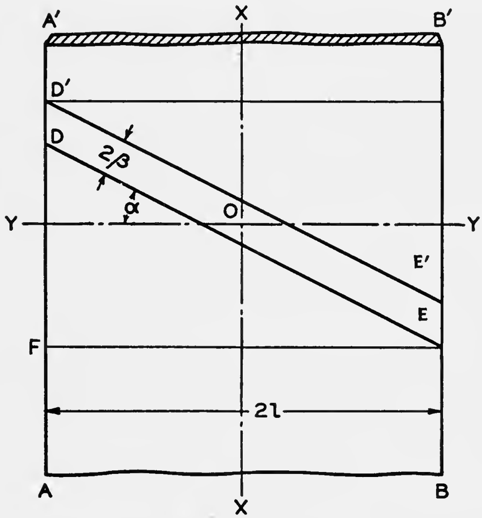

FIG. 2. Analysis of scanning loss effect of azimuth deviation.

and finally

$$Tr_t = \frac{4Y_{max} \sin(p\beta \sec \alpha)}{p^2 \tan \alpha} \cdot \sin (pl \tan \alpha) \cdot \cos px \ldots\ldots\ldots \quad (8)$$

Then the average transmission incident upon the photo-electric cell is

$$T_{av} = \frac{T_t}{A_s} = \frac{4Y_{max} \sin(p\beta \sec \alpha)}{p^2 \tan \alpha} \cdot \frac{\sin (pl \tan \alpha)}{2l \sec \alpha \cdot 2\beta} \cos px \quad \ldots\ldots \quad (9)$$

$$= Y_{max} \cdot \frac{\sin (p\beta \sec \alpha)}{p\beta \sec \alpha} \cdot \frac{\sin (pl \tan \alpha)}{pl \tan \alpha} \cdot \cos px \quad \ldots\ldots\ldots \quad (10)$$

The maximum amplitude of the transmitted light is then

$$Y_{av} = Y_{max} \cdot \frac{\sin x}{x} \cdot \frac{\sin y}{y} \qquad (11)$$

in which $x = p\beta \sec \alpha$ and $y = pl \tan \alpha$.

If $Y_{max} = 1$, then the scanning loss for an azimuth deviation of an image width of 2β is

$$\text{Scanning loss in db.} = 20 \log_{10} Y_{av} \qquad (12)$$

If the azimuth is zero, the third factor of equation (11), which is the azimuth factor, is unity and equation (12) reduces to equation (3). We shall therefore term the second factor of equation (12), the image width factor.

For very small angles, 0 degrees to 6 degrees, which covers the cases in which we are interested,

$$\sec \alpha = 1 \text{ and } \tan \alpha = \frac{\beta}{l}$$

$$\therefore \beta \sec \alpha = l \tan \alpha$$

$$\text{and } \frac{\sin x}{x} = \frac{\sin y}{y} \qquad (13)$$

Therefore, the image width factor is equal to the azimuth factor when the azimuth deviation, *FD*, is equal to the slit image width. In brief, the scanning loss for an azimuth deviation of a particular value is equal to that for an image width of the same value.

The author expresses his obligation to Mr. S. A. Schelkunoff of these Laboratories for assistance in the derivation of formulas given above.

DISCUSSION

MR. E. D. COOK: Mr. Stryker's paper is concerned primarily with reproduction and my earlier paper (*J. Soc. Mot. Pict. Eng.*, **XIV** (1930), p. 650) considers both recording and reproduction. The curves check my own work very well for reproduction only. This is as one would expect if the two analyses were correct. In recording, the aperture effect is also present and it is easily seen in the variable amplitude or width record. There is some introduction of harmonics as well as an alteration of the various amplitudes in the recording process but in the reproduction only the attenuation is present. These effects can be made negligible, and my only point in bringing it up was that it had not always been negligible. In any designed system these effects can be compensated for. I am happy to find a close agreement between the two methods of analysis.

MR. TAYLOR: Two points strike me on this, one the practical and the other the academic. Why do you call this "azimuth?" I think that latitude is better than azimuth, but the committee on nomenclature may deal with this. The other point is the linear departure from normalism that counts rather than the angular departure. If you have a track 120 instead of 80 mils wide, you must be three times as careful about the parallelism of the film track.

MR. STRYKER: The term "azimuth" after some discussion has seemed satisfactory.

On a track 120 instead of 80 mils wide one would have to be 1.5 times as careful instead of 3 times as careful in the azimuth adjustment.

MR. KELLOGG: Mr. Cook brought up the point that in the variable area system, recording slit width may result in some wave-shape distortion not present from the same cause in the variable density system. That is true, but it is easy to over-exaggerate its importance. This wave-shape distortion is not serious below 3000 to 4000 cycles and most sound reproducing systems (apart from the photographic or optical losses) have dropped off so much in response for the first over tones of these frequencies (namely, 6000 to 8000 cycles) that it would take a careful aural test to find any evidence of the wave distortion.

The other reason for discounting the importance of the distortion mentioned is that the prediction of wave form distortion is based largely on the assumption that wherever there is any exposure at all the film is jet black. That was the case analyzed. If you assume that you are illuminating the slit with a definite rectangle of light which moves back and forth, and that wherever there is any exposure the image is jet black, you get serious losses and considerable wave-shape distortion for frequencies high enough to make the slit width equal to a quarter wave-length or more. On the other hand, if there is the least tapering off of the exposure—if the cutting edge of the light spot is soft, for example, or if the lighter exposures result in gray instead of black areas, the wave-shape distortion goes down very rapidly. With films developed to give a gamma product of unity, the wave-shape distortion due to recording slit width disappears entirely and the high frequency loss takes the value given by Mr. Stryker's formula. Only with very high contrast is the additional loss appreciable. We do use high contrast in variable area recordings, and we justify it by the fact that the distortions are of very minor order of magnitude.

MR. E. D. COOK: It has not been my contention that these points will unsettle the industry. I have on other occasions pointed out that both the introduction of harmonics and the alteration of the amplitudes in the recording process can be minimized, or at least put in parts of the frequency range which are not so essential. The phenomena discussed do occur however and the fact that if apertures are used which are truly only $^1/_2$ mil in width, these effects may be practically neglected in the final result, does not render the analysis valueless. It is regretted that it is necessary to idealize the problem in order to make it amenable to mathematical treatment but this is usually the case in practical problems. The facts discussed by Mr. Kellogg are granted but an analysis which would include these effects would not yield enough fruit to warrant the additional work assuming that the solution were possible. The analysis made on the assumption of complete exposure wherever light strikes the film at least gives a superior limit to the distortions involved. It is hoped that this statement will completely clarify my previous statements in this matter.

A MOTION PICTURE MADE IN 1916 BY A TWO-COLOR SUBTRACTIVE PROCESS

GLENN E. MATTHEWS*

The working principle underlying the two-color process known as *Kodachrome* is the use of a tanning bleach for treatment of the duplicate negative, which removes the negative image and differentially tans the area where the image existed. When the film is treated subsequently with dyes capable of dyeing soft gelatin, a positive dye image is produced.[1]

This tanning bleach effect was first observed accidentally by J. G. Capstaff about 1910 when engaged in experiments to find a method of making carbon prints without recourse either to artificial light or to daylight in order to tan the bichromated gelatin tissues. In the course of his work, a darkroom safelight was required and he decided to make one by dyeing a waste plate. Not having one handy, he used an old negative plate, which he bleached, washed, and immersed in the dye solution. On examining the plate he was greatly surprised to observe that it showed a dye image. No further use was made of the observation, however, until several years later, after he had joined the staff of the Kodak Research Laboratory.

Experiments on the Kodachrome process were initiated by Mr. Capstaff in the fall of 1913, using glass plates as the preliminary materials with which to work out the details although from the beginning the process was regarded as one to be developed for color cinematography. So successful were these experiments that, in the fall of 1914, exhibits of color portraiture on plates were sent to London and to the Panama Pacific Exposition in San Francisco. Examples of the process were first shown publicly during the month of November, 1914, at the Memorial Art Gallery, Rochester, N. Y.[2] Besides its use for portraiture, Kodachrome attracted the attention of the medical profession as a process especially adapted to photography of pathological specimens. Dr. N. T. Beers, a prominent Brooklyn surgeon,

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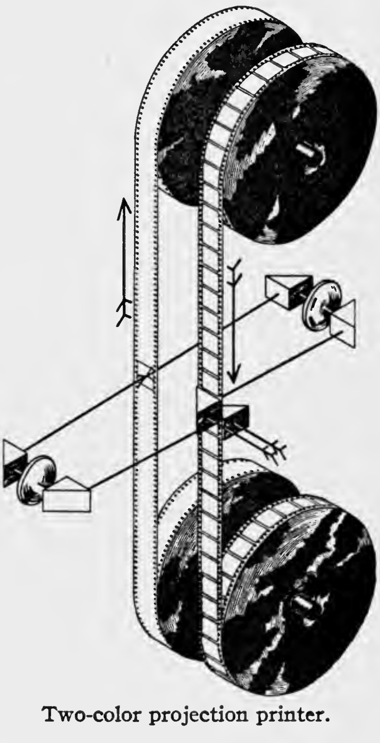
* Research Laboratories, Eastman Kodak Co., Rochester, N. Y. (Read before the Society at Washington.)

has made many fine color transparencies with the process during the past fifteen years.

Early in 1915, the first experiments were started to work out the adaptation of the process to motion picture photography. A three-color camera was made over into a two-color camera using twin lenses for exposing the film, two pictures at a time, through green and red filters, the pull-down moving two frames each time.

The method of printing[3] consisted in printing negative images from a master positive on opposite sides of a double coated film by means of an optical printer, a rough sketch of which appears in the figure. The duplicate negative was then bleached in a tanning bleach, cleared, and dyed with dyes complementary to the dyes used in the camera filters. The developing and dyeing equipment was of the crudest sort for these first experiments, and considering this fact, the quality of the pictures obtained at that time was remarkably good.



Two-color projection printer.

After the preliminary tests had been made on the process during 1915, it was decided to test the practical value of the method by actually photographing a motion picture story. Incidentally it was considered that this would reveal the weaknesses of the process as well. Miss Sylvia Newton prepared a scenario and the scenes were "shot" on the roof of the Laboratory and in Mr. Eastman's garden. Outside of the film and laboratory labor, the cost of the production was about zero. It is believed that this picture is the first motion picture story to be photographed by a two-color subtractive process. Gaumont and Urban had, of course, made pictures by additive processes previous to that time. The date of the production, July, 1916, is established by a date on an actual letter written by request which appears in the first part of the picture.

The cast of characters in the picture which was called "Concerning $1000" was as follows:

A promising young inventor	H. L. Halburt
His sister	Sylvia Newton
A friend	Doris Long
A child	Doris Mees
The father	Dr. C. W. Frederick

The results were naturally crude considered in the light of quality of present day color pictures, but are historically interesting as an example of an early color process. It may be noted in passing that one member of the cast has since married and is the mother of two grown children, whereas another member, the child, is now ready to enter the university.

Note.—The original two-color subtractive print (about 600 feet long) was shown at the conclusion of the paper.

REFERENCES

[1] U. S. Pat. 1,196,080, applied for Sept. 21, 1914.

[2] *Brit. J. Phot. Color Supp.*, **9** (Jan. 1, 1915), p. 3. See also note in *Brit. J. Color Supp.*, **8** (December 4, 1914), p. 48.

[3] U. S. Pat. 1,478, 599, applied for Sept. 21, 1914.

A REPLENISHING SOLUTION FOR A MOTION PICTURE POSITIVE FILM DEVELOPER*

J. I. CRABTREE AND C. E. IVES

The successful operation of a motion picture laboratory depends very largely on its ability to produce prints of uniformly good quality. Such prints can be produced only by maintaining constant the various factors which control the exposure and degree of development of the image, and of these the developing power of the developing solution is, perhaps, the most difficult to control.

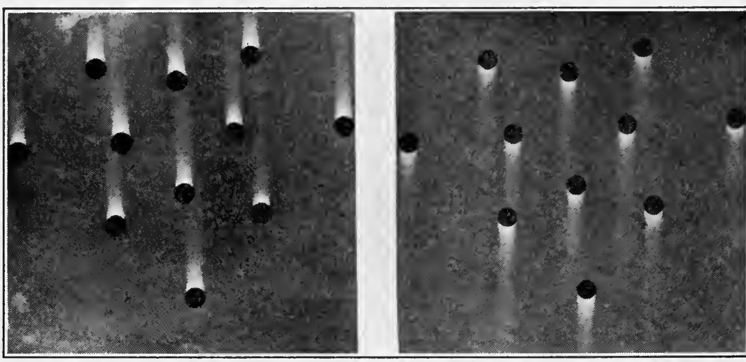
Effect of Exhaustion of a Developing Solution.—A developing solution usually consists of four essential ingredients: the developing agent, sodium sulfite or bisulfite, a suitable alkali such as sodium carbonate, and a suitable restrainer such as potassium bromide. The chemical reactions involved in converting the exposed emulsion grains to metallic silver are somewhat complicated but can be represented by the following scheme.

Emulsion (Silver bromide and silver iodide) + Developing Agent + Sodium Carbonate	=	Metallic Silver + Oxidation Products of Developing Agent + Sodium Bromide + Sodium Iodide + Sodium Bicarbonate

The purpose of the sodium sulfite or bisulfite is to protect the developing agents from oxidation by the air, since the air tends to attack these compounds, converting them to the inert substance, sodium sulfate, in preference to attacking the developing agent. Some of the sulfite is also used up in combining with the oxidation products of the developing agent to form sulfonates[1] but, in view of the relatively

* Communication No. 437 from the Kodak Research Laboratories. (Read before the Society at Washington.)

large quantity of sulfite which is usually present in a developer, the quantity used up in this manner during the useful life of the developer is relatively small. Also, only a small proportion of the total quantity of the carbonate is used up in the chemical reactions involved. This is probably changed to bicarbonate which, in turn, exerts a restraining effect upon development. In the case of an elon-hydroquinone developer, the oxidation products are usually colorless so that the color of the developer is not necessarily an indication of the degree of exhaustion of the developer. These products restrain development in a manner similar to potassium bromide but also have the property of preventing aerial fog[2] and when present in small quantities are therefore beneficial. It is somewhat anomalous that



Wetted Dry

FIG. 1. Showing restraining effect of developer exhaustion products migrating away from image.

aerial fog should be produced while the developer is being oxidized in contact with the film and that the oxidation products, when added to a fresh developer, should prevent aerial fog. Apparently, the aerial fog is produced by an intermediate oxidation compound which may be a powerful reducing agent.

The essential changes going on in a developer during use therefore consist of a depletion of the developing agents and the accumulation of restraining products, namely, developer oxidation products together with sodium bromide, sodium iodide, and sodium bicarbonate.

The restraining effect of the developer reaction products is clearly shown in Fig. 1. This picture was obtained as follows. A number of holes were punched in a sheet of black paper which was used as a negative to expose two sheets of film. The films were then slightly fogged and afterward both were developed in a tank while held stationary. One of the films was soaked in water previous to development. In the case of the dry film the reaction products of development which were heavier than the surrounding developer gravitated downward and restrained the development of the fogged area immediately below the black circles thus producing white streaks. In the case of the wetted film, the reaction products diluted with water had a lower specific gravity than that of the developer and therefore traveled upward, producing streaks above the black dots.

A similar effect occurs during the development of any photographic image at the junction of a shadow and a highlight and is often apparent in the print as a white line around an object. This is known as a "Mackie line." The effect is more noticeable in the case of fully exposed films developed for a short time and tends to disappear with full development. Agitation will largely prevent it.

It is very important to get a clear conception of the effect of the developer reaction products on the nature of the developed image. It is well known that potassium bromide restrains development and has an effect similar to that produced by decreasing the exposure. An old developer contaminated with developer reaction products is therefore incapable of getting the maximum out of an underexposure so that films developed in an old developer appear relatively underexposed.

The magnitude of the effect produced by the accumulated soluble halides, such as sodium bromide and sodium iodide, depends upon the nature of the original developer formula. Developers having a high reduction potential, such as those compounded exclusively with elon, are more resistant to the effect of restraining agents than those having a lower reduction potential, such as developers containing only hydroquinone.

Ordinarily, an elon-hydroquinone-sodium carbonate developer, as used for motion picture positive film, normally requires the addition of a little potassium bromide to prevent fog. If the bromide is omitted in the first place, the developer is apt to give fog but the fog disappears as the developer is used and the rate of development of the image decreases somewhat. A slight increase in gamma for a constant time of development may result from this decrease in fog and it is common practice to process a little waste film in the freshly prepared developer or to admix as much as 10 per cent of old developer with the new in order to overcome the "rawness." These expedients are not necessary if the developer formula is properly compounded.

In the case of developers containing a considerable quantity of sodium carbonate, the slight depletion of this as indicated by the chemical reactions above is not noticeable during the early stages of the life of the developer. In a previous communication[3] it has been shown that some very mildly alkaline developers are quickly deprived

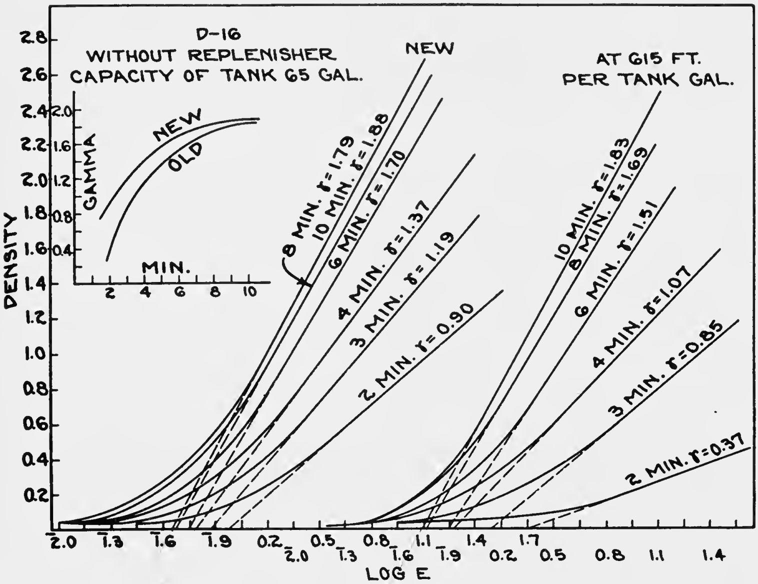


FIG. 2. Characteristic curves showing the performance of D-16 developer before and after exhaustion without the use of replenisher.

of the necessary alkali during use, and modified formulas have been given which, by means of their buffering effect, maintain any desired low alkalinity together with a considerable reserve of alkali.

The effect of exhaustion on the rate of development as indicated by a change in gamma for a constant time of development is clearly shown in Figs. 2 and 3. From the H & D curves and the gamma-time curves in Fig. 2 it is seen that exhaustion of the D-16 developer largely affects the rate of development. The effect of exhaustion on low densities, gamma, fog, and speed is shown in Fig. 3.

During the early stages of exhaustion, gamma increased slightly and when developing for 6 minutes the gamma changed from 1.7 to 1.5 after exhaustion with 600 feet of film per gallon, and for a development time of 3 minutes the change was from 1.2 to 0.8.

The greatest effect of exhaustion is noticeable in the case of the

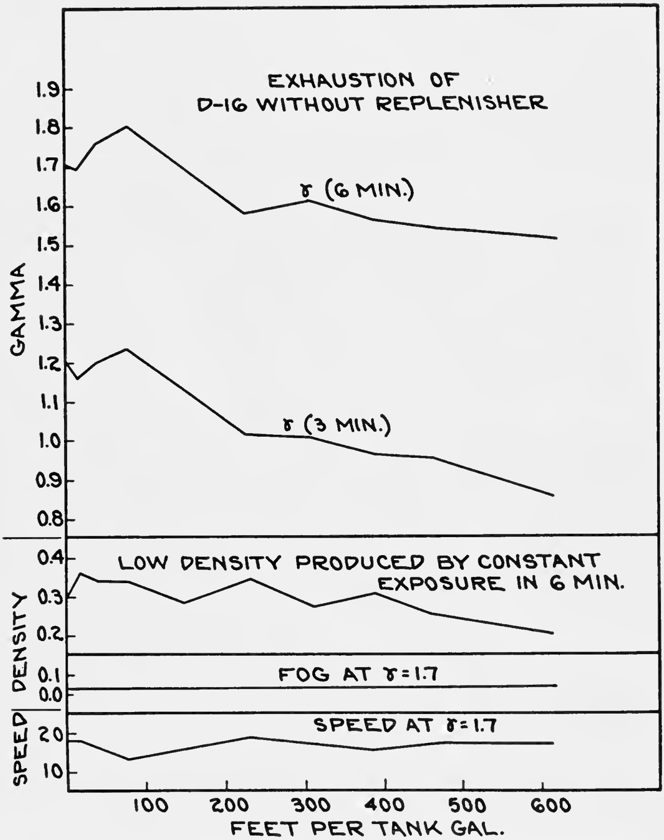


FIG. 3. Curves showing change in performance of developer when exhausted without the addition of replenisher.

lower densities. For example, when developing for 6 minutes a density of 0.4 dropped to less than 0.2 after exhaustion. There was no noticeable change in fog during exhaustion because the fresh developer was relatively free from fog. The speed at a gamma of 1.7 likewise did not change greatly during exhaustion but in practice the speed of positive film is governed by the exposure necessary to produce a definite density in a fixed time of development which is obviously affected by exhaustion.

Curves which indicate the behavior of the developer during use with the addition of replenisher are shown in Figs. 4 and 5. From these it is seen that for all practical purposes the properties of the developer were maintained constant during its useful life.

Revival of Developer.—In order to offset the gradual loss of developing power with use, the time of development may be increased or the

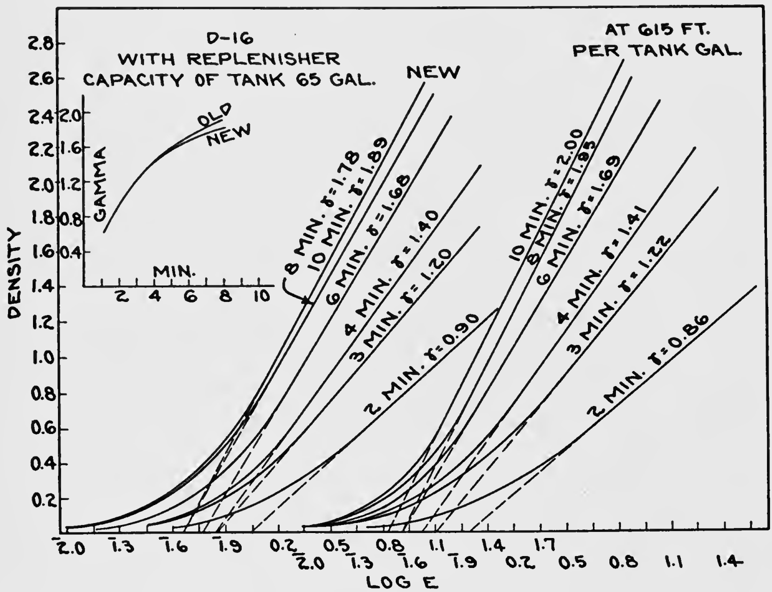


FIG. 4. Characteristic curves showing the performance of developer before and after processing 600 feet per gallon with use of replenisher.

temperature of the developing solution raised, but these adjustments are not desirable and beyond a certain degree are ineffectual and dangerous. After the developer has become exhausted to such an extent that the time required to produce a given gamma or degree of contrast has increased by 25 per cent or more above that required by the new bath, the quality of the picture produced by this increased time of development is likely to be very different from that produced by the fresh bath. For instance, when a developer is exhausted without the addition of replenishing solution, it becomes necessary to give more and more exposure in printing in order to obtain a desired density even if the time of development is prolonged to give the correct contrast, while the color of the silver image is apt to become redder as a result of the presence of the excess bromide.

Two methods of revival are in general use:

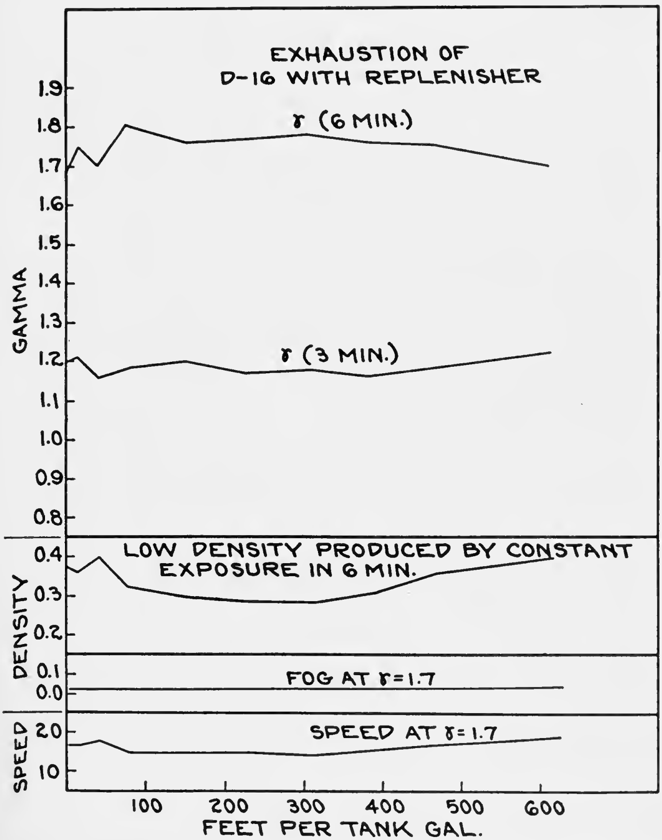


FIG. 5. Curves showing change in performance of developer with use when replenisher is added.

(1) More or less of the developing solution is continuously replaced with fresh developer of the same composition as the original formula. In some laboratories the developer is circulated through a large auxiliary or storage tank and a certain proportion of the total volume is replaced at intervals with fresh developer. In other cases, fresh de-

veloper is allowed to flow into the developer tank near the point at which the undeveloped film enters, and the waste developer overflows where the film leaves the developing solution. This scheme is advantageous because experiments have shown that if, in the case of motion picture negative film, development is started in a perfectly fresh developer so that shadow detail just begins to appear, then development can be continued in a relatively exhausted developer without loss of shadow detail.[4] In other words, once the detail has appeared, the old developer is capable of building up the density.

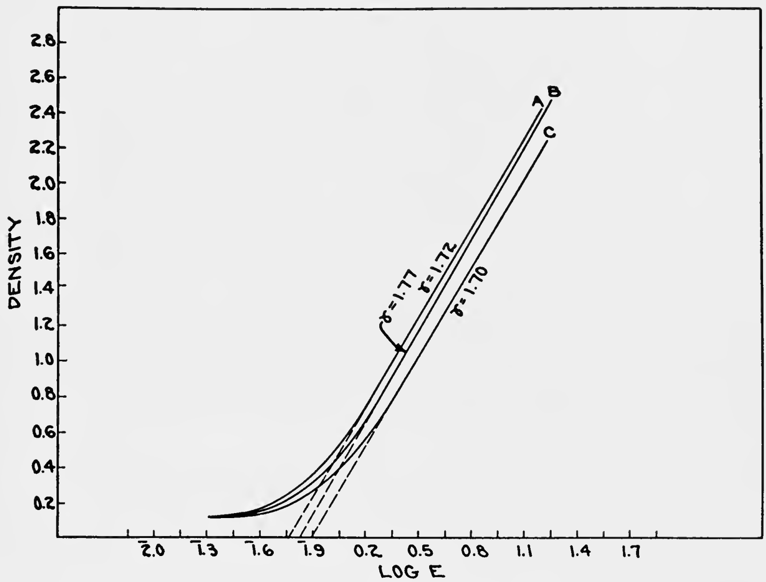


Fig. 6. Curves showing the effect of exhaustion of developer on emulsion speed.

This system is not quite so advantageous when developing motion picture positive film as shown in Fig. 6. Curve *A* was obtained by developing motion picture positive film in fresh D-16 developer to a gamma of 1.72. Curve *C* was developed to approximately the same gamma in the developer exhausted with 600 feet of positive film per gallon and the speed loss is very apparent. Curve *B* was obtained by developing in the new D-16 developer for 2 minutes and then placing in the old D-16 solution for 6 minutes. The speed loss as compared with a fresh developer is very slight indeed.

In most cases when handling positive film, the absolute speed value is of less importance than the securing of uniform prints by virtue of the maintenance of constant development conditions. For example, if the original developer was compounded without potassium bromide, it might be advantageous in machine processing to allow fresh developer to enter at the point where the film leaves the developer tank. In this way, when the film entered the first tank, it would come into contact with developer containing potassium bromide and developer reaction products which would reduce the effective speed of the film slightly but would be sufficient to prevent fog. The concentration of these reaction products could be kept constant by regulation of the influx of the bromide-free developer. In this way the cost of the bromide in the original developer formula could be saved.

(2) An alternative procedure is to revive the bath with a replenishing solution, the composition or concentration of which is different from that of the original developer.

The nature of the replenishing solution will depend upon the following factors:

(*a*) The nature of the original developer formula.
(*b*) The type of the emulsion developed.
(*c*) The quantity of silver halide reduced per unit length of film developed.
(*d*) The volume of developer carried out of the bath by the developed film and racks.
(*e*) The degree of contamination or dilution such as by desensitizing solutions.
(*f*) The degree of aerial oxidation produced during storage.

The quantity of silver halide reduced per foot of film varies according to the picture subject and the quality desired but the percentage which is reduced tends to become constant for quantities of several thousand feet.

For many reasons it is desirable to introduce the replenishing solution at a rate which is proportional to the quantity of film developed. In this case, the volume of liquid carried out of the bath by the film and racks will depend on the number of feet of film developed. With developing machines it is convenient to use automatic means for measuring the volume of liquid introduced,[5] although, if the quantity of developer in the entire system is large, the replenisher can be introduced in relatively small batches. With the rack and tank system, the introduction of small quantities of replenishing solution, in order to maintain at a constant level the volume of the bath contained in the work tank, takes place at a rate which depends directly on the quantity of film treated. If it becomes necessary to discard continuously a proportion of the circulating developer, this also should be done at a rate which is related to the quantity of film being treated. All other irregular losses of developer caused by leaks and similar factors should be reduced to a minimum because they interfere with any attempt to correlate the other factors. Likewise, conditions which cause contamination and dilution should be determined and remedied. Sometimes the developer becomes contaminated by foreign materials carried in by the developing racks. This can be minimized by the application of a nitro-cellulose lacquer to the racks and by the exercise of care in the washing process.

Nature of the Replenishing Solution.—From the above discussion of the chemical reactions which take place during development, it is obvious that in order to replenish a developer it is necessary to add more of the developing agents together with some alkali (carbonate) in order to offset the restraining action of the developer reaction products. Only enough sulfite need be added to maintain the concentration in the original formula while, of course, no bromide is necessary because the developer already contains enough anti-fogging ingredients.

In practice, the only known method of selecting the replenishing solution formula is by trial and error. The preliminary tests may be carried out by the use of small scale apparatus, but the conditions existing with large scale apparatus cannot be simulated accurately on a small scale. This is largely because of the difficulty of duplicating the conditions of agitation.

A reasonable starting point when designing a replenishing solution is a formula, the composition of which is identical with that of the original developer except that the potassium bromide is omitted. Photographic tests are made in the fresh developer and then periodically as it is used. During this time, a fraction of the developing solution is discarded either continuously or intermittently and replenisher added so as to maintain the original volume. Under these conditions the activity of the developer is determined by the volume of liquid discarded. This should be of such magnitude and the replenishing should be performed with such regularity as to maintain the developing power of the developer constant. If a replenisher is used which is not correct for the purpose intended, the bath will reach a condition where its performance is very different from that of the original developer but a point will eventually be arrived at when the bath functions in a consistent manner.

An account is given below of the procedure followed in adapting a replenisher formula to the D-16 developer used in a tank having a capacity of 120 gallons for the processing of motion picture positive film by the rack method.

Method of Testing the Condition of the Developer.—When a new batch of developer was placed in service, sensitometer strips and lengths of film printed from a negative of good quality were developed for various times under the regular conditions of processing but with special attention to the measurement of time and the maintenance of a constant and uniform temperature and degree of agitation. The times of development were chosen so as to reveal the performance of the developer over the whole of its useful range. The tests were repeated after 40 feet of film per gallon had been processed and again after 80 feet per gallon. Thereafter, tests were made at processing intervals of 80 feet per gallon.

The sensitometer strips were made on a time-scale sensitometer and the positive prints were made all at one time from a uniform negative of good quality. The developed sensitometer strips were measured and curves plotted according to the H & D methods.

Any change in the behavior of the developer was at once observed by a visual comparison of the prints, and any change in the color of the image or the tendency of the bath to produce stain was also carefully recorded.

The replenishing solution was added as necessary in order to make up for the loss in volume due to developer being carried out by the film and racks.

Replenisher Formulas Tested.—The first formula tested (formula No. 1, Table I) was identical with that of the original developer minus potassium bromide but exhaustion tests with this resulted in a gradual loss of developing power and effective emulsion speed. An increase in the time of development did not compensate for this speed loss but merely made the print more contrasty. The replenisher formula was then modified by increasing the concentration of elon and hydroquinone by 10 per cent (formula No. 2). Tests with this formula showed that the change was generally in the right direction but the replenisher was not sufficiently energetic.

The quantity of elon was then increased to 135 per cent, the hydroquinone to 125 per cent, and the sodium carbonate to 133 per cent (formula No. 3). This change proved to be more than sufficient to correct for the apparent loss of emulsion speed shown by films developed in the used developer but the prints lacked contrast after about 400 feet of film per gallon had been developed.

The next formula (formula No. 4) contained 105 per cent of the original quantity of elon, 135 per cent of hydroquinone, and 125 per cent of sodium carbonate. With this formula the contrast was not quite sufficient but the apparent emulsion speed was correct at the end of the run.

TABLE I

Experimental Replenishing Solutions Used with D-16 Developer

	Replenishers			
	No. 1	No. 2	No. 3	No. 4
Elon	0.3 gm.	0.3 gm.	0.4 gm.	0.3 gm.
Hydroquinone	6.0 gm.	6.6 gm.	7.5 gm.	8.1 gm.
Sodium Sulfite (E. K. Co. des.)	40.0 gm.	40.0 gm.	40.0 gm.	40.0 gm.
Sodium Carbonate (E. K. Co. des.)	19.0 gm.	19.0 gm.	25.2 gm.	23.8 gm.
Citric Acid	0.7 gm.	0.7 gm.	0.7 gm.	0.7 gm.
Potassium Metabisulfite	1.5 gm.	1.5 gm.	1.5 gm.	1.5 gm.
Water to make	1.0 L.	1.0 L.	1.0 L.	1.0 L.

TABLE I (*Continued*)

	Replenishers		
	No. 5	No. 6	No. 7
Elon	0.3 gm.	0.3 gm.	0.3 gm.
Hydroquinone	8.1 gm.	8.1 gm.	9.0 gm.
Sodium Sulfite (E. K. Co. des.)	40.0 gm.	40.0 gm.	40.0 gm.
Sodium Carbonate (E. K. Co. des.)	25.6 gm.	38.0 gm.	38.0 gm.
Citric Acid	0.7 gm.	0.7 gm.	0.7 gm.
Potassium Metabisulfite	1.5 gm.	1.5 gm.	1.5 gm.
Water to make	1.0 L.	1.0 L.	1.0 L.

Accordingly, with the content of the elon and hydroquinone equal to that in the original formula, the sodium carbonate content was increased to 200 per cent of that contained in formula No. 1 (No. 6). With this formula, the contrast was almost maintained during use of the developer. The hydroquinone content was then increased to 150 per cent of that in formula No. 1 and this combination proved satisfactory (No. 7). The formula adopted (No. 7) contained 50 per cent more hydroquinone than the original formula and 100 per cent more sodium carbonate while the remaining constituents were retained in their original concentration with the exception of the potassium bromide which was omitted.

The behavior of a developer revived with the above solution after exhaustion with 600 feet of motion picture positive film per gallon as compared with a fresh developer is shown in Fig. 4. From the curves it is seen that the rate of development as represented by the gamma measurements was maintained although a very slight loss in emulsion speed resulted.

The curves in Fig. 5 indicate the extent of the variation of speed, fog, gamma, and the density for a given exposure with exhaustion and revival. It is seen that all these values within the limit of experimental error remained constant throughout the exhaustion.

When about 600 feet of film have been processed per gallon, it usually becomes necessary to discard the developer because of its tendency to produce stain. As explained in a previous communication[2] the formation of this stain is hastened by the presence of hypo which is carried into the developer by the racks but in the case of processing machines the developer is not contaminated in this manner and the life of the developer is therefore longer.

SUMMARY AND PRACTICAL RECOMMENDATIONS

When processing motion picture positive film it is desirable that the developer should behave in a constant manner throughout its life and this can be insured by the addition of a suitable replenishing solution at intervals. If the developer is not replenished the rate of development falls off with use and it is then necessary to increase the time of development which is not always possible when using processing machines.

The following replenisher formula is satisfactory for use with the D-16 developer for motion picture positive film when developing by the rack and tank system.

	Formula D-16		Replenisher Formula	
	Metric	Avoirdupois	Metric	Avoirdupois
Water (about 125°F.)	500.0 cc.	64 oz.	500.0 cc.	64 oz.
Elon	0.3 gm.	17 gr.	0.3 gm.	17 gr.
Sodium Sulfite (Des.)	40.0 gm.	5 oz. 130 gr.	40.0 gm.	5 oz. 130 gr.
Hydroquinone	6.0 gm.	350 gr.	9.0 gm.	1 oz.
Sodium Carbonate (Des.)	19.0 gm.	$2^1/_2$ oz.	38.0 gm.	5 oz.
Potassium Bromide	0.9 gm.	50 gr.	....	....
Citric Acid	0.7 gm.	40 gr.	0.7 gm.	40 gr.
Potassium Metabisulfite	1.5 gm.	85 gr.	1.5 gm.	85 gr.
Cold water to make	1.0 L.	1 gal.	1.0 L.	1 gal.

Sufficient replenishing solution should be added to compensate for the loss due to removal of developer by the film and racks. The formula is so compounded that when added in this manner the activity of the developer is maintained constant with respect to motion picture positive film.

The above formula is not necessarily the correct one for use when processing by machine in which case replenishment is carried out in any of the following ways:

(*a*) By allowing fresh developer (minus potassium bromide) to enter the tank where the film enters and to overflow where the film emerges.
(*b*) By adding replenishing solution to the recirculation tank so as to maintain the volume constant.
(*c*) By discarding a certain proportion of the developer in the system at intervals and replacing with replenishing solution.

The nature of the replenishing solution will vary in every case and the correct formula and method of use can only be determined by trial. In general, the formula should contain a relatively greater proportion of the developing agent, about 25 to 100 per cent more sodium carbonate, no potassium bromide, and enough sodium sulfite to maintain the concentration of sulfite in the developer at a constant value. With recirculating systems the oxidation of the developer is usually more rapid than in a non-circulating system and in such cases it may be necessary to increase the concentration of the developing agent as much as ten times.

The authors are indebted to Mr. A. J. Miller who assisted in the experimental work.

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SOME NEW PROJECTION EQUIPMENT

HERBERT GRIFFIN*

Having been requested by the Papers Committee to report to the Society on any new apparatus placed on the market by our company during the past year, I shall give you in as few words as possible a description of two pieces of equipment recently developed which are now replacing a great deal of the older equipment installed. These two units are the Super Simplex mechanism and the new rear shutter assembly for the old type Simplex mechanism.

THE SUPER SIMPLEX MECHANISM

Oiling System.—A simple and yet efficient oiling system now forms part of the Super Simplex main frame assembly. All bearings in the frame are now reached by means of oil tubes conveniently located on the gear case side of the mechanism. (See *A*, Fig. 1.) There is but one bearing which has a direct oil hole on this side of the apparatus; this oil hole is for the lubrication of the rear bearing of the shutter shaft and is shown at *C*, Fig. 1. All oil tubes but one are plainly visible upon opening the mechanism door on the gear enclosure side. The visible oil tubes have within them a wick which reaches the bearing and a few drops placed within the tubes each day is more than sufficient to take care of proper lubrication.

Oiling Intermittent Movement Casing.—The one oil tube which is not immediately visible is that which carries oil directly into the intermittent case; it is reached through the shutter shaft casting, *E*, Fig. 1, just above the flywheel of the intermittent movement at *B*, Fig. 1.

The new mechanism is supplied with the vertical sliding aperture plate in which are two standard apertures, one having the standard dimensions for straight silent film projection (0.906 × 0.6795 in.) and the other having standard dimensions for sound film projection (0.800 × 0.6795 in.), or the proportional aperture (0.800 × 0.607 in.)

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for the projection of sound film to give a screen picture of the same dimensions as obtained with the standard silent projection aperture. With the use of this latter aperture it is necessary to change to shorter focal length lenses and this can be readily and quickly done as will be explained later. It is also possible to furnish Super Simplex projectors with the lateral type of sliding aperture in which all types of apertures may be used interchangeably if desired.

Aperture Plate.—The aperture plate, *E*, Fig. 2, slides vertically

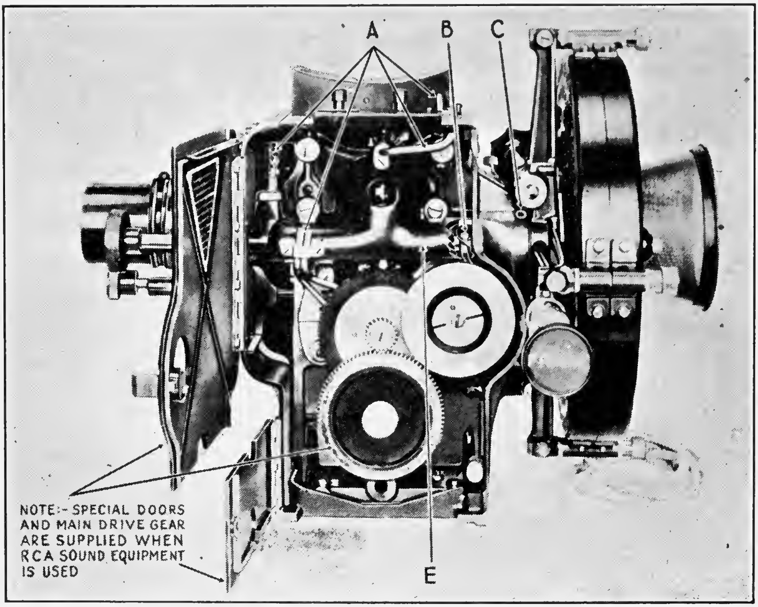

FIG. 1. Gear case side of Super Simplex mechanism.

behind the film tracks on the film trap. In its upper position it carries the standard silent film aperture. When slipped into the lower position it carries the standard sound film aperture or the standard proportional aperture, depending on which is ordered with the projector. When using the standard sound film aperture or the proportional aperture it is obvious that the lens mount with relation to the center of the aperture is off center, due to the masking of the sound track and, therefore, throws the picture to one side on the screen. We have designed and built into the Super Simplex projector the ideal method of correcting this condition. On the front and top of the lens mount, outside of the mechanism (see Fig. 3) will be seen a lever, *A*, which may be thrown laterally from left to right. In the position shown the lens is accurately centered on the standard or proportional sound film aperture, and thrown over to the left position it will be centered for the standard silent or disk aperture. Stops *B*, Fig. 3, are provided on this adjustment so that the length of its throw may be predetermined in order that the

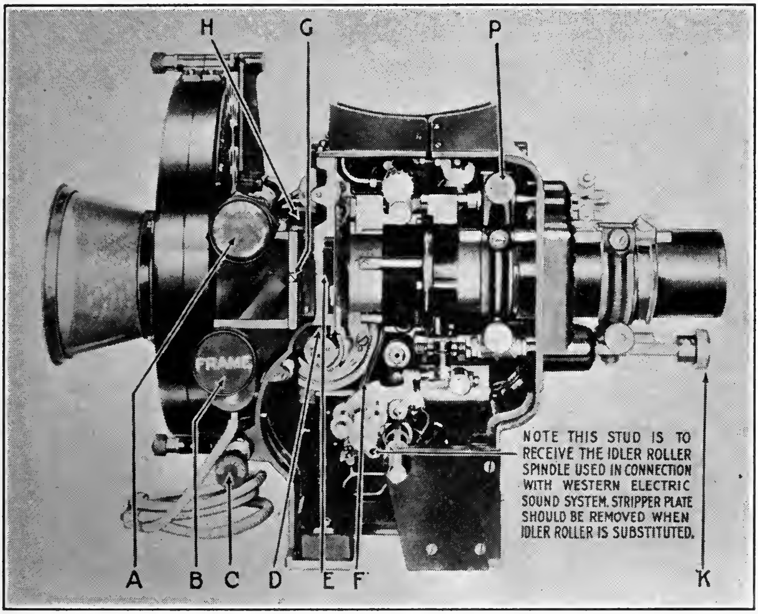

FIG. 2. Aperture side of projector.

lens may also come into the correct relation with the projection apertures and the projected picture; these stops fetch up against the stationary stop shaft, *C*. Ideal results are secured with this arrangement when using the proportional aperture because, when this aperture is used and a change made to the correct shorter focal length lens, a picture of the same proportions as that projected through the silent film aperture is projected to the screen, and by simply moving the lens centering lever to its correct position no further change is necessary on the stage, such as sliding in tabs or masks. Just within the glass door of the mechanism in the upper right-hand corner at *P*, Fig. 2, will be found a lens holder lock screw. This screw is attached to a clamp provided in order that the lens centering lever may, if desired, be locked in fixed position and also to apply a slight tension that eliminates vibration of the lens centering unit.

New Super Simplex Revolving Shutter.—Several improvements in design have been incorporated in this shutter. Its extremely large diameter provides for increased screen illumination and, because of its position with relation to the lamphouse and aperture, it greatly

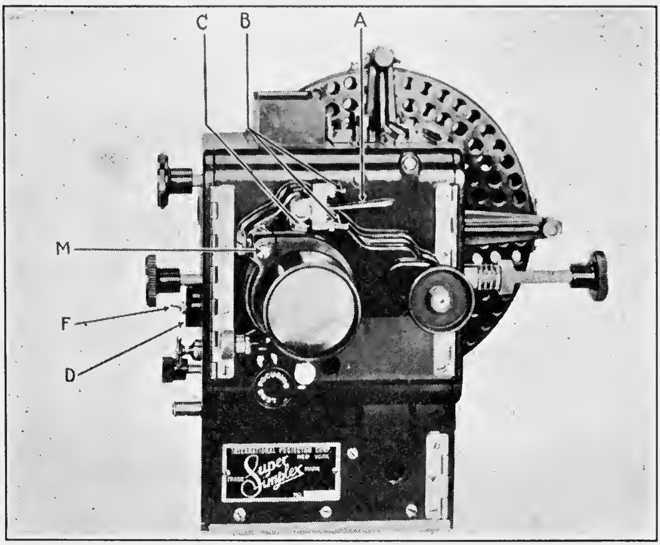

FIG. 3. Front view showing lens adjusting devices.

reduces the heat at the aperture, operating as it does between the light source and the film. In addition to this, the shutter is so designed that it creates a partial vacuum in front of the aperture so that the cooling effect obtained during its operation reduces the heat at the aperture approximately seventy-five per cent over the older types of equipment. It will be appreciated that this is of utmost importance when projecting sound film because it reaches the sound projection aperture in an undistorted condition.

The shutter construction is shown in Fig. 4. The entire shutter may be exposed by removing the front shutter guard. This is accomplished by simply removing the three nuts and washers, *D*, Fig. 4, and slipping the front shutter guard from its supporting studs.

Eye Shield.—The eye shield on the Super Simplex has been designed to protect the projectionist's eyes entirely from the bright rays from the spot at the aperture. This eye shield is an entirely enclosed device and the colored glass therein may be readily removed for cleaning by loosening screw *G*, Fig. 2. This eye shield together with the framing and threading lamp is attached by means of screws to the front section of the shutter guard A slot is provided

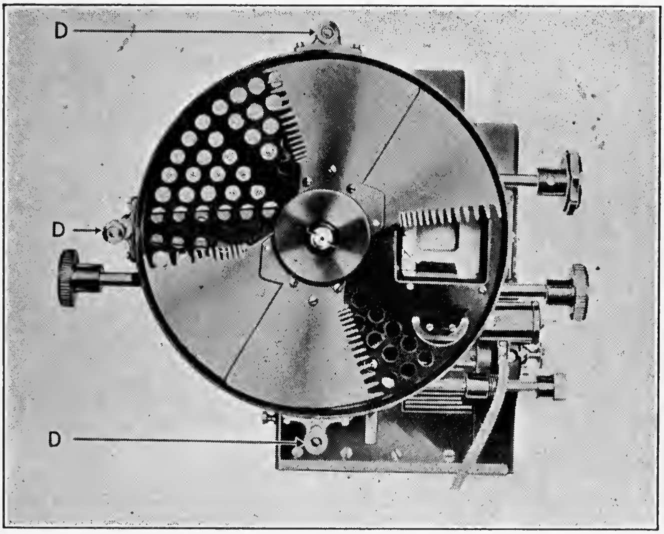

FIG. 4. View of shutter construction.

in the eye shield assembly just behind the aperture (see *H*, Fig. 2) so that change-over devices using an aperture cut-off may be readily adapted.

Threading and Framing Lamp.—A threading and framing lamp has been provided and is mounted below the eye shield assembly. (See *D*, Fig. 3.) This lamp directs a strong beam of light up behind the eye shield to the aperture and by this means it is possible for the projectionist to place the film in frame readily while threading the projector. A small switch is provided, *F*, Fig. 3, by means of which the lamp may be thrown on or off at will, and armored cable is supplied for connecting the framing lamp assembly to any convenient source of 110 volt supply.

Gate Opening, Framing, and Shutter Adjusting Knobs.—These knobs are plainly visible in the figures and very little need be said with regard to their operation. The film gate knob, *A*, Fig. 2, controls both the film gate latch and the gate opening device, and it is turned about a quarter turn to the left as indicated by the arrow thereon to open the gate. When the gate is opened, upon being

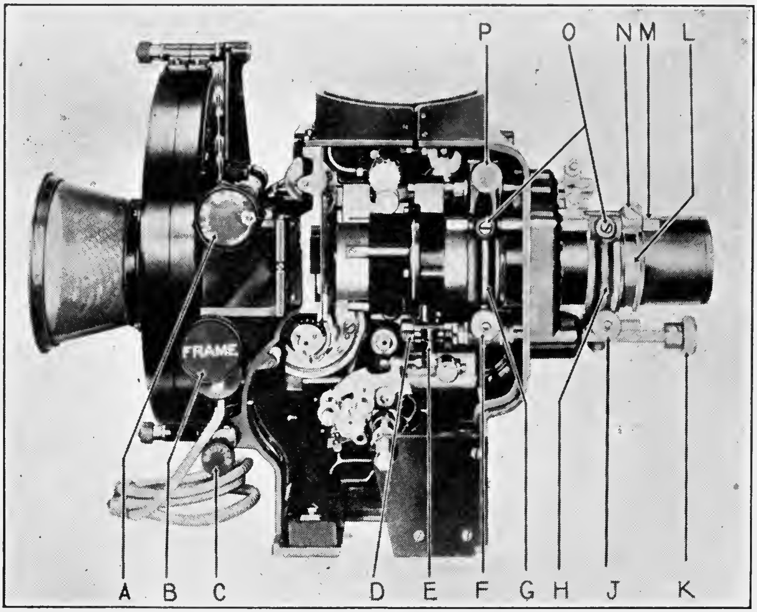

FIG. 5. Aperture side of projector.

released by lever *F*, Fig. 2, it both closes and latches readily. The framing handle, *B*, Fig. 2, is so mounted upon the shaft that when the word "FRAME" is read in a horizontal position, as indicated in Fig. 2, the framing device is centrally located, allowing approximately the same throw to right and left for framing purposes.

The shutter adjusting knob, *C*, Fig. 2, is connected through the gear train and shafts to the shutter shaft and turning it in either direction will revolve the shutter shaft to the right or left, respectively, so that the shutter may be accurately set with the projector in operation after it has been temporarily set and locked on the shutter shaft.

The lens focusing knob, *K*, Fig. 2, projects out through the front of the mechanism and is of the micrometer type. One complete turn of this knob moves the lens mount approximately 0.040 in. forward or backward, depending upon the direction of its rotation.

Lens Mount.—The lens mount is so constructed that it will rigidly support any type of lens having dimensions established by the Standards Committee of the Society of Motion Picture Engineers. These call for an outside barrel diameter on the Series 2 lens of $2^{25}/_{32}$ in.

The lenses are held firmly in place by means of two lens clamps,

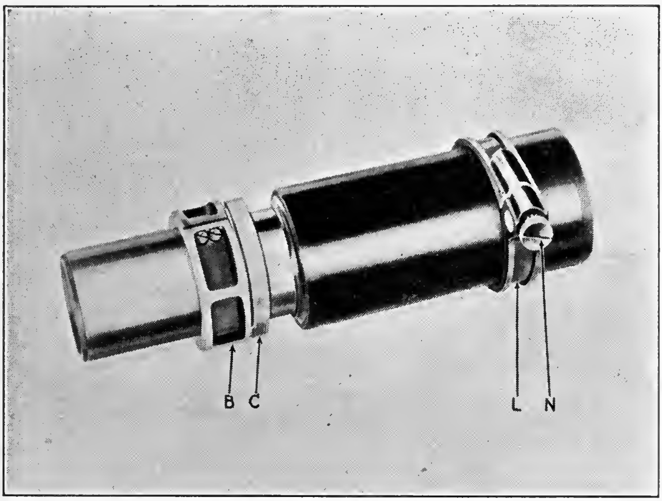

FIG. 6. Lens mounting.

one within the projector mechanism, *G*, Fig. 5, and one on the outside in front of the mechanism. (See *H*, Fig. 5.) With some Series 2 or half size lenses of various focal lengths it is necessary to use especially designed adapters on the rear element so that the lens may be properly accommodated in the rear lens clamp, *G*, Fig. 5. Series 1 and quarter size lenses of all makes may be readily accommodated in the Super Simplex lens mount by the use of adapters especially made for them. Complete data with regard to these adapters is furnished with each shipment.

Fixed Focus Clamp.—In theaters where proportional size aperture plates or effect masks are used, it is necessary, of course, to quickly change lenses from one focal length to another, and it is essential that each and every lens used in this connection be absolutely in focus without adjustment on the part of the projectionist when the change is made. Where it is desired to change lenses quickly from one focal length to another this is taken care of by means of an auxiliary lens clamp, *L*, Fig. 5, which clamps to the lens proper by means of screw *N*. After the lens is sharply focused, this auxiliary lens clamp is simply slipped over the front end of the lens barrel and brought tightly against the front lens clamp as shown at *L*, Fig. 5,

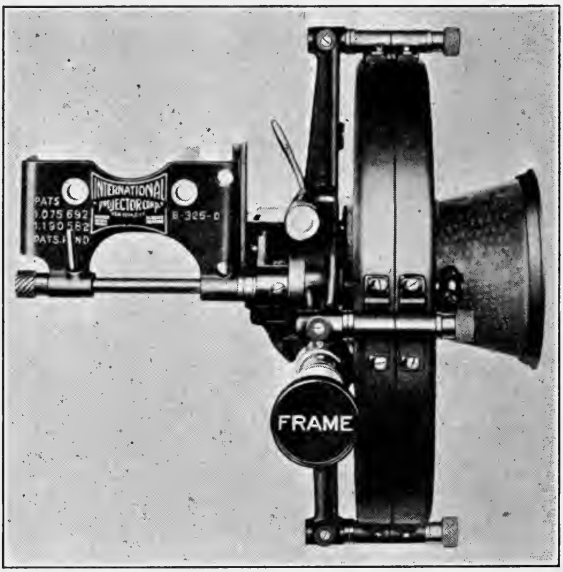

FIG. 7. Rear shutter assembly to replace old type previously used.

and securely locked on the lens barrel at this point. It is obvious, therefore, that after this is done any number of lenses once focused and equipped with this fixed focus clamp may be removed and replaced at will in a short time, and will always remain in focus.

In order to insure that the lens will always be in the same position with regard to rotation, means have been provided on the auxiliary clamp to always locate the lens in the same position. In Fig. 6, it will be noted that there is a hole drilled in this clamp; this hole is so placed that the clamp, when attached to the lens, may slip over the shaft *M*, Fig. 3, as will be readily seen upon examining Fig. 3, which shows a lens in position as above described. The lens will always be not only in focus but also in the same position rotationally. A half size lens with rear adapter and fixed focus clamp is shown assembled in Fig. 6.

THE NEW REAR SHUTTER ASSEMBLY FOR REGULAR SIMPLEX MECHANISMS

To supply the needs of theater owners who have installed the regular model Simplex projector, we have designed and placed on the market a new rear shutter assembly similar to the one furnished

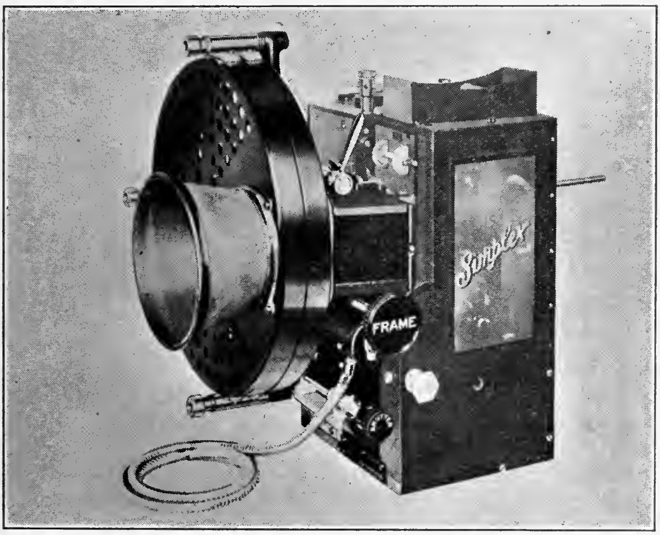

FIG. 8. New rear shutter assembly mounted on regular Simplex projector.

with our Super Simplex projector. This assembly shown in the illustration, Fig. 7, is attached to the regular Simplex mechanism, and by its use all the advantages are acquired which are gained through the use of the rear shutter assembly on the Super Simplex. A glance at the illustration will readily suggest that the new unit is not a makeshift proposition. It has been practically designed, is easily adapted, and is attractive in appearance.

This new assembly includes many features found only in the Super Simplex, such as the new type gate opening device, eye shield, new type framing device, the pilot lamp assembly, and the shutter adjusting mechanism. All of these are manipulated from the operatin side of the mechanism as shown in the illustration. This assembly ha been in practical operation for some time on the Super Simplex an when attached to the regular model Simplex projector gives equall satisfactory results. It is shown assembled to the mechanism in Fig. 8

The advent of sound pictures made it necessary to discard th old type opaque screens and substitute therefor various types o perforated screens so that the sound might be more satisfactoril transmitted through the screen. Porous screens have reduced th light from twenty-five to forty per cent, necessitating the use o much higher amperage in order to bring screen brilliancy back t somewhere near normal. The result of this increased amperag has been a greatly increased amount of heat at the aperture plat and over the rear of the mechanism. This caused warpage an damage to the rear of the mechanism. It also developed a grea deal of buckling of the film and a corresponding amount of distortio of the sound track on the film. The former is readily visible o the screen and most annoying to the observer. The latter has no been so obvious but it can be readily appreciated that sound wave upon distorted film cannot possibly reproduce with proper fidelit the excellent results obtained in present-day recording.

The elimination of these two defects has naturally been of grea importance, but the fire hazard which developed through the use o higher amperage was far more serious. It has been thoroughl realized that the film has never been adequately protected by coolin devices during its transit through the projector, but due to relativel lower amperages and various protective devices on the projecto the fire hazard has not been a particularly serious problem. With the introduction of sound the greatly increased amperages aggra-vated the hazard to such an extent that fire authorities throughou the country have become very much interested in the matter. The problem, however, has been satisfactorily solved by the introductio of the Super Simplex mechanism and the rear shutter assembly. Exhibitors are now enabled at a very low cost and little or no trouble to equip their projectors properly and protect the film from the excessive heat. The same equipment also solves the problem of buckling and sound distortion because these troubles were primarily due to the excessive heat heretofore projected to the film.

Attempts have been made in various ways to reduce the heat and eliminate buckling but the results have never heretofore been satisfactory. The most successful effort to cure this serious evil has been through the use of the rear shutter, but practical difficulties were encountered which required long and careful study to overcome. It is a great satisfaction to the International Projector Corporation to make this device available to users of regular Simplex equipment. The rear shutter assembly entirely meets the exacting demands of present-day projection by providing more light and at the same time reducing the heat at the aperture. Illumination is increased greatly, the percentage increase depending on the focal length and type of lens being used, and the heat at the aperture plate is reduced between fifty and seventy-five per cent. This improvement is due to interposing the new shutter assembly between the arc lamp and the film thereby making it unnecessary to use heat plates or shields in proximity to the film. The blades of the shutter in their new position immediately eliminate fifty per cent of the heat from the arc and, in addition, a further large decrease in heat is obtained by using this shutter to create a partial vacuum at the aperture and set up an air disturbance in the beam of light. The air current set up by the shutter will keep the film cool and therefore prevent buckling. The width of the rear shutter blade no longer depends on the size of the lens so that a shutter using a ninety degree effective blade can be used with a lens of any diameter, while with the old type shutter a minimum of one hundred and two degrees was necessary.

This assembly, as already stated, may be attached to any existing old type Simplex projector mechanism in a very short time. By its installation the projectionist may be relieved of the strain of projecting motion pictures and sound under the old conditions, and may offset any drastic regulations which may come about through the increased fire hazard present in the old type equipment.

Fig. 9 shows the new type Super Simplex mechanism mounted on a new type pedestal known as Simplex Model R. This pedestal was designed primarily for use in connection with sound attachments. While such an angle is not to be recommended, it may be tilted to an angle of approximately thirty-five degrees. No rear braces to support the lamphouse casting are necessary with this pedestal inasmuch as the lamphouse support casting and pedestal are rigidly locked together by means of locking screws, one of which may be seen at *A*. The entire non-operating side of the pedestal has been cleared of mechanical obstructions so that sound equipment manufacturers may utilize this side of the pedestal for sound equipment driving apparatus and disk operating equipment. The base of the pedestal has been so designed that it may accommodate disk turntable equipment by attaching it at point *B*. The upper part of the pedestal, the mechanism, magazines, sound attachment, lamphouse, switch box, *etc.*, may be tilted upward or downward very readily by turning the tilting screw shown at *C*. This wheel may be easily operated with one finger, so readily does it respond to adjustment and so well is the apparatus balanced.

The speed indicating device shown at *D* is furnished if desired with

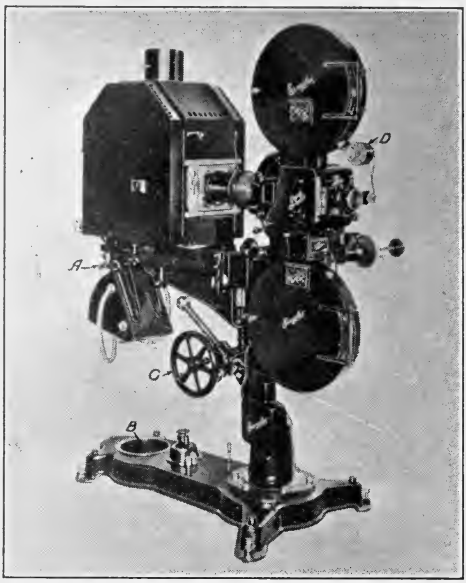

FIG. 9. New type pedestal mounting.

the apparatus, and the bracket for this indicator forms part of the upper magazine support casting. The indicator is driven through a pulley attached to the shutter shaft of the mechanism and the calibrations on the indicator dial are in feet per minute and minutes per thousand feet.

I had hoped to be able to show the new wide film equipment being developed by our company but the time was too short and due to the non-standardization of film width, this matter has unfortunately been considerably delayed. However, undoubtedly at the next convention this equipment will be on display.

A NEW RECORDER FOR VARIABLE AREA RECORDING

EDWARD W. KELLOGG*

A recorder embodying certain new principles in its design and operation has recently been adopted by RCA Photophone, Inc. It is designated as Type PR-4. The optical system has been redesigned and a number of improvements made, especially in the direction of providing better facilities for adjustment. The sound record produced is of the variable area type which has been used from the beginning by this company, and which has given excellent results. It is, however, in the means employed for providing uniform movement of the film past the point where the recording is done, that the new recorder differs most radically from its predecessors.

Inherent Fault in Sprocket Drive.—It is recognized by engineers who have analyzed the question carefully that a sprocket, however perfectly formed, rotating at uniform speed, can in general impart to the film only an approximation to uniform speed. In spite of the accuracy with which the film perforating is done, the subsequent shrinkage of the film results in variations in length, and a sprocket which just fits one film will not fit the next. Fig. 1 shows what is meant here by "fitting." When the film is pulled snugly around the sprocket, the angular pitch of the sprocket perforations and teeth are exactly the same, so that all of the teeth engaged are in contact ready to contribute their shares of the total pull. Under these conditions, the sprocket can, theoretically at least, impart uniform motion to the film. No slippage takes place when the forward tooth disengages and a new tooth enters, and the speed of the film is just what it would be if there were no teeth but only a smooth drum of the same diameter with no slipping of the film.

Fig. 2 illustrates the relation between perforations and teeth when the film is shorter than a fit. It will be noticed that the last tooth toward the slack side is the only one that can exert any pull, since the others do not touch either edge of their perforations. Fig. 2 might

*RCA Victor Co., Inc., Camden, N. J. (Read before the Society at Washington.)

represent either a pulling sprocket with counter clockwise rotation or a hold-backs procket with clockwise rotation. Let us consider the case of a pulling sprocket. So long as the film is against the bottom of tooth No. 1, no other tooth being in contact with film, there will be no slipping over the cylindrical supporting surface, and the film will move at the non-slip speed, $V = \pi(D + t)n$, in which D is the diameter of the cylindrical supporting surface, t the thickness of the film, and n the number of revolutions per second. When tooth No. 1 reaches the end of the arc of wrap and the film begins to strip from No. 1, it must slip back by the amounts by which tooth No. 2 previousy failed to touch, before No. 2 can exert any pull. After this slip-back has occurred and tooth No. 2 is in contact, the film speed

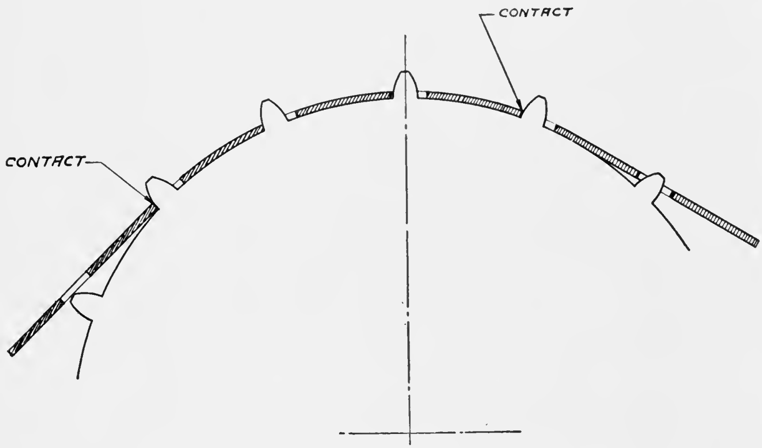

FIG. 1. Sprocket and film with perfect fit.

resumes the non-slip value until No. 2 begins to strip. The film motion thus consists of a series of movements at non-slip speed, alternated with movements at lower speed during which the slip-back is taking place.

What the speed of the film is during slip-back and what fraction of the time the slipping back occupies, depends on the shape of the teeth and the manner in which the stripping takes place. The ideal stripping would be for the film at a certain point to cease following the arc and follow a tangent. Tooth roughness would cause inevitable departures from the manner of stripping just described, with consequent irregularities in the film velocity, but only by assuming that the film moves outward from the sprocket at some definite rate can we figure the rate of slip-back in terms of tooth shape. If the tooth surface were a circular involute no slip-back could occur while the film is sliding up along the tooth surface, and the inevitable readjustment would take place when the film is actually clear of the tooth, at which time a jump-back would occur. The tooth should evidently be cut back—more taper than an involute—so as to permit the film to slip back continuously while the stripping is taking place. Two suppositions may be considered, (1) that the tooth is so cut that the rate of slip-back is not constant, for example, that the slipping back is slow at first and more rapid later, and (2) that the tooth is cut to give a constant rate of slip-back. The first design obviously gives a net film speed which is not constant, although the departure from

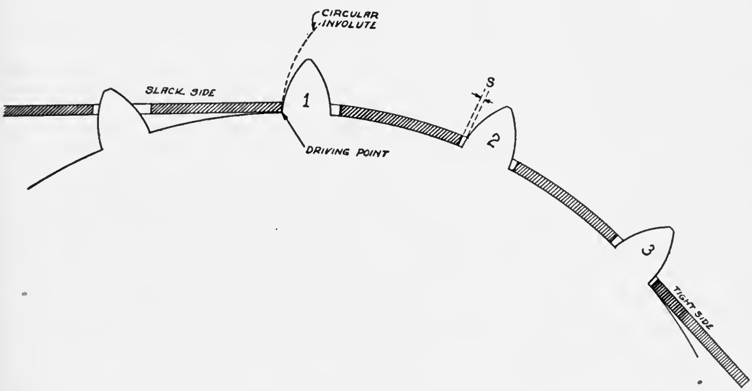

FIG. 2. Relation between sprocket teeth and film perforations when film is short.

constancy may with good design be small. If the tooth is so cut that with stripping of the kind mentioned above, the slip-back is at a constant rate, then there are three analyzable cases to consider. (1) The film slips back sufficiently to touch the bottom of tooth No. 2 before it begins to strip from No. 2, or, in other words, before it pulls away from the cylindrical surface at the bottom of tooth No. 2. (2) The film slips back sufficiently to touch the bottom of tooth No. 2 just as the stripping from No. 2 begins, and (3) the film does not slip back sufficiently to touch No. 2 when stripping from No. 2 begins. These three cases might arise from use of different tooth pitch and shape with a film of given perforation spacing, or with a given sprocket they correspond to three different degrees of film shrinkage.

In case (1), the film moves at non-slip speed so long as it remains against the bottom of the tooth. Thus there are two film speeds, one during the interval that the film is being stripped from the pulling tooth, and another while it is resting against the bottom of the next tooth. In case (2) the latter period is zero. The film is at all times undergoing stripping from the tooth which is doing the pulling. We have assumed that the tooth surfaces are so designed that during stripping there is a constant rate of slipping back. Therefore, with case (2) the film progresses at a constant speed, namely, the slip-back speed.

In case (3), the film fails to engage tooth No. 2 at all until it has been slipped off the end of No. 1. The case is similar in this respect to that where the tooth was shaped as a circular involute. Despite the fact that the tooth has been cut back to permit a certain uniform rate of slip-back as the film slides up the tooth, the slip-back speed is not as slow as a film of this shrinkage requires, and an additional jump-back occurs as each tooth in turn is cleared. The jump-back may occur before the second tooth begins to strip, or afterward. In the latter case, the surface of the second tooth recedes just fast enough to stay clear, until the first tooth disengages.

We have found, then, two conditions which can give, at least on paper, constant film speed. In one, the film fits perfectly and there is no slipping, and with the second condition the film is always slipping back at a rate determined by the tooth shape. But out of the infinite gradation of possible film sizes or degrees of shrinkage there are two specific sizes that meet these requirements, and their probability of occurrence is exactly two divided by infinity or zero. We may say then that from a purely theoretical standpoint, in view of the variations in size of the films to be handled, a sprocket rotating at uniform speed will not produce uniform motion of the film. In practice, the performance will inevitably be poorer than that predicted by a theoretical analysis based on ideal conditions or, in other words, on the assumption of perfect workmanship. The use of a flywheel on the sprocket shaft or of mechanical filtering, while it may eliminate speed irregularities due to imperfections in the driving system, can go no farther than to rotate the sprocket uniformly which is the condition assumed for the discussion. The irregular motion of the film due to tooth action remains.

The analysis need not be repeated for the cases so far not covered, *i. e.*, film too long instead of too short and hold-back sprockets instead of pulling sprockets. The actions that take place are similar but may occur at a different point. For example, in the case of the pulling sprocket with over length film the tooth next the tight side does the pulling, and the slipping occurs during engagement instead of during stripping.

To show that a sprocket cannot, even under ideal conditions, impart perfectly uniform motion to a film, does not dispose of it as a practical means of driving the film in making a sound record. The question is rather how great are the variations in speed and how detrimental is their effect on the quality of reproduced sounds. The magnitude of the variations in speed is difficult to estimate, but the total phase shift produced by the readjustment when a new tooth comes into engagement cannot exceed a certain value. In the case of a recorder, the variations in film length probably do not exceed one-half of one per cent. If the film on which the record is being made deviates by one-half of one per cent from the length which would just fit the sprocket, then the readjustment would be of the order of one mil, since the perforation pitch is nearly 200 mils. One mil is a quarter wave-length at 4500 cycles, a twelfth of a wave-length or 30 electrical degrees at 1500 cycles, 10 degrees at 500 cycles. A recurrent break in continuity, occurring as this does 96 times per second, produces a modulation or fluttering of the tone if the cycle of speed change is regular, while the effect dwindles to a general roughening of the tone if the readjustments are small or irregular. This roughening of the tone, when it does not produce an actual flutter or "gurgle," gives an impression very similar to added ground noise. The tooth flutter characteristic is most noticeable with high pitched tones especially if the tones are smooth to start with. The effect is least when the sound recorded is general noise, speech, or music with complicated wave forms such as choral, band, or orchestra music. Rapid tempo also makes speed fluctuations less noticeable. While there are many classes of recording in which tooth flutter or "gurgle" is difficult to recognize even though present, there can be no question that some loss of quality is practically always involved, and on the principle that the best we know how to do is none too good, the engineers, who have taken part in the development of the Photophone system, have from the start attempted to minimize speed irregularities. This is especially true of recorders where the cost of refinements can be justified in view of the small number of machines involved.

Means of Obtaining Uniform Motion.—A toothless drum is the logical substitute for the sprocket when the steadiest speed possible is sought, and it is obvious that the drum must be true (not eccentric) and must itself rotate at constant speed, and, furthermore, the film must not slip on the drum. The first of these conditions calls simply for good machine work. A flywheel is the classical and unexcelled means of obtaining uniform rotation. The elimination of slipping depends on avoiding excessive tension on the film, the use of a drum surface which is not highly polished, and the maintenance of good contact pressure. The most satisfactory way of producing the desired normal pressure is to employ one or two soft tired pressure rollers bearing against the film.

Securing Correct Drum Speed.—A machine for recording synchronized sound must of course have sprockets, since it is the number of sprocket holes passing per second, and not the linear feet of film which must be the same in two synchronized films. The sprocket speed being fixed, the drum speed must be altered in accordance with the degree of film shrinkage. The drum can therefore not be positively driven, either by gears, belt, or friction drive, unless provision is made for altering the ratio of drum to sprocket speeds in a continuously variable manner and subject to automatic control by the film itself. If the drum is positively driven at a speed which is not exactly correct, the slack will disappear from one or the other of the film loops preceding or following the drum, and the film will get tighter until (if the film does not tear) sufficient slippage occurs over the drum to make up for the error in drum speed; and when this condition of slipping obtains, the drum is no longer of any assistance toward obtaining uniform speed.

The simplest method of driving the drum at the right speed is to let the film, acting as a belt, supply the power to rotate the drum. This system was employed in the pioneer work of Mr. C. A. Hoxie of the General Electric Co., and was later applied to some of the commercial recorders. A recorder employing a variable speed friction drive was developed by Mr. C. L. Heisler of the General Electric Co. The speed of the drum was governed by the length of a loop of film between the drum and one of the sprockets. An idler roller mounted on an arm, with a counterweight, served to measure the length of the film loop, and the position of the arm controlled the position of one of the friction rollers. Both of these machines when in proper condition gave excellent results. Mr. Hoxie also worked out a system with positively driven drum based on an entirely different principle, and Mr. Heisler has employed an all-geared system in both recording and reproducing machines.

Experiments with Magnetic Drives.—The PR-4 recorder had its origin in a laboratory model shown in Fig. 3 built several years ago under the writer's direction in the General Electric Research Laboratory. In this model effort was made to obviate some of the difficulties which had appeared in the machines in which a drum was driven by the film. In machines of the type just mentioned it had been found that increasing flywheel size was helpful up to a certain point, but beyond this there was no gain. The most plausible explanation

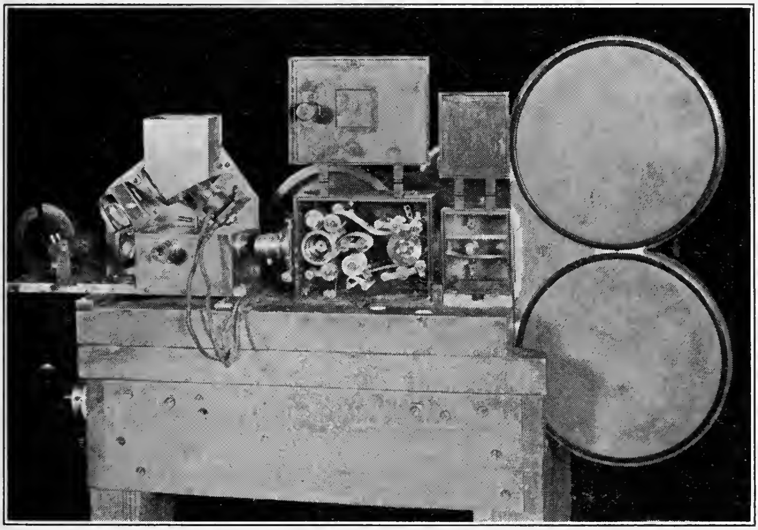

Fig. 3. Original model of PR-4 type recorder.

appeared to be that the heavier the flywheel, the more bearing friction was introduced, and the required traction became so high that slippage of the film over the drum occurred. The simple film-pulled drum system was subject to another fault, particularly when the traction was good. A slight irregularity in the speed of the sprocket would accelerate the drum to a speed slightly above normal, so that the tension on the film eased up. Since the drum was not now receiving enough power, it slowed down until the film was tight again, and a strong jerk occurred which again raised the speed above normal. A condition analogous to "hunting" of synchronous machines thus occurred, although instead of having a definite natural period the drum might be described as bouncing along. This action was not always apparent, and if the gearing was accurate it was largely eliminated.

In the laboratory machine just referred to, an auxiliary drive of the drum was provided which served both to reduce the traction required from the film, and to damp out any hunting which might occur. A copper flange was attached to the flywheel and a multi-pole electromagnet on a concentric shaft exerted a drag by inducing eddy currents in the copper flange. The magnet was driven through gears about 20 per cent faster than the normal drum speed, and therefore exerted a forward torque, which could be made to just supply the friction losses, thus relieving the film of all strain.

Prevention of Hunting.—The torque applied to the flywheel flange by such a magnetic drive is directly proportional to the relative velocity. Herein lies its potency in damping out oscillations. When the flywheel is running above average speed it receives less assistance from the auxiliary drive, and when it is below average speed it receives more. This amounts to superimposing upon the steady torque supplied by the magnet, an alternating torque, in phase with and opposing the motion of any oscillation which may be superimposed on the steady motion of the flywheel. Such a transient oscillation occurs, for example, when the machine is first started. The excess torque required for acceleration is supplied largely by the film, the tension being limited by the pressure with which the film is held against the drum. After the drum has reached normal speed it must run over speed for a moment in order to throw enough slack film into the lower loop to relieve the film of tension. It tends to continue over speed until the upper loop has lost its slack and begins to pull back. Such an alternation of over and under speed may continue through a good many cycles unless means of damping such as have been described are provided. With the magnetic drive the starting transient has spent itself and the drum reached steady speed within four or five seconds from the time of starting the motor.

Were the auxiliary drive of such a nature that the torque supplied was independent of relative speed, for example, if it depended on rubbing friction, it would serve to relieve the film of some of its tension but its damping effect would be nil. An auxiliary drive depending on viscosity of a film of oil would undoubedly work satisfactorily, but the magnetic drive has the advantages of ease of control, practical independence of temperature, and nothing to leak or spill.

Magnets Not a Source of Irregularity.—It might appear that the magnetic drive would itself produce speed irregularities, if the magnet is not driven at perfectly constant speed. It is easy to show by a rough calculation that reasonably good gears will reduce drum speed fluctuations from this cause to negligible magnitude. The slowest running gear in the train makes about three revolutions per second. Let us suppose for illustration that this gear is so eccentric that for a half revolution or a sixth second the magnet runs one per cent over speed while for the next sixth second it runs one per cent slow. Since the average slip is 20 per cent of drum speed, a one per cent change in magnet speed corresponds to a six per cent change in slip and therefore in the torque supplied to the flywheel. A well run-in flywheel takes about 30 seconds to come to rest from full speed when retarded by friction alone. The speed loss the first second will be a little greater than $^1/_{30}$, say, $^1/_{20}$ of full speed. Since the magnet torque is about equal to friction, a 6 per cent change in slip would cause the flywheel to change speed at the rate of $0.06 \times {}^1/_{20}$ of normal speed per second, and a sixth as much or $0.01 \times {}^1/_{20}$ in a sixth of a second. This total change in flywheel speed, which takes place while the magnet is running at, say, one per cent excess speed, carries the flywheel from its minimum to its maximum speed, so the net deviation from average speed would be $^1/_{40}$ of one per cent, as a result of an inconceivably bad gear.

Other Measures to Insure Good Operation.—In the original laboratory model, effort was made to stop all the leaks by which speed irregularities might creep in. The general arrangement is shown diagrammatically in Fig. 4. An extra sprocket was provided to relieve the sprocket next the drum from film jerks originating in the magazines. A flexibly mounted idler roller with dashpot attached was interposed in the film loop by which the drum was pulled, it being contemplated that the magnets would supply 80 to 90 per cent of the driving torque and the film the remainder. Two rubber tired pressure rollers were provided to hold the film in contact with the drum. In order that the film between might stay tight against the drum a retarding drag was provided at the upper or feed-on roller, and a forward drag applied to the lower roller. The power for the latter was obtained from the former through a friction drive connection between the two, and a smooth acting slipping device was interposed between the one roller and the intermediate rollers to take up the slip. If the tire had been removed from the lower roller so that it was clear of the drum it would have run about 10 per cent over speed. When in contact with the film the lower roller exerted a slight forward pull tending to stroke the film down onto the drum.

Tests indicated that in future designs all three of the foregoing expedients might be omitted. The extra sprocket was superfluous. The flexibly mounted idler came into play during starting and by reason of the dashpot, made the starting transient more "dead beat," shortening the time required to reach steady speed by a second or so, but once the machine was up to speed, the rocker that carried this idler was motionless, showing that it contributed nothing to the steady running of the drum. It was also found that the film stayed snugly against the drum whether the lower pressure roller was driven through the friction coupling or not. Film tension is the chief factor relied upon to keep the film against the drum, but evidently when the rollers are acting properly, a very slight tension suffices. The first films made with the laboratory model recorder proved at least equal to and perhaps better than the best records made on other available machines. Having no perfect reproducing machine it was impossible to test a recorder, and having no perfect recorder it was impossible to test reproducing machines. Not until the same machine was adapted for reproduction could its performance be fairly judged. The probability of speed variations in reproduction neutralizing the effect of the same variations during recording is extremely remote, and would not occur in two successive playings of a given record.

The Steady Tone Test.—The test for speed constancy which we have found most satisfactory consists in making a record by means of an oscillator, preferably of a series of tones from about 500 to 3000 or 4000 cycles, and then listening to the reproduction of the record using a loud speaker in a fairly large room in which strong standing waves are produced. This is about the severest test for speed constancy to which a recorder or reproducer can very well be subjected. Small recurring variations in speed cause marked pulsations in the loudness of the tone, which we have come to call "Wow wows." Nothing which the ear detects as a change of *pitch* occurs unless the irregularities are extremely bad.

An idea of the sensitiveness of this method of judging speed fluctuations may be gathered from a test made several years ago in the Fifth Avenue Studio of RCA Photophone, Inc., by Mr. L. E. Clark (now of Pathé Studios, Culver City, Cal.) in which he fed a loud speaker from a beat frequency oscillator with a tone that rose in frequency at a measured rate, and recorded the tone using a microphone about 15 feet away. Examination of the resulting record showed that two to one variations in amplitude resulted from frequency changes of less than one-tenth of one per cent. This is not surprising if we consider the manner of formation of the interference pattern in the room. Many of the wave trains passing the microphone have crossed the room several times and are compounding with waves that have traveled only a short distance. As a simple case, consider a train of plane waves of 3200 cycles reflected from a wall, and the pressure measured by a microphone at a point twenty feet from the wall. The wave-length would be about four inches, or there would be sixty wave-lengths between the microphone and the wall. A change in frequency sufficient to make this $60^1/_4$ wave-lengths would cause the microphone to be at a pressure node instead of a pressure loop, which represents a very large relative change in pressure for a change in frequency of one part in 240.

Various other means of testing speed constancy have been tried, such as stroboscopes, and folding a film record back on itself. When we recall that a speed change of a fourth of one per cent lasting a tenth of a second, results in a shift of the wave from normal position of only 0.0045 inch, it is not strange that the blurred lines shown by a stroboscope do not reveal speed fluctuations of the kind we are considering. Folding a steady tone record film back on itself and noting where the waves coincide and where they are offset, has been useful in some instances as a test of constancy of the recorder, but this again depends on accumulated phase shift, and therefore is much less sensitive as an index of speed fluctuations having a rapid cycle of repetition, than of slow variations. On the other hand, the rapid fluctuations make more impression on the ear than slower variations involving the same range of speed; and undoubtedly the rapid fluctuations are more deleterious to musical quality. A slow beat, it should be recalled, is a part of the "voicing" of many musical instruments, but rapid beats mean an instrument out of tune. Next to steady tones the sounds most noticeably affected by speed irregularities are piano selections, in which high grade mellow toned pianos are changed to cheap "tin-panny" instruments in bad need of tuning.

One possible measure to secure constant speed was not employed, namely, refined workmanship. Commercial spur gears were used throughout and no close tolerances were called for, beyond the requirements that the drum run true and run freely and that the flywheel be balanced.

Film Instability.—It should not be inferred that no "grief" was experienced with the first magnetic drive machine. The first film we tried to put through it ran off the end of the drum. Putting a single tire in the middle of the lower pressure roller instead of one at each end seemed to help slightly, but still the film was unstable. Adjustments of pressure and tension had only small effect. Finally Mr. C. W. Rice made the apparently absurd suggestion that the guide flange on the roller marked "*A*" in Fig. 4 be removed. It worked.

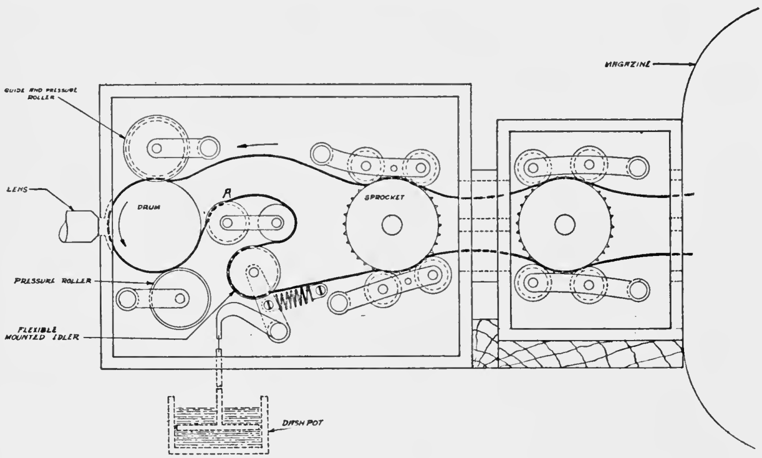

FIG. 4. Sprocket and roller arrangement in first magnetic drive recorder.

Thereafter the instability quite disappeared. There remained a slight sidewise weaving, due to the fact that the film was not sufficiently positively steered as it entered between the flanges of the combination pressure and guide roller above the drum. A change which gave the film a substantial wrap around the guide roller cured this difficulty.

The theory of the instability just mentioned is interesting. It is a factor which must be taken into account whenever a film is pinched between two rollers. As a simple case, consider a film guided at *A*, Fig. 5, running between a pair of rollers at *B* and guided again at *C*. So long as it is not displaced sidewise at *B* nothing happens, just as a balanced stick does not begin to fall if it is exactly vertical. Next suppose that the film is displaced, as shown in Fig. 6, being straight from B to C, and the kink occurring between A and B. The rollers at B do not encourage the film to move parallel to its center line but rather force it to move perpendicular to their own axes. Thus, if d_1 is the point now central with respect to the rollers, the next parts of the film to occupy this position will be d_2, d_3, d_4, successively, each farther from the center line of the film, so that the film is rapidly pushed off to one side. If, on the other hand, the film is tight from A to B and the kink occurs between B and C, it will be stable, for, as

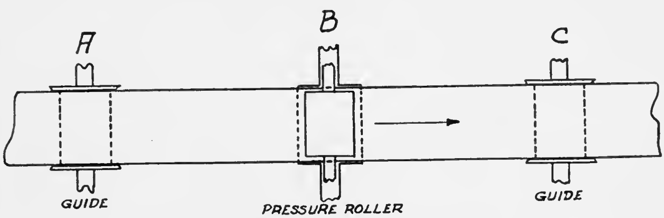

FIG. 5. Situation where instability may appear.

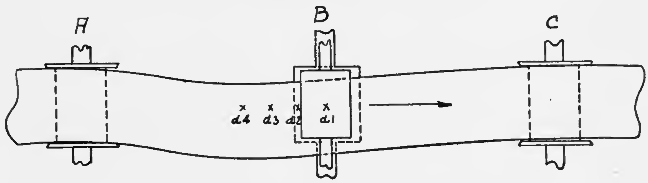

FIG. 6. Unstable condition at pressure roller.

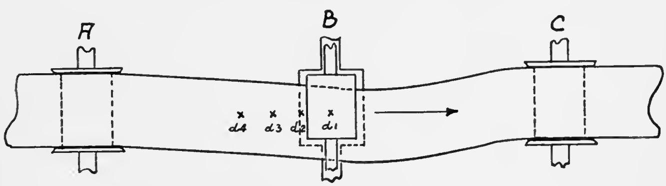

FIG. 7. Stable condition at pressure roller.

shown in Fig. 7, if the film is displaced, the parts of the film d_1, d_2, d_3, d_4 to reach the center of the rollers are successively closer to the center of the film.

Two ways of preventing such instability are now evident. (1) Provide positive guiding at B, or (2) make it easier for the kink to occur between B and C than between A and B. The second plan means making the film as stiff as possible between A and B, and flexible with respect to taking up edgewise displacements between B and C. The desired stiffness is helped by making the span short and straight or supported, and having considerable tension, while the flexibility is helped by low tension, a long span, and by carrying the film around bends. The desirability of low film tension on the feed-off side of the pressure rollers suggests the advisability of over driving rather than under driving the drum, and this feature has been incorporated in the commercial design.

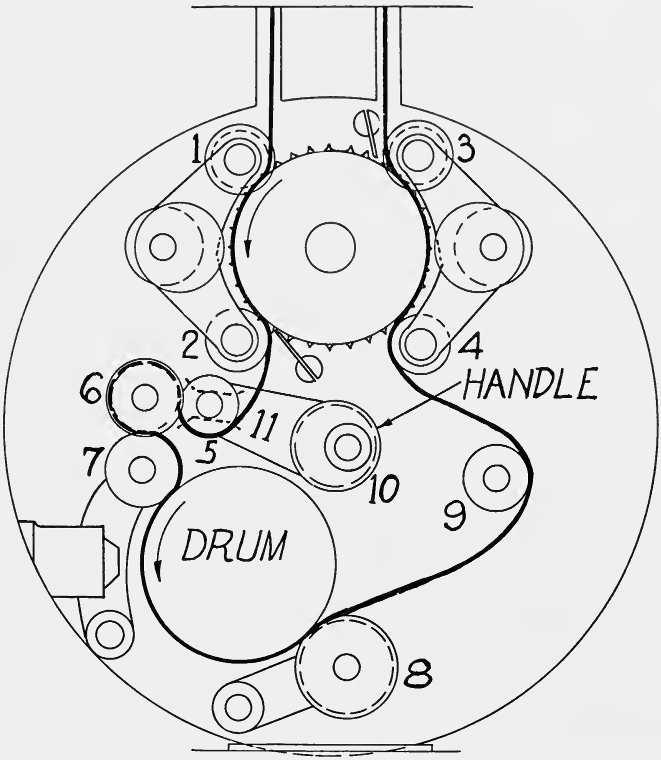

FIG. 8. Sprocket and roller arrangement for PR-4 recorder.

Design of Commercial Model.—The design of the commercial model was worked out by Mr. G. M. Jones and Mr. D. G. Tilton, to whom are due the elements of convenience, rugged and workmanlike construction, and neat appearance. All questions involving changes which might influence performance were carefully checked experimentally by Mr. Tilton, and the samples so far tested have given performance at least equal to and probably slightly better than the original. The general arrangement is shown in Fig. 8. Rollers, 1, 2, 3, and 4, are sprocket pad rollers. No. 5 serves to give a large wrap around the guide roller, 6. It can be moved clear of the guide roller for threading, by means of the handle, 10, which turns an eccentric and slides the carriage, 11, to the right. No. 8 is a rubber tired pressure roller.

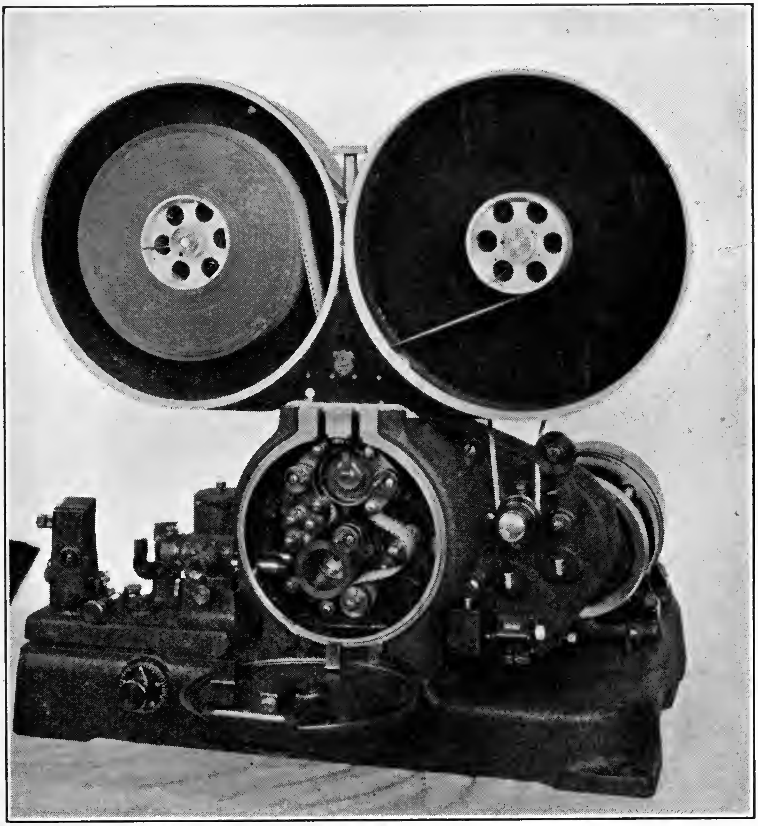

FIG. 9. Type PR-4 recorder.

No. 7 was originally intended as a pressure roller, but Mr. Tilton found that it worked as well when just failing to press the film against the drum, so a solid metal roller, clearing the drum by about $^1/_{32}$ in., is used here instead of a rubber tired pressure roller. The purpose of roller No. 9 is to cause the loop to take such a shape that the film is under slight tension where it issues from between the drum and the pressure roller, 8. If the pressure roller is dropped the film will still stay against the drum, and this condition, it was felt, would be favorable to the film always staying snugly against the drum when the roller, 8, is in contact. By way of comparison, notice the shape of the upper film loop in Fig. 4. With a loop of this shape the film is under slight longitudinal compression and would tend to jump away from the drum if the pressure roller were raised.

The excess magnet speed has been reduced in the new design to

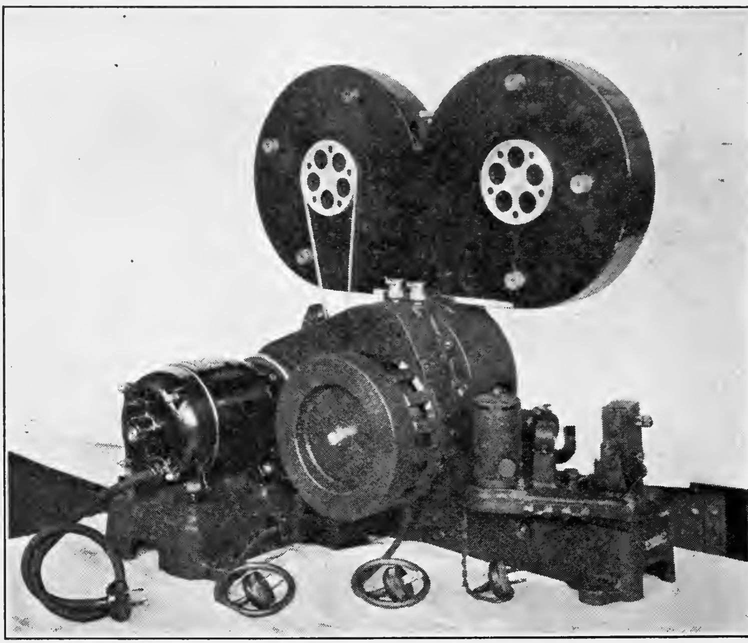

FIG. 10. Recorder from rear showing auxiliary magnetic drive.

15 per cent. This results in a stronger damping action for the same average torque supplied. On the other hand, more possibility of the magnetic drive itself introducing speed fluctuations is brought about by working with lower slip, but we have seen that this is not a real danger.

Adjustment of Magnet Current.—It has been usual to adjust the magnet current by running an exposed film through the machine and judging when the best value is reached from the appearance of the film loops. It is found that there is a considerable range of current within which both loops are definitely loops and not straight tangents from one roller to the other, and that records made with the magnet current within this range are about equally good. Normal operation is with the drum slightly over driven by the magnets, or, in other words, with the slack mostly in the lower loop and the film in the upper loop pulling back slightly. This condition is favorable to satisfactory guiding, and since the only pressure roller is the one below the drum, the slight tension in the upper loop is needed to insure that the film will stay snugly against the drum. As an illustration of the range of satisfactory operation, it was found in one machine tested that $1^1/_4$ amperes were required to throw the slack into the

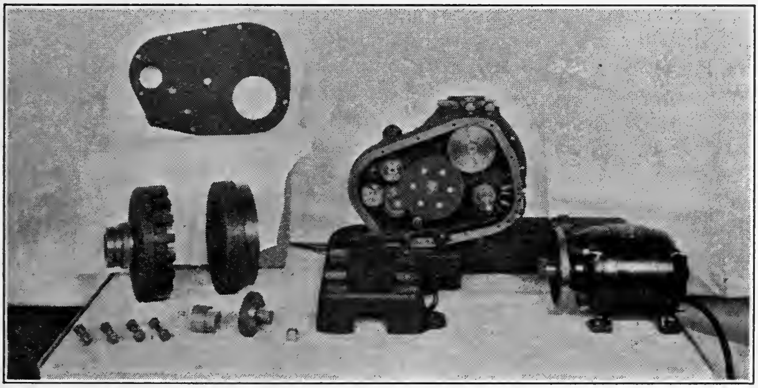

Fig. 11. Recorder disassembled.

lower loop, and that operation was satisfactory up to $1^3/_4$ amperes. With higher currents a slight tremolo appeared in steady tones recorded.

The wide latitude possible in magnet current setting, and the fact that steady motion of the film is not dependent on refinements in gear construction, are believed to augur well for consistently satisfactory results with the new machine.

The recorder imposes a very light load on its driving motor (about ten watts motor output), a favorable factor especially in case Selsyn motor drive is wanted.

The existence of slack film loops on either side of the drum might lead to the inference that there would be sufficient variation in the amount of film between the sprocket and recording point to cause uncertainty in regard to synchronism. Under actual running conditions the difference between a very loose upper loop and a tight one is not more than $^1/_8$ inch, which is less than the variations in threading between two sprockets in a machine having several driven sprockets. The amount of slack in the lower loop seems to have no effect on the operation of the machine, from $^1/_8$ inch to $^1/_2$ inch being satisfactory.

Fig. 9 shows the PR-4 recorder with door open and film in place. A rear view, Fig. 10, gives an idea of the magnet construction. In Fig. 11 the machine is disassembled to show the simple gearing arrangement.

DISCUSSION

MR. RINGEL: It has been my experience with regard to variations in speed due to irregularities in sprocket drive of film in projectors, that such variations are more noticeable on high frequency sounds than on low frequencies. This is particularly true in the case of higher pitched tones of the violin and the soprano voice. The raspy effects resemble the sounds obtained from an overloaded amplifier tube so closely as to deceive an inexperienced listener as to the true source of the trouble; sprocket variations, however, give objectionable results principally on higher frequencies. About a year and a half ago, we checked the cause of the trouble in a projector in the following manner:

A variable area record was made of a 2000 cycle tone on one of the recorders described by Mr. Kellogg. Its freedom from non-uniform speed was verified by folding a strip of film 7 or 8 feet in length back on itself, and observing that every cycle of the overlapped film coincided with every cycle on the film below. This film was played in the projector under test and the electrical output applied to two terminals of a Wheatstone bridge arrangement, one of whose arms consisted of a series resonant circuit turned to 2000 cycles. The bridge was balanced so that this frequency would be eliminated from the opposite pair of terminals which was connected to the recorder and recorded on film. Examination of this new film revealed little groups of 2000 cycle waves occurring at sprocket intervals —with no modulation in the spaces between these groups, indicating that the pull on the sprocket holes was responsible for changes in speed of the film, with resultant changes in the frequency of the reproduced sound.

MR. E. D. COOK: In this recorder we have one of the most beautiful developments we have ever seen. The principle involved is unique since most of the energy used to move the film is supplied through the best filtering means designed so far. I refer to the induction drive. The small amount of additional energy necessary to maintain the machine at a speed consistent with the number of sprocket holes passed per second by the sprocket, is supplied through the film itself. Because the sprocket is isolated by a loop from the drum, that percentage is again reduced. I don't think I have ever seen a mechanical filter system more unique or more desirable.

A COMPOUNDED GENEVA PULL-DOWN FOR MOTION PICTURE PRINTERS

FORDYCE TUTTLE*

Practically any mechanism used for moving film intermittently in motion picture apparatus can be run at a speed a great deal higher than the normal operating speed of intermittent printers without damage to the film. The time occupied for the actual movement of the film in an intermittent printer is time lost, of course, from the useful part of the shutter cycle; that is, during the movement of the film there can be no exposure. It would be advantageous, then, if the shutter cycle could be reapportioned, allowing more time in the useful part of the cycle by speeding up within the permissible limits the movement of the film.

This reapportioning of the cycle has been accomplished in several types of claw pull-downs by the introduction of "idle strokes" in the claw movement. Thus, a simple Lumière cam for up-and-down and a face cam for in-and-out pull-down movement, which normally takes 120 degrees for moving the film, can be made to take only 60 degrees of the shutter cycle by running the Lumière at double speed and allowing the claw to pull down the film only on alternate down strokes. Very little work has been done, however, in the shortening of the pull-down period in geneva pull-downs. A four-point geneva, which is the fastest geneva movement in common use, has a 90 degree pull-down period; that is, during one-quarter of the time the film is in motion. A six-point geneva has a 120 degree pull-down; an eight-point, 135 degree.

A mechanical arrangement for putting two genevas in series to speed up the movement of the film is shown in Fig. 1. In a printer, the shutter would be located on the shaft which carries the driving pin, *A*. This driving pin drives the first geneva, shown in a four-point form. For each complete revolution of the pin shaft, the geneva star shaft will turn through 90 degrees. The geneva shaft carries a gear which

* Development Department, Eastman Kodak Co., Rochester, N. Y. (Read before the Society at Washington.)

is meshed at a 4 to 1 ratio with a gear on a third shaft carrying the driving pin, *B*. For every 90 degree movement of the four-point geneva shaft, driving pin, *B*, will turn one complete revolution. The second geneva, shown as an eight-point geneva, can be made to move one frame of film during a movement of 135 degrees of the driver, *B*.

Now to reason out the time taken for the movement of the film on the basis of one complete revolution of driving pin, *A:* During 90 degrees or one-quarter of the movement of *A*, *B* moves 360 degrees. During 135 degrees of the movement of *B*, film is moving. One hundred thirty-five degrees is 135/360 of the total angular movement

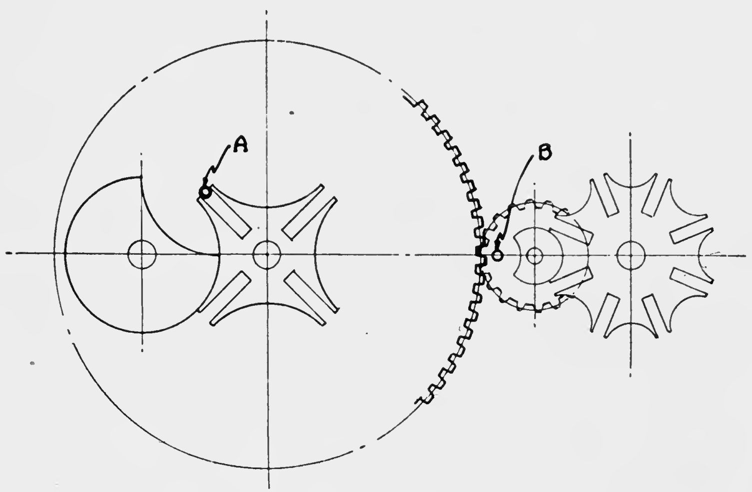

FIG. 1. An arrangement for compounding a four-point with an eight-point geneva to shorten the pull-down angle.

of *B*, but because *B* is not moving at a constant speed, it may take more or less than 135/360 of the time it takes *B* to make one revolution for *B* to move the 135 degrees. By making the pin, *B*, drive the geneva star while it is moving at its slowest speed or while it is moving at its fastest speed we can change the time during which film is moving from less than one-half to about one-sixth of the time *B* is moving; that is, we can pull down film while *A* is turning less than $^1/_8$ of a revolution or about $^1/_{24}$ of a revolution, thus cutting down the pull-down angle to less than 45 degrees or to about 15 degrees. The eight-point geneva alone would take 135 degrees to move the film. Combining the eight-point geneva with a four-point geneva can save as much as 120 degrees of the pull-down angle, and in a printer add more than 50 per cent to the time for exposure.

One of the chief advantages of the geneva form of pull-down is

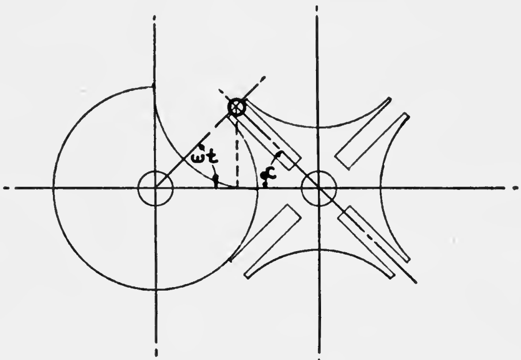

Fig. 2. Diagrammatic sketch of a compounded geneva showing the angles considered in the displacement, velocity, and acceleration formulas.

the way in which the film is accelerated during its movement. Other things being equal, a good measure of the damaging effect of a pull-down on film is the maximum positive acceleration of the film obtained

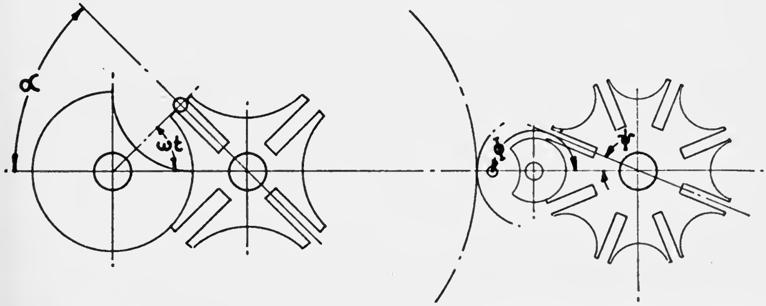

Fig. 3. Diagrammatic sketch of a compounded geneva showing the angles considered in the displacement, velocity, and acceleration formulas.

during the pull-down movement. In combining genevas, we must make sure that we have not undesirably altered the shape of the acceleration curve. Let us examine analytically the characteristics of the movement of film by compounded genevas and compare the

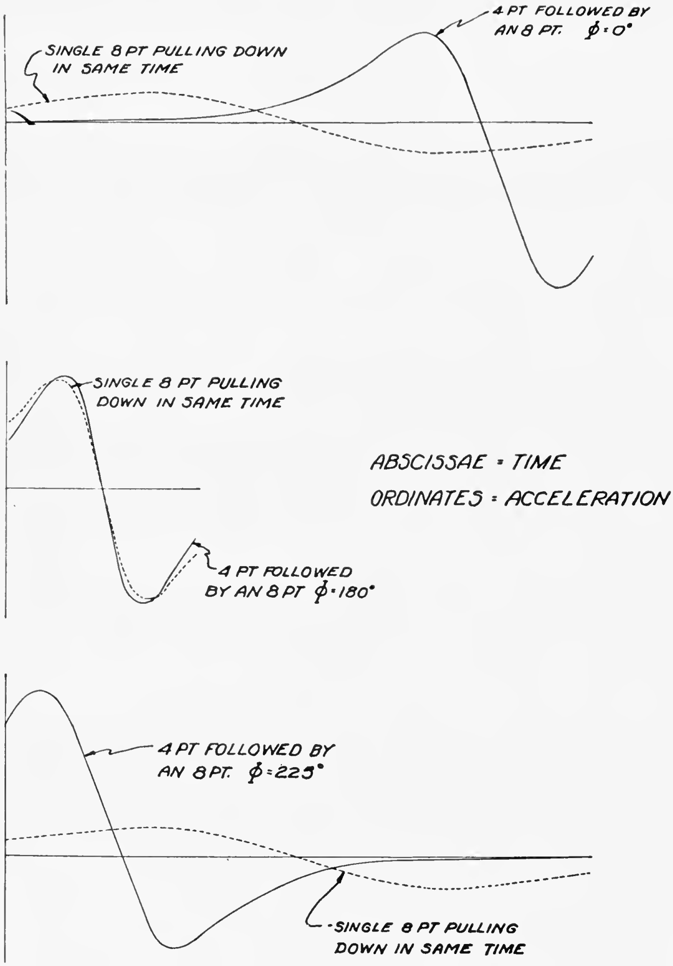

FIG. 4. Acceleration curves for single genevas and compounded genevas.

characteristics with those of the movement of film by a single geneva.

The equations for a single geneva movement are (see Fig. 2):

$$\text{Angular displacement} = \alpha = \tan^{-1}\left(\frac{k \sin \omega t}{1 - k \cos \omega t}\right)$$

where k = cos $^1/_2$ total pull-down angle

ω = angular velocity of the driving pin shaft

α and ωt are measured from the line connecting the centers of the driving pin shaft and the geneva star shaft.

$$\text{Angular velocity} = \frac{d\alpha}{dt} = \frac{k\omega(\cos\ \omega t - k)}{1-2k\cos\ \omega t + k^2}$$

$$\text{Angular acceleration} = \frac{d^2\alpha}{dt^2} = \frac{kw^2 \sin\ \omega t(k^2-1)}{[1-2k\cos\ \omega t + k^2]^2}$$

For 2 genevas in series (see Fig. 3):

$$\text{Angular displacement} = \psi = \tan^{-1}\left[\frac{c\sin\ (n\alpha-\phi)}{1-c\ \cos\ (n\alpha-\phi)}\right]$$

where c = cos $^1/_2$ total pull-down angle of second geneva
n = ratio of gear on first geneva to gear on second geneva driver
ϕ = angle through which driver, B, must move before $\psi = 0$

$$\text{Angular velocity} = \frac{d\psi}{dt} = \frac{d\psi}{d\alpha}\frac{d\alpha}{dt} = \frac{cn[\cos(n\alpha-\phi)-c]}{1-2c\cos(n\alpha-\phi) + c^2}\frac{d\alpha}{dt}$$

$$\text{Angular acceleration} = \frac{d^2\psi}{dt^2} = \frac{d^2\psi}{d\alpha^2}\left(\frac{d\alpha}{dt}\right)^2 + \frac{d\psi}{d\alpha}\frac{d^2\alpha}{dt^2} =$$

$$\frac{n^2c\sin\ (n\alpha-\phi)(c^2-1)}{[1-2c\cos\ (n\alpha-\phi) + c^2]^2}\left(\frac{d\alpha}{dt}\right)^2 + \frac{nc[\cos(n\alpha-\phi)-c]}{[1-2c\cos\ (n\alpha-\phi) + c^2]}\frac{d^2\alpha}{dt^2}$$

In Fig. 4 are shown some acceleration curves for single genevas and compounded genevas. The solid line curves are for the compounded genevas and the dotted curves are for a single eight-point geneva pulling down film in the same time as the compounded genevas.

It should be mentioned that a compounded geneva movement is not as impractical as it may seem at first glance. The first geneva does not affect the steadiness of the film in its rest position, and, therefore, although the first geneva should be made rugged, it does not have to be exceedingly accurate.

A NEW BUFFING MACHINE

A. S. DWORSKY*

The cleaning and processing units discussed in this paper have been demonstrated at a previous Society meeting, and a detailed description of the various cleaning processes at this time would be merely repetition. This paper will therefore treat only of the improvements effected in these units which contribute to a marked increase in operating efficiency.

Several important changes have been made on the buffing machine previously described before the Society. To the new model has been added another buff, thus making a total of seven buffs—6 on the emulsion side and one on the celluloid side of the film. A much better polish is thus obtained.

The back panel on the old model has been eliminated, and the new model offers an openwork construction which permits of greater accessibility and practically vibrationless running. A more desirable arrangement for the troughs containing the processing fluid has also been effected. The elimination of the back panel also permitted the addition of a second buffing train to the machine, thus doubling its capacity. Two buffing trains on the one machine require the attention of only one operator. Important economies are thus effected by increased production at no increased expense for labor. An improved arrangement for the trough containing the processing liquid has been provided and insures a constant supply of fluid.

The old model buffer had a direct motor drive. On the new model there has been provided a drive shaft. This addition eliminates any possibility of slippage, provides a more uniform drive, precludes the possibility of motor strain, and offers easier adjustment. A $1^1/_4$ inch flat belt is used from the motor to the drive shaft, and $^3/_8$ inch round belting is used from the drive shaft to the buffs. An adjustable idler arrangement has been added to the frame

* Dworsky Film Machine Co., New York City. (Read before the Society at Washington.)

to take up any belt slack. Thus no cutting of the belt is necessary.

A variable speed motor is another improvement on this new buffer. Through the use of this type of motor an adjustment of the buffing pressure may be had, in that when the motor is speeded up the flannel buffing surfaces offer a less velvety face to the film. Buff pressure adjustment is thus easily controlled.

Two idlers are provided for film take-up from the feed reel. Both single and double reels may be run. Approximately 8 minutes is required for the passage of 1000 feet of film through the machine. It should be noted here that the buffs rotate approximately five times as fast as do the idlers which feed the film, thus insuring a thorough buffing process.

Idler adjustment has been greatly simplified by the open face spacing arrangement of the machine components.

The celluloid buffer is an integral part of the frame and is the first link in the buffing chain. Buffer shafts have been improved by a wider spacing of the bearings. The threading operation has been greatly simplified by the open construction of the machine.

A wiper with three idlers upon which is wrapped cotton flannel is provided at a spot just before the film enters the take-up reel. These idlers are adjustable. The flannel wrapping on these idlers may be changed quickly and easily through the use of a small gripper. This wiper insures clean film just prior to rewinding.

An automatic braking arrangement is provided in the event of a film break. Two switches are used—one for the arm idler and one for emergency use. This new model buffer is constructed of aluminum throughout, which contributes to ease of handling and durability. The flannel buffers will efficiently polish single reels without changing. Adjustment of these buffers is possible, of course, during this period.

Among the other units are a 35 mm. and a 16 mm. combination cleaner-wiper. The former is for exchange and projection room light duty work after the print has been run several times. Weighing but five pounds, this unit affords a compact yet durable wiper.

Many improvements have also been made on the film renovator. These changes follow closely those made on the buffing machine. A knee control rewind has been supplanted by a foot control model.

The units described may be considered as important aids in insuring faithful reproduction of all film subjects. Beautiful photography, sound, and color mean nothing if the quality of reproduction suffers from the effects of unclean film. Eyestrain and impaired sound quality are the result of unclean prints. Production costs on color and sound films run into many thousands of dollars. Efficient print cleaning and processing should interest the motion picture engineer, for they are of prime importance to him in that they are the cheapest possible insurance for the faithful reproduction of his work.

THE CINEMATOGRAPHY OF BROWNIAN MOVEMENT WITH THE FILMO CAMERA

R. FAWN MITCHELL*

"Brownian movement" is the term applied to the peculiar spontaneous movement which is inherent with small particles in suspension in a fluid or colloidal solution. Without digressing to give any further explanation regarding this phenomenon, let us consider a specific example of research work which necessitated taking motion pictures of such particles.

The author was called on to assist a medical friend who was conducting an investigation wherein the Brownian movement of the proteid particles in the blood cells, and in the blood serum, played an important part. For the purpose of facilitating comparisons and furnishing more effective proof of the results, it was desirable that motion pictures be taken of the movements and activity of these particles under different conditions. This paper will outline the problems, methods, and results of the particular investigation, but the same procedure is equally applicable to the cinematography of any similar subject.

To permit visualizing the problem more clearly, let us enumerate some of the salient factors involved. First of all, the ordinary white corpuscle has a diameter of about two or three microns, while the proteid particles therein are about one-tenth of a micron.

It was desirable that the pictures of the cell be sharp and that the small particles should register so that their movements could be plainly seen. This indicated the magnification necessary.

The next question was that of illumination. Owing to the high magnification involved, the use of an arc was found imperative as the image of a Mazda lamp filament registered in the microscope gave a very uneven illumination over the field. The Ediswan Pointolite lamp was tried, but gave only sufficient illumination to give an image of the cells at small magnifications, and it gave no trace of the colloidal particles at all on the film.

* Bell & Howell Co., Chicago, Ill. (Read before the Society at Washington.)

Focusing is probably the most serious question for several reasons. The particles are so small and the magnification so high, that the slightest movement beyond very small limits caused failure. In fact, even when using an extremely thin film of serum on the slide, the particles could easily move up and down in the fluid and thereby move out of focus. Therefore, it was necessary to be able to check the focus at any instant, preferably even while taking the picture.

As previously indicated, the use of an arc lamp was found necessary. Unfortunately, the arc made operation more difficult, though the light did enable good exposures to be obtained. Slight inequalities in the burning and in the feed of the carbons often threw the light spot out of the microscope field entirely. Even a movement in the position of the crater from the center of the carbon darkened a portion of the field. This necessitated strict care at all times, and indicated still further the advisability of being able to see the subject all the time while making the exposure.

This question was solved by the author by using a Microphote in conjunction with a Filmo camera. The essential of this unit is a split-beam prism which transmits about 5 per cent of the light and reflects the rest into the camera. With the illumination available, it was possible to check the focus and also see instantly if the light should happen to change.

However, before photographing extremely small particles, it was found necessary to have some means of focusing with the maximum illumination available. For this a reflex device was screwed on the Filmo camera itself. The reflex consists of a prism suitably mounted to permit it to slide in front of the camera aperture and to reflect the light to a ground glass and focusing eyepiece.

The eyepieces of the Microphote and reflex were adjusted so that both were in focus. This adjustment was found to be of great help in photographing particles in the serum adjacent to a cell—the subject was focused in the reflex and then the focus of the cell was checked through the Microphote eyepiece while actually filming. The split-beam prism passed just enough light to permit this being done satisfactorily.

In photographing such small particles, they had to be magnified sufficiently to register on the film. This brought in the question of grain and complicated matters because the higher the magnification, the more light was needed, and the greater the difficulty in keeping the particles in focus.

A series of preliminary experiments was conducted with several arc lamps, different carbons, and different films, using both the Filmo (16 mm.) and Eyemo (35 mm.) cameras. Tests were taken at different magnifications so as to provide a comprehensive comparison of the results under different conditions and thereby indicate the best combination.

Using the Eveready Sunshine (type A) carbons, a little better result was obtained by using 16 mm. panchromatic reversal film, but the best combination was found to be the Eveready Therapeutic (type C) carbons and 16 mm. orthochromatic film. The difficulty here was that these carbons have quite a large core which caused sputtering and made the crater jump. This was most exasperating because just as soon as one had a suitable subject all lined up and focused, the crater would shift and necessitate adjusting the reflector to center the light again.

Finally, some German carbons with a very small core were tried. These carbons gave a very much steadier arc, and while they did not give as much effective light as the other carbons, the extra steadiness was more valuable.

The comparative loss of illumination was overcome by cutting out some of the resistance used with the arc, increasing the current, and also by using 5× and 7× eyepieces rather than the 7× and 10× used with the other carbons. Probably the greatest help was the ability to run the Filmo camera at half speed or less and still obtain perfectly even exposures.

In this manner, we were able to use the 20× eyepiece for picturing cell structure as the cell refracted so much more light than the particles, that the higher magnifications could be used.

Probably the most peculiar aspect of these tests was the fact that the combination of A carbons, or the thin cored German carbons, with panchromatic reversal film gave better definition for pictures of white cells. However, when it was desired to photograph the small colloid particles only, then the use of the C type carbons and orthochromatic reversal film gave far better results. We have, therefore, reached a point where different combinations are used according to the size of the object we want to photograph.

At a casual consideration, it would seem that the ultra-violet, to which ortho film is more sensitive, and of which the C carbon generates more, resolves the smaller particles more effectively than the rays of longer wave-length. The cells, on the other hand, are more refrangible and can refract the longer waves and permit the higher intensity of the red rays generated by the A carbons registering on panchromatic film.

L. A. Jones and J. I. Crabtree[1] give curves showing the spectral sensitivities of films, which have been reproduced in Fig. 1, together with curves showing the corresponding spectral radiation of the A and C carbons.[2]

It is rather interesting to compare the spectral emission of the carbons used, with the spectral sensitivity of the orthochromatic and

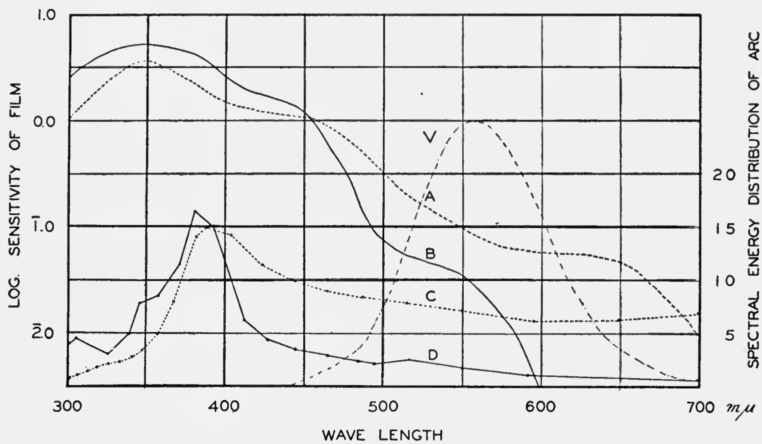

FIG. 1. Graph showing comparative spectral sensitivity of orthochromatic and panchromatic film, and the comparative spectral energy distribution of arcs.

A. Panchromatic film
B. Orthochromatic film
C. Eveready Sunshine (A) carbon arc
D. Eveready Therapeutic (C) carbon arc
V. Visual luminosity curve

panchromatic films. The A carbons have a maximum radiation intensity at about 390μ and the C carbons at about 375μ. The maximum intensity of the A carbon is 15×10^{-7} watts per square millimeter at a distance of one meter. The intensity of the C carbon is about 16×10^{-7} watts per square millimeter. Unfortunately, data as to the radiation characteristics of the thin core carbon are not available, but it seems to give approximately the same results as the A carbons with less sputtering.

A rather interesting fact was brought out in checking the possibilities of taking 35 mm. negatives and making reduced prints, as compared to direct 16 mm. pictures.

In order to obtain the same comparative size of image on the two sized films, a greater magnification had to be used for 35 mm. film. Due to the focusing and illumination problems, it was found that the direct 16 mm. picture was most satisfactory for our particular work.

Therefore, while our remarks apply to the use of the Filmo camera, it can be stated at this point that the Eyemo camera can also be used and very satisfactory results obtained, should the use of 35 mm. film be preferred. Fig. 2 shows a sample of the work done with the Eyemo camera with the same set-up of microscope, light, and Microphote as used with the Filmo camera.

FIG. 2. Blood cell showing hog cholera germ. (Taken with Eyemo camera.)

Incidentally, the stills convey a very poor impression of the results actually obtained on the screen. It is intensely fascinating to see these pictures reproduced on the screen, *in vivo*, actually reliving and pulsating with all the mysterious manifestations so characteristic of Brownian movement.

Fig. 3 shows the particles in an *Eosinophile* and a *Neutrophile* cell, and gives a fair idea of the results obtained, though, unfortunately, the small particles outside of these cells do not show.

Fig. 4 shows the particles even better. This is a cell taken from the saliva. Note the well defined nucleus and the outer membrane.

Figure 5 shows a mass of *amoebae* and shows the small particles very clearly.

Figure 6 is from a scene showing the actual splitting up of an *amoeba* in addition to the Brownian movement of the particles in it.

MODUS OPERANDI

Fig. 7 shows how the apparatus was arranged to secure the pictures shown.

The Filmo camera and microscope are set up on separate stands to prevent camera vibration being transmitted to the microscope.

A microscope arc lamp, operated on direct current, provides the light which is focused on the plane mirror of the microscope.

It is best to set the light to project horizontally onto the mirror. This insures the image of the crater being focused by the cardioid

FIG. 3. Enlargement from scene showing Brownian movement in an *Eosinophile* and a *Neutrophile* blood cell.

FIG. 4. Cell from saliva. Shows intense activity on screen. Note well defined nucleus and outer membrane.

condenser as a circular spot. Also, sparks from the carbons cannot drop onto the focusing lens of the arc lamp.

A water cell is inserted between the light and the microscope to absorb as much heat as possible.

The cardioid type of condenser was found best for this work. It concentrates the light at such a flat angle that the microscope slides have to be just the correct thickness so that the focal point of the condenser will be in the film of serum on the slide.

To avoid excessive scattering of the light and the consequent lack of contrast in the dark field, and also on account of the motion of the particles, the serum film should be kept as thin as possible. A small drop of serum is put on the slide, the cover glass dropped on and gently squeezed with a clean blotter. Incidentally, scrupulous attention has to be paid to the cleaning of the glass slides and cover glasses to remove every trace of dirt residue in the tiny crevices of the glass surfaces. Often, it is found necessary to put the glasses through two or even three washings—starting off with ether, then alcohol, and, finally, hot distilled water. This is extremely important, owing to the high magnifications involved, and also due to the fact that any trace of sediment on the slide seems to have a tendency to attract the small particles in the serum and cause them to settle.

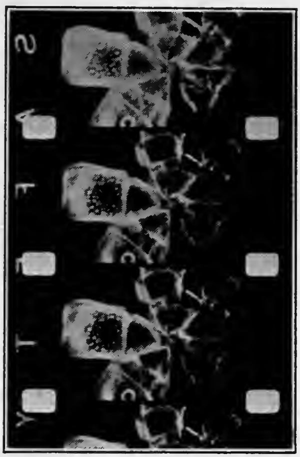

FIG. 5. Pond amoebae.

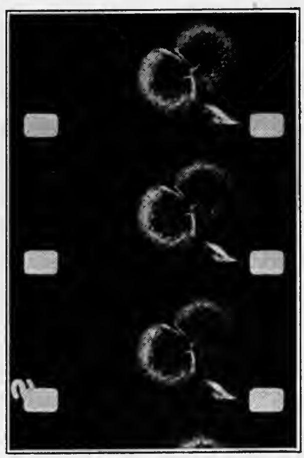

FIG. 6. Pond amoeba splitting up.

Before putting the slide on the microscope, a drop of pure cedar oil is put on the condenser. Then the slide is set in position and the condenser raised until contact is made between the slide and the drop of oil. Then the 16 mm. objective is swung into position and the 5× eyepiece used to align the condenser and the light.

This operation is rather difficult to explain, as it is largely a matter of trial and error.

The light is focused to just cover the plane mirror. The mirror is then adjusted and the condenser raised (or lowered) until the image, as seen through the eyepiece, is that of a perfectly circular spot of light surrounded by a dark circle, and this, in turn, by another circle of light. The eccentric adjustment of the condenser is then operated to place the spot in the exact center of the field.

Then another drop of cedar oil is put on the cover glass of the slide and the oil immersion objective swung into position and lowered until it just touches the drop of oil. The Zeiss 3 mm. oil immersion

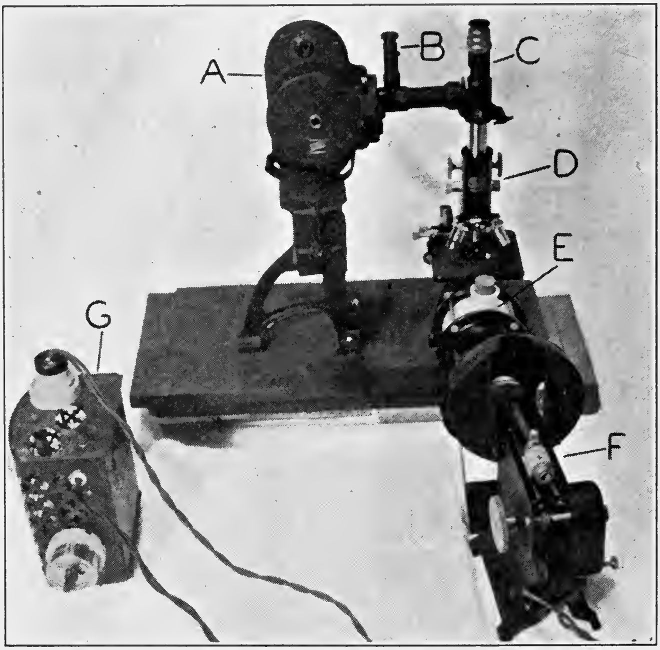

FIG. 7. Set-up showing the arrangement of the apparatus for ultra-microscopic cinematography.

A. Filmo camera on adjustable stand.
B. Reflex focuser.
C. Microphote.
D. Microscope.
E. Cooling cell.
F. Arc lamp.
G. Arc lamp resistance and switch.

objective, which has a numerical aperture of 1.0 with the iris open, and 0.85 with the iris closed, was employed for all tests.

$$\left(\text{Numerical aperture} = \frac{\text{Sine of } {}^1/_2 \text{ the angle of aperture}}{\text{Refractive index of the immersion fluid}}.\right)$$

The 20× eyepiece is then substituted for the 5×, the microscope focused, and a suitable subject located.

A rather peculiar fact was discovered, in that it was easier to photograph extremely small particles when they were adjacent to a cell. The cell seemed to reflect light and facilitate the photographing of the small particles adjacent to it.

When a suitable subject is found, a 7× or 10× eyepiece is substituted, and the Microphote placed on the microscope tube. The adjustment of this unit is quite important.

First of all, the clamp on which the Microphote rests is set on the microscope tube, just below the eyepiece. With the eyepiece of the microscope in position, a piece of ground glass is held above it until the image appears sharp. The distance from the top of the clamp to the ground glass is measured in millimeters and the scale of the Microphote set at the corresponding position. This sets the Microphote prism at the focal point of the microscope eyepiece.

When the reflex is used, the final adjustment can be made with the reflex and the eyepiece of the Microphote set to match the eyepiece of the reflex. However, it is necessary to set the Microphote prism very accurately to catch all the light passed by the eyepiece.

With the Microphote in position, the camera on its base and ready to operate is moved over so the light trap on the connecting tube fits into the side of the Microphote. Care should be taken, however, not to let the two units touch each other.

The sliding prism on the reflex is moved down to intercept the light coming from the Microphote, and the image focused. The subject is then examined through the Microphote to make certain that it is in the center of the spot of light. Then the prism of the reflex is retracted and the picture taken.

While the Filmo is operating, the object must be carefully watched through the Microphote eyepiece in case the crater of the arc should move even a shade.

Possibly, at this point, it might be interesting to figure just what magnification is obtained with the equipment described.

Magnification is obtained by multiplying the effective magnification of the objective by the power of the eyepiece used. The magnification of the 3 mm. oil immersion objective used is given as 60×.

Therefore, using the 10× eyepiece, the total magnification would be 600. Due to the inserting of the reflex device, the camera was placed a little farther away, so that the magnification on the film was actually higher than this figure. The Filmo projector was used to show a picture 8 × 10 ft. This means that the 16 mm. film was enlarged about four hundred times, so that the total enlargement on the screen would run about two hundred and fifty thousand.

In conclusion, it is hoped that this analysis of the particular problem presented, and the manner in which it was solved, will help others to obtain results in the extremely fascinating field of ultramicroscopy.

REFERENCES

[1] JONES, L. A., AND CRABTREE, J. I.: "Panchromatic Negative Film for Motion Pictures," *J. Soc. Mot. Pict. Eng.*, X (October, 1926), No. 27, p. 140.

[2] "Radiation Characteristics of Eveready Sunshine and Therapeutic Carbons," National Carbon Co., Cleveland, Ohio. Form CP. 1044.

A METHOD FOR THE DETERMINATION OF EXPOSURES IN CINEMATOGRAPHY*

R. P. LOVELAND

One of the questions confronting a photographer which must be answered each time before he starts taking is "What exposure is to be given?" This question must be answered so frequently in actual motion picture work that a quick and easy method is needed to give the answer. The experienced photographer is fortunate, for he is able to judge the best exposure after inspection of the subject or its image on the ground glass of the camera. Persons with the ability to do this, in most cases, are not interested in other methods, and this paper is not for them. The man, however, whose subjects vary from insects to studio sets may find that it takes a long while to gain the ability to judge exposure by inspection. Moreover, the accuracy of the exposure determination needed varies greatly from time to time. The man, who either is inexperienced in photography or is working in some field new to him, must seek to determine his exposure. For work in the field with daylight illumination an actinometer may be useful, but it is of little value in the studio. Various optical methods may be useful in the studio including the use of a photo-electric cell for measuring the total illumination reflected toward the camera. Their chief qualification is often the speed of the determination. They may not be practical under all conditions since the range of any one instrument is usually limited. The exposure value must allow for the degree of the close-up, all the way up to the high magnifications obtained with a microscope. The range of illumination included between that used for the cinematography of growing plants and that required for some miniature work is enormous. Moreover, it may not always be satisfactory to use the value of illumination obtained by integration of the whole field. The background may form a large fraction of the area, and yet its rendering may be unimportant.

The final resort of the operator, who must determine his exposure

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in the studio or laboratory, is to make the usual trial exposure-development test. Objections to this procedure are only too well known. For one thing, in order to tell by inspection of the frames of the test strip whether the trial exposure will give a good negative, it is necessary that the development of this test strip be comparable to that which the negative will receive. This is a time-consuming process. For another, the test requires good personal judgment in the inspection of the trial negative. Except in the hands of the experienced, the result can never be as accurate as when there is an objective standard.

Requirements of Ideal General Exposure Method.—The chief requirements of the ideal general exposure meter or method of exposure determination may be enumerated as follows:

(1) It must utilize only the light to be used in photography or be proportional thereto. That is, it must correctly take into account any camera distance or field magnification. It must also properly consider the effect of back and side lighting, spotlights, and other lighting effects. Apparently it is necessary to form an image with a lens, either an auxiliary lens or that of the camera to be used.

(2) The method must be controlled by the characteristics of the subject, its range of contrast, the relative position in the illumination scale of the centers of interest; and it must be able to disregard areas whose correct rendition is unimportant, as in silhouette work, photomicrographic transparencies, and work of similar nature. This seems to eliminate any method that measures only the integrated whole of the illumination from a subject.

(3) It should be able to measure illumination of unlimited range, and its range of working conditions should also be unlimited. It should be useful in both field and studio.

(4) It must be useful whatever the color distribution of the illumination, and have the same spectral sensitivity as the emulsion being used.

(5) It should eliminate personal judgment and render photographic experience unnecessary. Obviously, therefore, there must be some objective standard for comparison purposes.

(6) The method should be comparatively quick and simple to operate.

Qualifications of Method Recommended.—The method proposed does not completely fulfill all of the conditions enumerated. It is strictly a studio method and so violates condition (3) as to its generality, although there is no limit to the range of illumination that can be measured. Moreover, it practically eliminates personal judgment as a factor. Within the studio (or where a dark-room is available), its general applicability is its greatest value; but it cannot compete with the faster optical methods in their special fields, which include almost all dramatic cinematography. It is applicable wherever the usual trial exposure-development test would be used, but it is considerably faster and more accurate. It should be valuable for special process work where two independent exposures must be matched as in attaching a cross dissolve or in making a composite scene.

Principles of the Method.—The basic assumption of the method is that negative can be depended upon to have a constant degree of development from day to day. The increased accuracy of present-day development of negative, due largely to the increasing use of developing machines, makes this assumption a practical one. The essence of the method is as follows:

A trial guess exposure is made behind a lens, either that of the regular motion picture camera in position, or that of an auxiliary hand camera, using a piece of the same film as will be exposed for the final negative. Other small areas of that same strip of film have had impressed on them a series of exposures whose values are known in terms of the development to be given the negative, in a way to be explained later. This group of previous exposures is called the standard exposure. Now, whatever the development of this test strip, as long as the fog is not excessive, *two areas having equally blackened images must have received the same exposure* since the development of each was identical. We have but to find a density of the standard exposure equal to a portion on the trial picture, to know the exposure value of the latter in the same terms as the standard is known. This may be determined for as many points of the trial picture as is desirable. Two such points are usually sufficient. Naturally, the fastest and easiest development will be given.

The procedure is based upon the sensitometric method and its principles are well known. The vital difference between this and the usual trial exposure-development method is that an independent photographic standard is set up. This standard is a photographic image which has had the standard exposure and the same development as that given the final negative, which we will call the standard development. The photographic tones of the standard image are arranged in orderly sequence; in Fig. 1 is shown a film in which the exposure of each successive step was half that of the previous one. This photographic step strip is a contact print made from a similar sensitometric tablet to be described later. The exposure can be accurately repeated. The steps of this photographic standard image are measured on some such instrument as the densitometer described by Capstaff and Purdy.[1] The results, of course, are expressed as densities which are the logarithms of the opacities of each step. These densities are then plotted as ordinates against the relative exposure that produced them, to give the familiar characteristic curve (Fig. 2) which is called our reference standard. The regularly spaced step numbers are the units actually used. Here we recognize the straight line portion, produced by exposures which, by definition, lie in the latitude of the film. In actual practice, of course, much of the image of the usual motion picture negative lies on the lower curved portion or toe, and is useful in forming the positive image down to where the gradient is about 0.2.[2] By the term, gradient, is meant the slope of the curve or the trigonometric tangent of the line which is tangent to the curve. The slope of the straight line portion, termed gamma, is a measure of the degree of the development, and in this case is assumed to be constant for all the negative for which this reference standard is to be used. Moreover, the speed of the film or the position of the curve along the exposure axis will be constant as long as the film of the same emulsion number is used. We have, on a number of occasions, found the reference standard obtained with one emulsion number to be quite good enough for use with another.

FIG. 1. Sensitometric strip having standard exposure and development.

[1] CAPSTAFF, J. G., AND PURDY, R. A.: "A Compact Motion Picture Densitometer," *Trans. Soc. Mot. Pict. Eng.*, **XI** (1927), No. 31, p. 607.

[2] JONES, L. A., AND RUSSELL, M. E.: "The Expression of Plate Speed in Terms of Minimum Useful Gradient," *Proc. Seventh Internat. Cong. Phot.* (1928), p. 130.

A family of standard curves may be shown on the same reference standard. Each curve has a different gamma and, therefore, represents a different time of development. These will be the various degrees of development that are available for negative. Each curve is a possible reference standard.

Routine Procedure.—Our actual procedure is as follows: The film to be used for one production is set aside and the emulsion number recorded. At some convenient time before production begins, several photographic standard images, such as shown in Fig. 1, are prepared, being given the standard exposure by printing through the

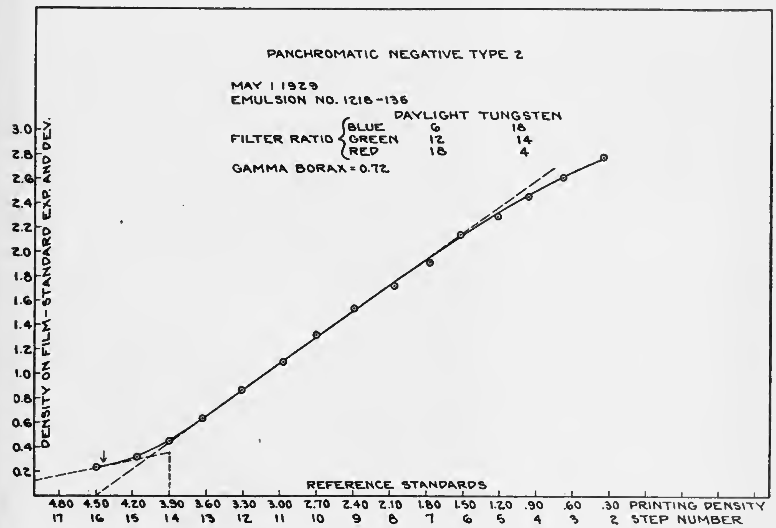

FIG. 2. Characteristic curve of negative material.

sensitometric tablet under constant specified conditions and sent to the place where all negative is developed to receive the same development. The curves which are our reference standards are prepared from the measurements, and all interesting constants, such as the gammas and tri-color speed ratio, are noted on the graph.

A quantity of other short strips of the same film are exposed similarly and these undeveloped strips bearing the latent step image from the standard exposure are kept for future use where they are readily accessible, for instance, in one black can inside of another. One strip is usually kept ready in a small auxiliary hand camera, with an unexposed portion behind the lens.

The best exposure for any given studio subject or special process negative can then be determined at any time as follows:

(1) A rough guess as to the exposure value is made and a picture is taken on one of these strips which has also been given the standard step exposure, or a strip from a trial exposure made in the motion picture camera is stapled to a standard exposure strip in the dark-room. In case the operator has very little idea of the best exposure, two trial pictures with a large exposure difference may be made on the one strip.

(2) This test strip (Fig. 3) of film is then developed and fixed by the most rapid and convenient method. We merely wish to discover two equal exposures so that a good quality picture is unnecessary on the test strip.

FIG. 3. Sensitometric image and picture on same strip of film.

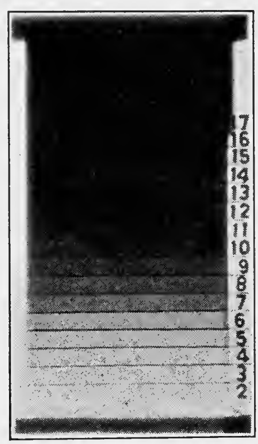

FIG. 4. Sensitometric tablet negative.

Hence, the development time is a matter of seconds.

(3) The two images on the wet film strip are cut apart and the exposures of the standard image, equal to those given to points in the test picture, are determined by examination under a comparison mi-

croscope. The highest light of interest is put under one lens and the step number of the density most nearly equal to it is easily found, since the two are brought optically side by side into the same visual field. The number of the step density nearest to that of the deepest shadow in the test picture is also noted. For example, the density of the candle flame in Fig. 3 may be most nearly equal to that of step 7 and, therefore, it has had about the same exposure. Likewise, the black support of the ring stand has been given the same exposure as step 15 of the standard image. These two operations are merely a matter of sliding the step image back and forth in a track under one lens of the comparator and are accomplished in a few seconds' time.

(4) Referring to the reference standard (Fig. 2), the position of the test picture on the characteristic curve is at once evident, as it would occur with the standard development to be given the negative. The two step numbers represent the upper and lower illumination limit which produced the tones of any importance. In our example, it can be seen that the principal tones of the picture lie between the steps 15 and 7 on the curve. The candle flame could have been neglected and the white candle taken as the highest light to be rendered with detail.

(5) The exposure factor needed to change the density range of the photograph to any other portion of the curve can easily be determined without further trial, by the number of steps of known exposure difference needed to improve the exposure. The final picture, it may be noted, can be definitely placed anywhere one wishes on the characteristic curve. Referring to our example again, if it were decided to place the picture between steps 13 and 5 on the curve we count up the steps in geometric ratio (2, 4, 8, *etc.*, where the step difference is two), and our exposure factor would be 4. If we give the subject four times the exposure of the trial picture the negative will lie between those steps on the curve.

The total time required for this complete determination, from the time the trial exposure is to be made until the factor is known, takes from nine to ten minutes.

Two scenes taken in different cameras at different times can be matched by this method, if film of the same emulsion number is used in each case and each film given the same development. Although the exposures are only determined in terms of the step units the density difference between the exposure steps of the sensitometric tablet may be made as small as practical convenience will allow. Therefore, the possible accuracy of the match is limited only by the degree of constancy in the development of negative. Exposure steps differing by the factor, $\sqrt{2}$, instead of 2, would consume very little if any extra time in the comparison. It is easily possible to estimate the exposure match to within one-half a step unit. This method might be valuable in testing or research work since the position of a picture on the characteristic curve is easily determined.

Technic and Apparatus.—The standard exposure is produced by exposing the film through a sensitometric tablet made according to methods described by Jones and Crabtree,[3] except that the steps are

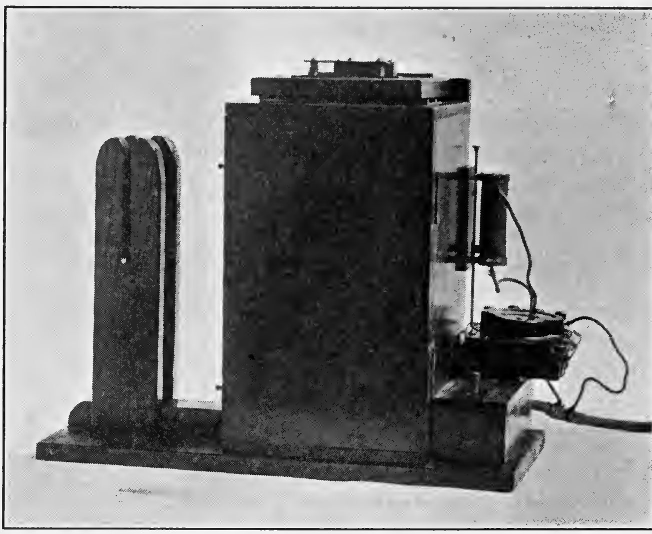

FIG. 5. Exposure box.

only 4 mm. wide. Our tablet has seventeen steps (step 1 has no density) which have a constant density difference of 0.3. Each step produces twice the exposure on the film as that produced by the next denser step. Another exposure difference might have been chosen, such as a density difference of 0.15, but the total range between the first and last step must be large. If the lowest step is perfectly transparent (density = 0) the highest should have a density of about 5.0

[3] JONES, L. A., AND CRABTREE, J. I.: "A New Sensitometer for the Determination of Exposures in Positive Printing," *Trans. Soc. Mot. Pict. Eng.*, No. 15 (1922), p. 89.

to take care of possible over-exposures in the trial picture. It is not necessary to have the density difference between each step of the tablet strictly a constant as long as the values are known because in making the characteristic curve of the test film, the densities printed on the film are plotted against the density that produced them, and the same curve is still obtained whatever the distances between the plotted points. It is wise to place a thin sheet of Kodaloid over the density step tablet to protect it from dirt and abrasions.

A simple exposure box of the usual type is used to produce a con-

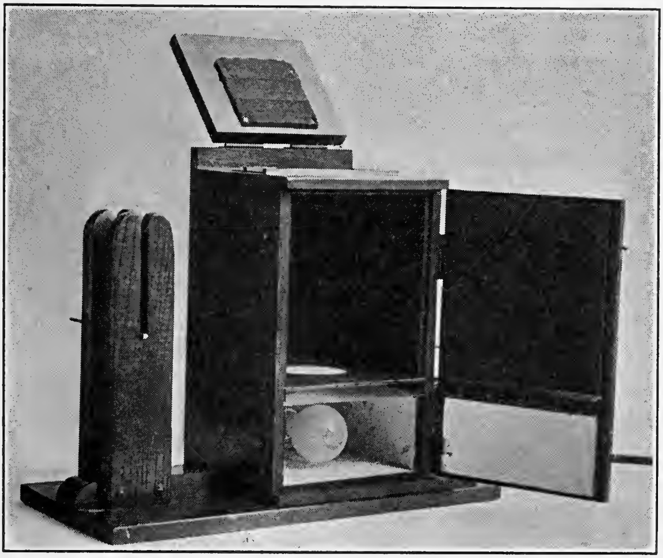

FIG. 6. Exposure box open.

stant exposure (Figs. 5 and 6). A well diffused illumination is needed that is uniform over the surface of the step tablet. The intensity of the light is varied by either changing the wattage of the bulb or the size of a black cardboard diaphragm inside the box. The illumination value is kept constant by keeping the current at a constant amperage as read on the meter and controlled by a rheostat. Exact limits to the exposure interval are obtained by using a door jamb switch. An automatic exposure interval timer would be a big advantage since otherwise a seconds clock must be accurately read in the dim light of the dark-room and the exposure prolonged to at least eight seconds for the sake of accuracy.

Two different notches are automatically cut into the edge of the film at each end of the exposure tablet so that the exposed area will not be loaded behind the lens during an exposure test with the auxiliary camera. Either 35 mm. or 16 mm. film may be used in the box.

It is most convenient to use an auxiliary hand camera for the test exposure whenever possible, since it is then unnecessary to cut the film in the magazine of the motion picture camera when several scenes are taken in succession. Any camera will do, such as the vest pocket type, that allows easy loading of a short strip of motion picture film. For most purposes the difference is negligible between $^1/_{25}$ second given by the hand camera shutter and the $^1/_{35}$ second given by a motion picture camera.

The time of development and fixation is the chief factor in the total time required for such a determination. In this case time can be reduced to a minimum since the determination is almost independent of the nature of the test development and quality is not a consideration as long as there is not too much fog.

It is very convenient to keep the developer in two solutions, as recommended by P. V. Joannovich.[4] The first solution contains the developing agent, sulfite, and bromide; the second solution is made up of 5 per cent sodium hydroxide and 1 per cent formalin. The film is merely dipped first into Solution *A;* then, after the correct interval, transferred to the caustic Solution *B* without rinsing. Thus no time is consumed in preparing for development and the developer keeps well as two solutions, which can be kept and used in the same (Mason jar) containers. The time of development given is such as to make the gamma approximately equal to that of the standard development. While it is not at all essential to match the development of the negative even approximately in this test, the development must not be too strong in order to keep down excessive fog. It is as easy to keep the development approximately at this same gamma as any other and it helps to prevent gross mistakes. If the test is a fairly good looking negative it is an aid in developing the judgment as to its position on the characteristic curve since the judgment is so soon checked up.

Any two-solution developer can be used in this fashion, forcing the speed of development by substituting caustic soda in Solution *B* for

[4] *Lux*, **37** (Jan. 1, 1926), p. 23.

the normal milder alkali such as carbonate. For example, we have used Solution A of the contrast plate developer D-28.*

	Avoirdupois	*Metric*
Water (about 125°F.) (32°C.)	16 ounces	500.0 cc.
Elon	60 grains	4.2 grams
Sodium sulfite	1 1/2 ounces	45.0 grams
Hydroquinone	120 grains	8.4 grams
Potassium bromide	50 grains	3.5 grams
Water to make	32 ounces	1 liter
Solution B for test developer		
Cold water	32 ounces	1 liter
Sodium hydroxide (caustic soda)	1 ounce (334 grains)	50 grams

No time is taken to bring the developer to any prescribed temperature. Table I is a chart showing the time of soaking the strip in Solution A which gave us a gamma of 0.8 with panchromatic Type 2 film (matching the gamma of our negative). The strip is developed in Solution B for 15 seconds in each case. Where practical, the developer is kept near the lower limit of temperature, where the fog is

TABLE I

Temperature F.	*Time in Solution A*
76°	9 seconds
75°	10 seconds
74°	10 1/2 seconds
73°	11 1/2 seconds
72°	12 seconds
71°	13 seconds
70°	14 seconds
69°	15 seconds
68°	16 seconds
67°	16 1/2 seconds
66°	17 1/2 seconds
65°	18 seconds
64°	19 seconds

negligible, by standing the containers in the sink with cold water. Note that the development time is a matter of seconds instead of minutes as would be necessary in the usual test where the picture is judged by itself.

The strip is then fixed, until clear, in the usual ultra-rapid acid fixing bath (F-1). Care must be taken to keep the bath acid since

* "Elementary Photographic Chemistry," *Eastman Kodak Co.* (1928), p. 49.

appreciable amounts of sodium hydroxide will be introduced each time.

The strip is washed briefly (in running water when available), wiped, and can be examined wet.

Four Mason jars are kept in a box with a handle, two for the de-

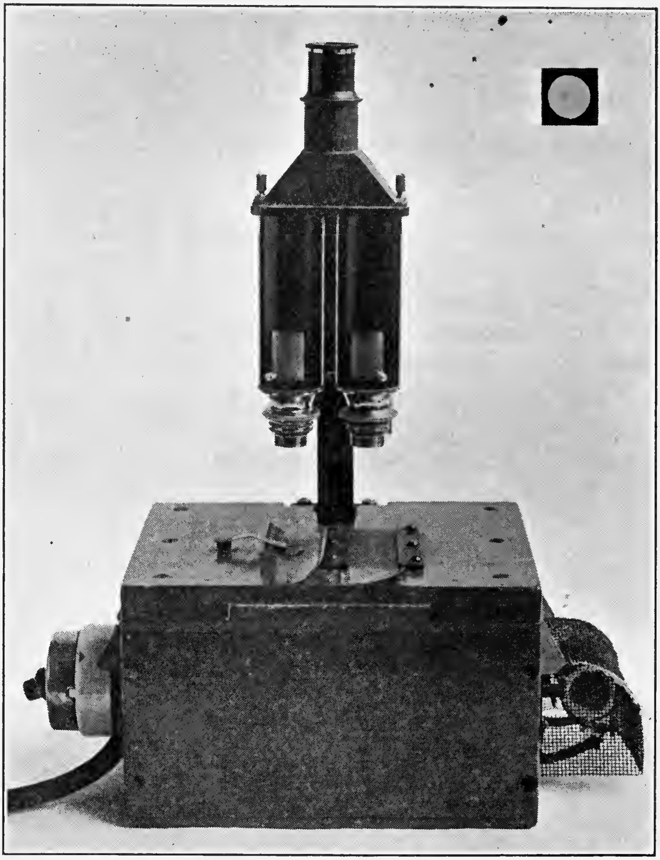

FIG. 7. Comparison microscope.

veloper, one for the fixing bath, and one for rinse water. In this way it is possible to operate without a sink.

An ordinary comparison microscope with 48 mm. matched objectives (Fig. 7) is used as a comparator. The source of illumination is an asbestos lined wooden box with two Mazda lamps, one beneath each of the two pieces of opal glass. The illumination is equalized by varying the current through one of the lamps. This produces some color difference between the two, but not enough to be serious. A track is provided for sliding the step tablet back and forth.

Conclusion.—A method has been described for the determination of the best photographic exposure or for the matching of two exposures in the studio or laboratory. It assumes that the development of negatives is a constant factor.

To judge exposure directly from a developed test strip requires that the test development should, at least approximately, match the final development, which is a time-consuming process. The time is much reduced and the determination made more accurate by setting up a standard exposure for comparison. Personal judgment is practically eliminated in the comparison.

This method is comparatively speedy. It is a basic method by which other optical methods may be compared or calibrated. It is not limited in the range of the illumination that can be measured.

DISCUSSION

MR. PALMER: I understand this method to be a double exposure method; first the film is exposed to a standard exposure strip and then a test exposure of the scene to be photographed is made on the same emulsion. It seems to me in theory that is very good but practically there would be many difficulties in applying it in motion picture work. Usually a cameraman doesn't finish lighting the scene to be photographed until about ten seconds before the first scene is shot because he never gets a chance to see what the action is going to be until he gets his people there and starts rehearsing, so that there would be no time to make this test exposure and develop it before exposing.

MR. LOVELAND: I appreciate these points; in fact, the principal application would not be in that field. I think the method proposed has advantages for the man who is photographing a very wide range of subjects and is working under almost laboratory conditions. It is preferable to going in, developing a negative, looking at it, and trying to decide whether you have the best exposure. I might say that I think it would have application in research for those who want to know exactly what part of the curve they are using.

OPERATION OF PROJECTION ARCS FROM MOTOR GENERATOR SETS

C. C. DASH*

When series arc generators were introduced and used successfully in theaters, the projection requirements were relatively simple. The projection room equipment usually consisted of two projectors with vertical carbon lamps with the addition in some instances of a spot lamp requiring the same amount of current as the projectors. Arc controls first introduced and used were mostly of the intermittent type using a voltage relay, the coil of which is connected across the arc, in connection with an operating motor. The operation of these lamps was successful with the series arc generators, and as no ballast resistance was used in the projection arc circuit a maximum converting efficiency from alternating current supply to direct current for the lamps was obtained.

With the changes that have occurred in the projection requirements, theaters have been attempting to use existing generating equipment with results that are not satisfactory.

If a theater has a 75 or a 70 ampere series type generator set, it might be assumed that the generator will satisfactorily furnish 70 amperes to a reflector high intensity lamp. Experience has shown that this assumption is not correct.

Fig. 1 shows a typical volt-ampere performance curve of a 75 ampere series arc generator. Curve *A* is the performance with full field and curve *B* with the field regulator set for 70 ampere output at 60 volts. When you follow curve *B* up to 120 volts you will find that 73 amperes are obtained. The variation of current between these two points is not a straight line, but has considerable curvature.

The positive carbon of the high intensity lamp rotates and a continuous arc feed is customary. This condition combined with the volt-ampere characteristic in the region of the 60 volt point

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makes the arc unstable, resulting in poor light performance unless the projectionist is constantly regulating the arc control.

If the projectionist strikes his arc and sets the arc length so that he obtains 60 volts across the arc and the arc control is set so that the carbon feed exactly equals the rate of carbon consumption the

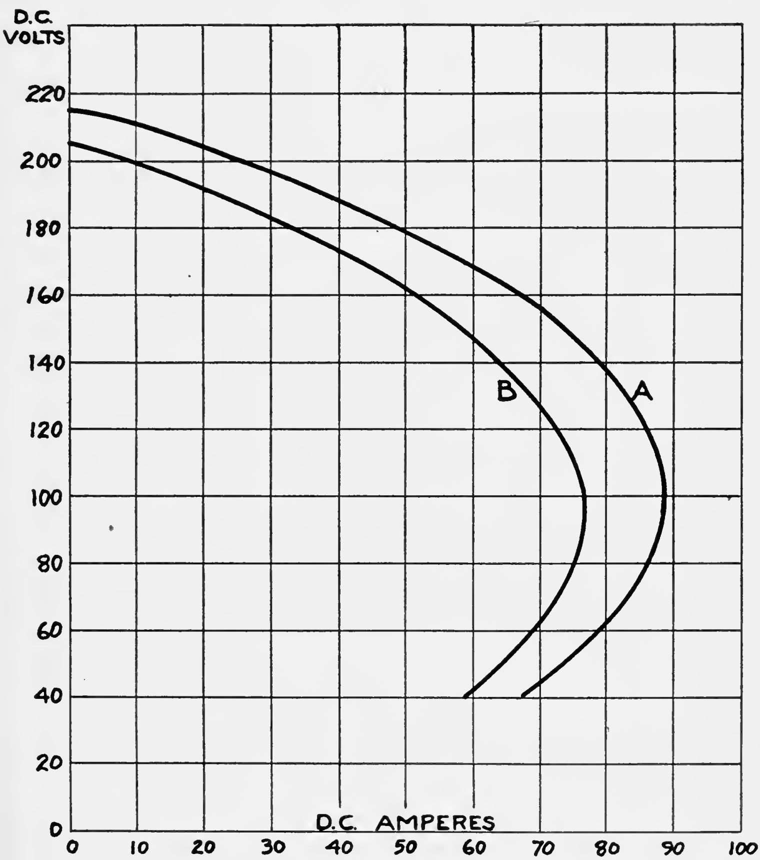

FIG. 1. Typical performance curve of 75 ampere series arc generator.

operation will be perfectly satisfactory; but if the arc feed is a trifle fast, the arc length is decreased which lowers the current and thus decreases the carbon consumption, making the shortening of the arc cumulative, resulting in a very poor light and light adjustment in a relatively short time. Conversely, if the carbon feed is slower than the rate of carbon consumption, the arc length and consequently the voltage across the arc increases. This results in an increased current which increases the carbon consumption so that this effect is also cumulative, and a long arc will result.

If the positive carbon starts to burn off eccentrically, a serious pulsation of current will result with each revolution of the carbon. This effect is also cumulative as the current is increased at the time when the arc is the longest. It can be seen, therefore, that a series arc generator cannot be expected to give satisfactory results on high intensity lamps with a continuous arc feed even though an attempt is made to use ballast resistance in series with the lamp.

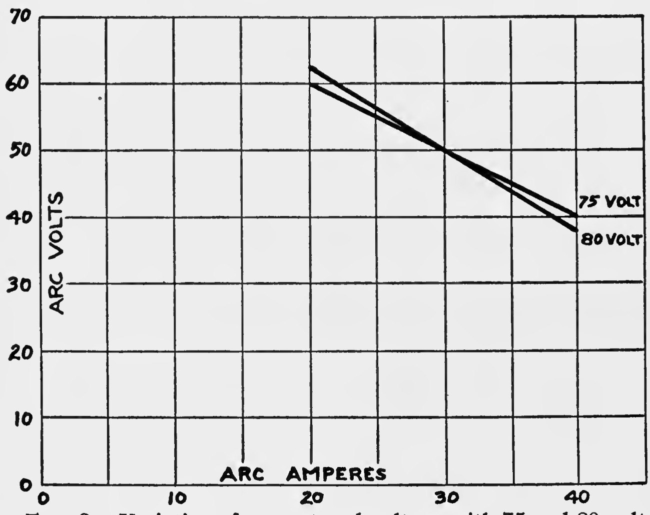

FIG. 2. Variation of current and voltage with 75 and 80 volt generators feeding a low current reflector arc set for a 50 volt arc at 30 amperes.

There have been attempts made to operate the low current reflector lamps with continuous arc feeds, and the same conditions obtain as with the high intensity lamp except that the difficulties caused by the rotating carbon are not encountered.

An electric arc is unstable when connected to a source of constant voltage without a ballast resistance in series with it. The generator voltage or supply voltage for stable arc operation will be in excess of the arc voltage by the amount of voltage drop in the ballast resistor. For satisfactory operation this ballast resistance voltage drop should not be less than 50 per cent of the arc voltage and for economical reasons should not be much over this value.

The combination of the ballast rheostat and an electric arc in series connected to a constant voltage direct current source is a simple electrical engineering problem, but as the conditions vary it becomes rather obscure to one not familiar with the problem.

An electric arc supplied with direct current cannot be figured as a rheostat on account of the fact that the resistance of the arc is a variable quantity. Carbon has a negative temperature coefficient of resistance, and the arc stream has apparently the same characteristic. This characteristic of the arc is shown in the low current reflector arc which, when adjusted for a constant arc length, has an

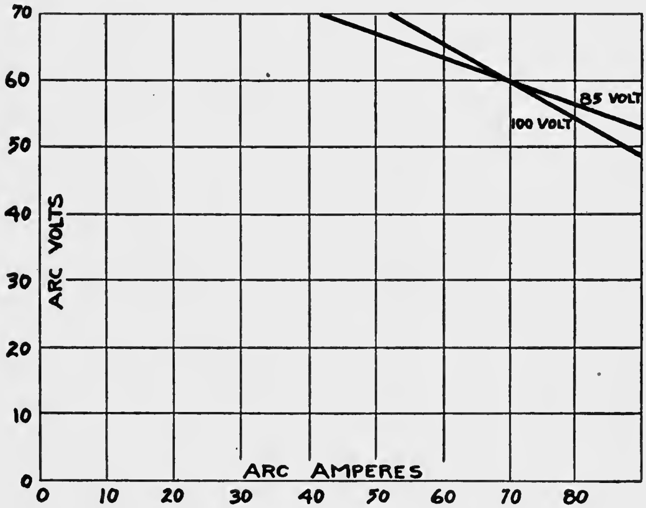

FIG. 3. Variation of current and voltage with 85 and 100 volt generators feeding a high intensity arc set for a 60 volt arc at 70 amperes.

arc voltage which is practically constant although the current may vary within the limits for which the carbon is designed.

If we assume a certain size carbon which is rated to operate from 25 to 30 amperes with a definite arc length corresponding to an arc voltage of 50 volts, at 25 amperes the apparent resistance is 2 ohms, and at 30 amperes, 1.67 ohms. If we take a piece of ordinary resistance material and change the current from 25 to 30 amperes, the voltage will vary directly as the current changes.

On account of this constant voltage condition we find that the variation of current in an arc with change of arc voltage caused by a change in arc length is much greater with a small difference between arc voltage and supply voltage than with a larger difference between arc voltage and supply voltage.

Fig. 2 shows this variation with a low current reflector type arc used with a 75 volt generator and an 80 volt generator, the basic adjustment in this case being for a 30 ampere arc with a 50 volt arc length. While the difference between the slopes of these two curves is not very marked, there is a big difference in the ease of operation and the resulting changes in current through the lamp with slight changes of arc length.

Fig. 3 shows the variation of arc current with change of arc voltage with a high intensity reflector lamp which is set for a 60 volt arc at 70 amperes. The change in current with the 100 volt source is much less than with the 85 volt source.

Fig. 4 shows the variation in current with variation in arc volts for a high intensity lamp adjusted for 125 amperes at 70 volts using an 85 volt generator and a 100 volt generator. Experience has shown that 85 volt generators are not desirable for high intensity lamps with an arc voltage of 70 volts because the change in current is greater with slight changes in arc voltage.

The rheostats used in connection with the projection arcs must be designed to give the proper voltage drop at the current required. With the variation of current which comes with a small change in arc voltage it is very easy to overload these rheostats. Assume a low current reflector arc nominally operated at 55 volts at the arc normal current 30 amperes from an 80 volt generator. The voltage drop across the rheostat will be 25 volts. With a variation of arc voltage the following rheostat loads would be obtained: With an arc voltage of 55, and an arc current of 30 amperes, the rheostat will be operating at 100 per cent load. If this arc voltage is reduced to 45 volts with the same generator voltage and same amount of resistance in the rheostat, the arc current will increase to 42 amperes and the load on the rheostat will be 196 per cent of normal.

There is a great deal of variation in the practice of projectionists throughout the country with respect to arc voltage, and the proper operating conditions with motor generator sets or any source of direct current power can be obtained only when all of the equipment, rheostats, arc controls, carbons, and direct current supply are properly matched.

One other item which should be considered is the proper connections when two constant voltage generators are installed in a theater. The natural way for an electrical engineer to connect these generators would be for parallel operation. When two generators of similar characteristics are connected in parallel they will operate satisfactorily and divide their load properly only when the induced voltage in the two machines is the same and the resistance of the armature circuit together with the interpole and series fields is inversely proportional to their capacity. Under conditions of operation where two machines would be started about the same time, there

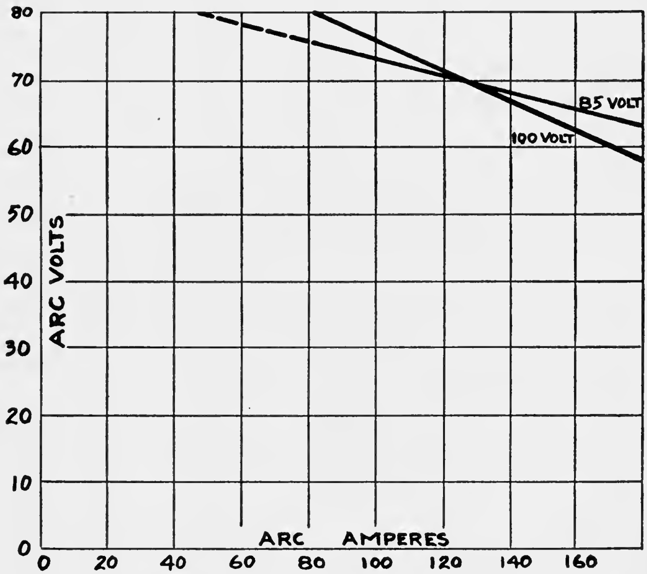

FIG. 4. Variation of current and voltage with 85 and 100 volt generators feeding a high intensity arc set for 70 volts at 125 amperes.

would probably not be much difficulty in obtaining a balanced load on the two sets, but with conditions as they exist in the theater where one lamp is operating for a period of from 25 to 30 minutes, making the load on the generating equipment rather light, it is not economical to be running the two machines. Under conditions as they obtain we find that when the heavy load comes on, the projectionist will start the second machine with cold windings and parallel it with the first which has been running probably long enough to have come to a stable temperature. He will adjust the generated voltage of the two machines so that a proper division of the load is obtained. In a short time the shunt field winding of the two

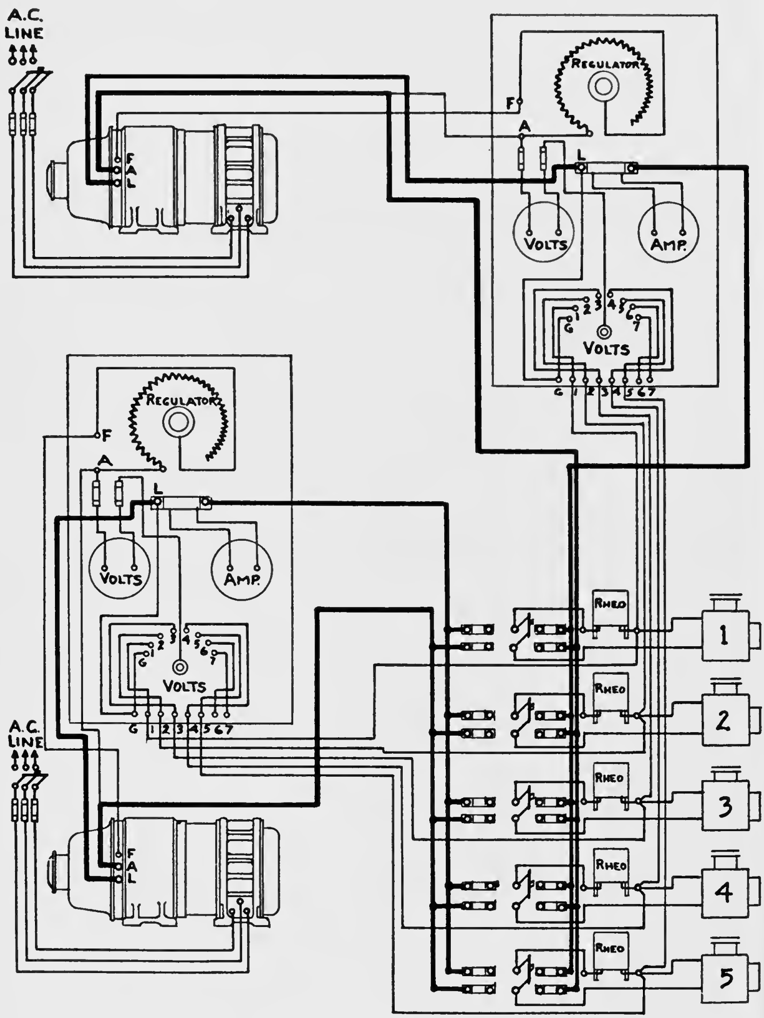

FIG. 5. Wiring diagram showing installation of two multiple arc units using panel "D."

machines will have warmed up enough to reduce the generated voltage in the second machine to the point where the loads are no longer equally divided. As a matter of fact, unless the generator has very close voltage regulation and very little change of voltage with change in temperature it may drop its load almost entirely, imposing the load on the machine which has been running the longer time. The necessity of frequent adjustment during the period of heavy load when the projectionist has the most equipment to look after, results in attempting to make him a switchboard operator as well as projectionist.

It has been found that by far the most suitable way to connect generators when there are two installed in a theater is to connect each generator to a separate bus and provide each projection lamp with a separate double pole switch so that any lamp can be connected to either generator as required. This connection gives all of the advantages of the parallel connection inasmuch as in the event of an emergency the equipment can be connected to either set, and when both generators are required to take care of the peak load each generator will supply its lamps without the continued attention of the projectionist.

A NEW PHOTOMETER EXPOSURE METER

JOSEPH A. DUBRAY*

There has been a long-felt want in the whole photographic field for an exposure meter that is fundamentally a scientific instrument, but one which has been refined to the point of practicality in the field, for the cinematographer or photographer—in other words, an instrument designed in accordance with scientific knowledge of light measurement, but one of simple operation and compact design.

A meter has been needed which enables the operator not only to determine the intensity of illumination of the whole field as most of the present instruments do, but, in addition, to enable him to determine the correct measurement for *any part* of that field or subject which is to be photographed.

In the *Journal of the Optical Society of America* (May, 1927), Mr. F. H. Norton presented a paper describing a "New Type of Photographic Exposure Meter and Photometer," upon the general principles of which the Bell & Howell Company has just completed the development of an exposure meter known as the "Bell & Howell Photometer."

In principle, this photometer permits the matching of a standard source of illumination to the illumination of the object to be photographed.

By means of a small flashlight bulb operating at low intensity (with current supplied by a single flashlight dry cell) the standard source of illumination is obtained, the intensity of which is controlled by a rheostat. A simple optical system superimposes an image of the lamp filament in the field of view. By adjusting the rheostat and thus varying the intensity of the filament image, the latter is brought to the point at which it matches the intensity of the object being measured. Graduated scales operating in conjunction with the rheostat lever make it possible to interpret the measurement obtained directly in terms of lens diaphragm openings (f ratings) or exposure time.

* Bell & Howell Co., Chicago, Ill. (Read before the Society at Washington.)

The Bell & Howell Photometer (Fig. 1) is of general cylindrical form, determined by the main elements of the unit and their functions. It is small, easily handled, and conveniently carried in the coat pocket.

In Fig. 2, the main sections of the instrument are shown. At one end are placed the optical unit and the lamp, next is the dry cell, and at the opposite end, built into the case, is the rheostat, the control brush of which is fastened directly to the end cap.

In operation, the instrument is held directly to the eye, and pointed at the object to be measured. The latter is seen directly through the light path, into which is imposed the image of the lamp filament by means of a transmitting-reflecting element (*B*, Fig. 3). A blue glass magnifying lens, *C*, between the lamp filament, *E*, and the reflector, *B*, brings the filament image to a virtual position of 29 inches in front of the eye so that it can be comfortably seen at the same time with the object. By turning the end cap, *M*, to control the rheostat, the intensity of the lamp filament illumination is varied to the point where it matches the intensity of the object to be photographed as seen in the light path. The direct readings for exposure are made on the scales on the rings, *O* and *P*. On this model, which is calibrated for Filmo 70 and 75 cameras, the ring, *O*, contains the diaphragm scale, and ring, *P*, contains the speed factor scale.

FIG. 1. The Bell and Howell Photometer.

The speed of manipulation depends upon the individual, but about 10 seconds has been found to be the average time necessary to make the measurement.

In order to compensate for variations in the current supply from the dry cell, due to age, *etc.*, it is necessary to obtain a "zero" setting of the instrument before a day's use. A shutter, R^1, is closed, making a dark chamber in which is seen only the lamp filament image. The intensity of the filament illumination is decreased, by adjusting the rheostat, *J*, to the vanishing point, and the exposure scale, *O*, is brought into the proper position, as indicated by arrows on the ring, *O*, and end cap, *M*. This setting is accurate for an average day's use, and only for the person who made the setting. Due to the slight variation in the eyesight of individuals, a "zero" setting must be made by each one using the instrument.

As it would be possible to make a "zero" setting when the dry cell is so weak that inaccurate readings would result at higher intensities, the ring, *O*, is limited in its setting possibilities within the range of useful dry cell strength.

Since the lamp is operated at about one-fourth of its rated temperature, the filament emanates a considerable amount of the red rays to which the regular photographic emulsions are not sensitive, but to which the eye is sensitive, the lens, *C*, through which the filament

FIG. 2. The main sections of the Bell & Howell Photometer.

alone is viewed is made of a blue glass of a filtering strength which eliminates about one-half of these rays. As reds, *not* containing appreciable amounts of shades to which regular emulsions are sensitive, are rarely encountered, the color differences, in comparing the illumination of the subject which will impress the emulsion with the illumination of the filament which is seen with the eye, are relatively small and negligible in a scene where red is not the predominating color. As only half of the red rays are filtered out of the filament image, no appreciable error occurs when panchromatic film is used. Sensitometric tests, emulsion tests, and even the close inspection of an experienced photographer cannot detect enough variations to destroy the effectiveness and reliability of the instrument. The latitude of exposure of an emulsion more than compensates for these slight errors.

The lamps are selected by careful comparison with master lamps in a dark room. As this is done at low intensity, close to the point where the glow is just perceptible, and since at this low temperature the emitted color is very strong in the red rays, which are eventually considerably absorbed by the lens-filter, it is seen that this comparison is made exceptionally close to "zero." A second similar comparison is made with the lamps at a high intensity through neutral density filters, with similar accuracy.

The selected lamps must have true and well centered filaments, and must be without lumps in the glass bulb that would have a lens effect. After prefocusing in the lamp clip, *F*, the bulb is coated with a flat black leaving only a $^1/_{16}$ inch opening over the center of the filament. This shortens the filament image so that it does not appear

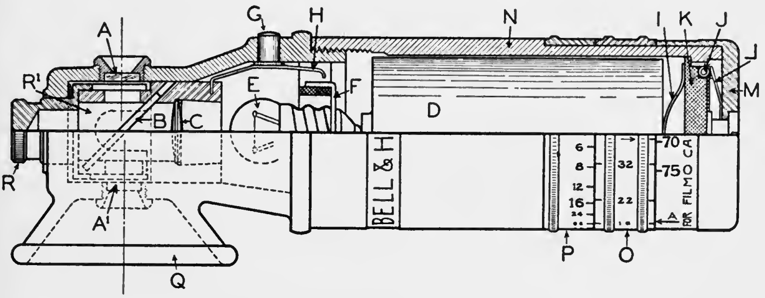

FIG. 3. Sectional drawing of the Bell & Howell Photometer.

extended beyond the field seen through the light path of the instrument, as the region bordering this field is dark, and would disclose the overlapping image at any intensity. The filament image is thus of sufficient size to take readings of any portion of the field with ease.

Owing to the low intensity at which the lamp is operated, its life is indefinite, running into years. The low operating point of the dry cell makes its life longer than usual also.

Although the present model of the Bell & Howell Photometer is calibrated for the Filmo 70 and 75 cameras, models for still and professional motion picture cameras will follow.

DISCUSSION

MR. OTTO COOK: Can that be used on both ordinary and panchromatic film?

MR. DUBRAY: Yes, sir; it can be used for both ordinary and panchromatic film.

As stated in the paper, this exposure meter is designed upon scientific principles, but with a view to practical use. The lens which formed the image of the lamp filament is made of blue glass, which absorbs a portion of the red rays and compensates to some extent for the differences in the sensitivity characteristics of the films. An average reading of the exposure is thus reached and the latitude of the film makes this average sufficiently correct for practical purposes.

I have personally taken hundreds of readings and made hundreds of actual photographic tests under a great variety of conditions, including interiors illuminated with artificial lights, and I have found that the photometer permits much more accurate results than if the exposures were determined through one's experience.

MR. GAGE: I would like to remark that one of the great difficulties with small, portable photometers and pyrometers is not in the design of the instrument but in the necessity of hooking the instrument up with an ammeter or voltmeter which may weigh many times as much as the instrument in order to take care of battery variations, contact resistance variations, and so on. In this instrument, the zero setting seems to be that concerned with how high a rheostat setting can be found before the filament of the lamp can be seen. If that proves to be sufficiently reproducible for the accuracy required for photography, it is a convenient method of giving the unit setting of the instrument to take care of the falling off of voltage as the battery grows older.

MR. DUBRAY: The useful life of the battery is predetermined by the limiting of movement of the "B" or "lens speed" dial, the index line of which is set in coincidence with the index line of the "A" or "resistance dial" at filament vanishing adjustment.

With regard to the lamps I would say that these are very carefully selected and only a very small percentage of the bulbs found on the market are accepted by our inspection department. This does not present a problem, however, because the life of each bulb extends over a period of several months, due to the extremely short burning time of the lamp for even a quite long series of readings.

MR. MATLOCK: How often is it necessary to calibrate?

MR. DUBRAY: We suggest calibrating every day, once a day, unless a great number of readings are taken in rapid succession, in which case it may be found necessary to calibrate twice or three times a day.

MR. KELLOGG: The point that Dr. Gage brought out was very interesting. We know that the sensitivity of the eye varies from time to time over tremendous ranges, so how can it serve as a gauge for setting the lamp rheostat? While the unaided eye may be an uncertain standard for measuring intensity you are not measuring the Illumination, but you are dealing with the threshold visibility in setting the rheostat. If the rate of change of luminosity with temperature is very great the variations in setting due to changes in eye sensitivity may not be serious.

PRESIDENT CRABTREE: On what part of the object is the instrument directed?

MR. DUBRAY: Personally, I prefer to take two readings; one in the shadow areas and one in the high lights of the subject, and determine an average between the two according to the preponderance of either one of the two areas.

MR. E. D. COOK: If two samples of this instrument are considered, isn't it true that calibration depends upon the reproducibility of the rheostat? You have No. 1 instrument and No. 2 instrument, and the readings depend on the accuracy with which the rheostat in No. 1 agrees with that in No. 2. It has been our experience in the manufacture of radio sets that it is difficult to make rheostats which are sufficiently alike unless they vary by steps.

MR. DUBRAY: We have developed in our research division a practical system for determining the reproducing ability of the rheostat. Unfortunately we could not incorporate this technical data in the present paper because the instrument is an entirely new development and the material collected has not, as yet, been sorted sufficiently to permit presentation in the proper form. We hope to be able to do this and prepare an article for the S. M. P. E. JOURNAL to supply such technical information.

STUDIO LIGHTING COMMITTEE REPORT*
May, 1930

INTENSITY MEASUREMENTS

Shortly after the organization of the committee, early in 1929, two meetings were held at which the program of the committee was discussed at considerable length and definite steps were taken to obtain answers to some of the questions involved.

One of the most vital questions was that of the relative merits of incandescent and arc lighting, and it seemed then and still is very desirable that a definite answer be obtained as to which of these methods or whether both should be used in most motion picture studio sets.

Several members of the committee brought up the question as to what was the cause of the so-called soft focus or out of focus effect which has been noticeable in a number of motion picture films. One suggestion as to a possible answer to a part of this question and also as to the respective photographic merits of the various types of lighting could be obtained if a large number of samples of film taken with known types of lighting could be obtained.

It is well established that there is a certain natural contrast range to be expected in negative films depicting each type of subject. A qualified research worker should be asked to examine visually and photometrically a large number of negatives taken with arcs and with incandescent lamps. He should report on the average shadow, middle, and highlight densities in the two divisions and he should further be asked to measure the average negative image densities of such typical sub-subjects as male dress clothes and shadows under furniture, then human features and other well recognized middle tones and, lastly, the densities of white collars, starched shirt fronts, *etc.*, and to make an estimate of the halation and crispness of outline of these objects lit by the two kinds of light.

Arrangements were made for the measurement of these films when samples were obtained, and the question of obtaining the

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* Read before the Society at Washington.

samples was taken up with the Technical Bureau in Los Angeles. After several letters had passed back and forth between the committee chairman and Los Angeles, it was definitely agreed that the samples would be obtained and a form for recording the information as to the lighting was worked out and approved by the Studio Lighting Committee. It was expected that this would result in the samples being forthcoming shortly, but some obstacle came up after, apparently, the program was entirely settled, which prevented any samples ever being obtained.

Since the work with regard to lighting has now been turned over to the Academy of Motion Picture Arts and Sciences, this will have to be done all over again, entailing a considerable loss of time, which is to be regretted.

The question of the use of light meters of some sort was discussed by the committee, and Mr. Palmer has done some work with photoelectric cells in the measurement of the photographic light on the sets. So far as can be ascertained, no interest has been exhibited in the use of light measuring devices in the studios in Hollywood, but perhaps the reason for this is the fact that there is not on the market an instrument which is simple, easy to operate, and accurate enough in recording the values of photographic rather than visual light to make it particularly appealing to the motion picture studio people.

A number of light measuring devices have been mentioned in the literature and attempts to investigate several have been made with, in most cases, no success whatever, due to the fact that the meters so described have apparently never actually been produced.

There seems to be no reason why a photo-electric cell could not be developed which would have a response curve closely approximating the sensitivity curve of panchromatic or any other type film which it is desired to use.

ELIMINATION OF ARC LIGHT NOISES

With the advent of sound pictures many inquiries were received as to methods which could be applied in the studios to eliminate the noise which had always been noticed in the arc lamps in the various studios. These noises, while not particularly loud and absolutely unobjectionable with silent pictures, became troublesome with the advent of the "sound picture." Experiments were made in various laboratories in the east and it was found that the noises were due to superposed alternating current from the direct current generators used for the power for the lamps. This noise is called commutator ripple.

Success was obtained in eliminating this noise in individual lamps in some of the laboratories, but the values of inductance or capacity found satisfactory were of no value when it was attempted to apply them to the conditions in the studios. However, this problem has been quite successfully worked out by the people in Los Angeles, particularly at the Fox Studios.

The following bibliography gives references to several articles which describe the methods found to be successful in the elimination of arc noises.

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STUDY OF LIGHT SOURCES

There are now available in the publications of the Society energy distribution curves of all of the various light sources used in the motion picture studios, which should be of some material assistance in the study in the various studios of proper light sources in connection with the various types of film.

It was suggested that a bibliography of various articles which have been published dealing with studio lighting and its various phases would be of some assistance. The committee has prepared such a bibliography, but at the present time this covers only our own publications.

Respectfully submitted,

L. J. BUTTOLPH   R. E. FARNHAM   M. W. PALMER
K. C. D. HICKMAN
A. C. DOWNES, *Chairman*

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Kodalite, EASTMAN KODAK COMPANY, Vol. XII, No. 34 (April, 1928), p. 563.

Characteristics of Photo-Electric Cells, L. R. KOLLER, Vol. XII, No. 36 (September, 1928), p. 921.

Visible Radiation from the Neon Hot Cathode Arc, FRANK BENFORD AND L. J. BUTTOLPH, Vol. XII, No. 36 (September, 1928), p. 1010.

A Photometer for the Measurement of Low Illuminations, L. A. JONES AND E. M. LOWRY, Vol. XII, No. 36 (September, 1928), p. 1054.

Heat Absorbing Glass, H. P. GAGE, Vol. XII, No. 36 (September, 1928), p. 1063.

Improved Reflectors for Motion Picture Studio Side Carbon Arc Lamps, E. R. GEIB, Vol. XII, No. 36 (September, 1928), p. 1180.

A New 125 Ampere Spotlight, KLIEGL BROTHERS, Vol. XII, No. 36 (September, 1928), p. 1190.

Electric Fire-Control of Flares, JOHN G. MARSHALL, Vol. XII, No. 36 (September, 1928), p. 1195.

Bulb Cleanser for Incandescent Lamps for Studio Lighting, D. K. WRIGHT AND C. E. EGELER, Vol. XIII, No. 38 (May, 1929), p. 346.

Characteristics of High Intensity Arcs, D. B. JOY AND A. C. DOWNES, Vol. XIV, No. 3 (March, 1930), p. 291.

Water Cooling of Incandescent Lamps, N. T. GORDON, Vol. XIV, No. 3 (March, 1930), p. 332.

A Light Intensity Meter, J. L. McCOY, Vol. XIV, No. 3 (March, 1930), p. 357.

REPORT OF COLOR COMMITTEE*
May, 1930

The demand for motion pictures in color which began in the summer of 1929 continues without abatement. It is reported that some of the larger producers would willingly change back to the black and white pictures but say that the demand for color pictures by the public is so insistent that they do not dare to change. The reason for such statements is based on the fact that the cost for color prints is such a great item.

TECHNICOLOR

Technicolor continues to produce most of the color prints. Some years ago they adopted the mechanical method of imbibing colors onto a "blank." Being well equipped for this type of work they have been able to supply the demands of producers. The excessive requests for prints have caused the release of prints not up to the possible standard of the company. It is understood that the Hollywood plant is now making prints by the imbibition method, and of good quality.

MULTICOLOR

At the monthly meeting of the Pacific Coast section held April 16, 1930, a demonstration of this process in connection with the Leon F. Douglass method of projecting 35 mm. films to give a wide film effect was shown to the members and friends.

The demonstration was impressive as an indication that color added to wide films will assist materially in giving the effect of relief on the screen.

No new technical changes were mentioned in connection with this exhibition by the speaker for Multicolor.

SENNETT COLOR

Public showings of the work done at this plant in Hollywood have been given to Los Angeles audiences.

The release prints are made on double sided film. Both sides

* Read before the Society at Washington.

are developed at one time and then toned red on one side and blue-green on the opposite side. The tones are two-bath metallic colors from iron and uranium.

The negatives are made with the film pack system of two films emulsion to emulsion in the camera. The front film carries a surface color of red-orange which acts as a filter to the back panchromatic film. The front film is not sensitive to red.

HARRISCOLOR

In this method as in other methods of color photography, independent color value negatives are first obtained. The Harriscolor process can employ one of the following two methods: Either a camera wherein the dividing light prisms are incorporated inside the camera, or two Bell & Howell cameras with a light-splitting device placed in front of the camera lenses can be used.

The first method uses a small surface silvered mirror placed behind the lens. Portions of the silver are removed from the mirror in the form of fine lines or circles and the mirror is placed at an angle of 45° to the lens. One film is placed directly back of the mirror with the emulsion side facing the lens and a second film placed at right angles to this first film. The two films can be either both panchromatic or one panchromatic and the other orthochromatic. If they are both panchromatic, then obviously two complementary color filters are used in obtaining the color value negatives. If orthochromatic and panchromatic negative is used, then only one color filter is necessary and that color filter would be red. The light passing through the lens then passes to the mirror. The silvered portions of the mirror will reflect the image at right angles and that image will then be recorded on one negative. The clear portions of the mirror, that is, where the silver has been removed, will allow the image to pass through and this will be recorded on the second negative.

If an orthochromatic and panchromatic combination is used, greater exposure will result since the absorption by one filter is removed. Since the orthochromatic film is insensitive to the red end of the spectrum, no color filter would be necessary since that negative would automatically record the blue-green end of the spectrum and the amount of exposure, which would ordinarily be absorbed by a color filter, can be compensated for in the construction of the reflecting mirror to the advantage of the negative which is back of the reflecting medium.

While for the point of illustration reference is made to the light-splitting device as a mirror, it should be understood that the two right angle prisms, one having the surface treated as already described, are cemented together.

With the method which employs two Bell & Howell cameras, these cameras are mounted on a base at right angles to each other. Arranged between the two lenses is a device, which for the sake of illustration we will call a transparent mirror, that is, a mirror capable of reflecting light and transmitting light. Procedure of photographing and the combination of negatives and color filters used are precisely the same as already described and with this method the light first comes in contact with the transparent mirror and is reflected at an angle of 90 degrees to one camera and at the same time the light which passes through the mirror is recorded on the negative directly back of the mirror.

So far then, we have described the methods of obtaining color value negatives. Harriscolor does not employ double-coated film in the manufacture of their color prints but uses single-coated film or film with one or more emulsions on one side of the celluloid base. The negative carrying the red color value images is printed through the base of the positive film and this film is then developed, washed, and colored with an iron solution and again washed and dried in the dark.

Onto the residual emulsion, which, of course, is on the surface of the emulsion, are printed images from the blue color value negatives. This in turn is developed in a solution that does not necessarily destroy the ferric image; the whole film is fixed and washed and the top image toned with the color complementary to the bottom image and with a bath which does not affect the existing blue image. The base of the film has a slight yellow tint which, it is claimed, gives an illusion of three-color photography.

VITACOLOR

This company purchased over thirty of the Prizma patents covering many stages of making additive and subtractive color photography. Recently licenses were issued to Consolidated Film Industries, Inc., for these Vitacolor-owned patents and Consolidated will enter the color print market. In previous times Consolidated made 65 per cent of the black and white release prints. No announcement has been made as to the exact system they will adopt for color prints.

FOX COLOR

A new laboratory for color prints is partially completed in Hollywood.

Their system uses a camera that pulls down two frames and exposes both at once through a pair of objectives. A prism is used in connection with a single objective when close-ups are to be made.

Prints are said to be made by the Kodachrome system which uses double sided film. The images having been developed are given a treatment in a tanning bath so that the dyes go into the soft gelatine only. Dyes are applied in a trough-like machine that protects the opposite side during these applications.

Respectfully submitted,
JOHN G. CAPSTAFF
WM. T. CRESPINEL
F. E. IVES
WM. V. D. KELLEY, *Chairman*

REPORT OF THEATER LIGHTING COMMITTEE*
May, 1930

Since the last report of the committee, contact has been established with the Screen Illumination Committee of the Academy of Motion Picture Arts and Sciences. The chairman of the Academy committee, Mr. Huse, is also a member of the Theater Lighting Committee. Several conferences were held between Messrs. Huse and Farnham during the latter's visit to the coast this spring, to coördinate the common activities of the two committees.

The Screen Illumination Committee of the Academy was formed to study screen illumination with special reference to the existing and required densities of positive prints. After some illumination data were obtained, it was evident that contrasts obtained in the projected pictures were important factors in judging the relative effectiveness of different intensities, it having been observed that the same picture appeared radically different with the same screen illumination intensities. This led to consideration of the stray light which previous work had shown to be an important factor in the projection of the screen picture.

Inasmuch as the present activity of the Theater Lighting Committee is the obtaining of additional brightness and illumination determinations in certain theaters selected on the basis of observed good or bad lighting features, it is logical that additional data can be obtained in California to the best advantage by coördinating the tests of the Academy committee and the S. M. P. E. committee. It is therefore planned to submit to the Academy committee a test procedure which will obtain the desired S. M. P. E. data. It appears as though this can be made to meet the Academy committee's requirements.

Indicative of the interests of others than motion picture and lighting engineers in the illumination of theaters and concert halls, is the comment by a leading symphony orchestra conductor, who advocates the elimination of glare from direct lighting units by the use of indirect lighting and the entire concealing of all light sources. He stresses the distraction caused by glaring sources, which often results

* Read before the Society at Washington.

in a mental state which makes it impossible for the listener to perceive the finer passages of music. For those who must read programs during the performance, he suggests a low candlepower unit which could be attached to the backs of the seats and which could be turned on without distracting the attention of the other patrons. While the lighting of motion picture theaters involves somewhat different major premises than apply in the treatment of concert halls, the Theater Lighting Committee and others can well consider some of the thoughts of this conductor for the illumination of the larger theaters during their musical programs.

Respectfully submitted,

J. C. AALBERG	F. FALGE	E. HUSE
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ABSTRACTS

The Editorial Office will welcome contributions of abstracts and book reviews from members and subscribers. Contributors to this section are urged to give correct and complete details regarding the reference. Items which should be included in abstracts are:

Title of article
Name of author as it appears on the article
Name of periodical and volume number
Date and number of issue
Page on which the reference is to be found

In book reviews, the following data should be given:

Title of book
Name of author as it appears on the title page
Name of publishing company
Date of publication
Edition
Number of pages and number of illustrations

The customary practice of initialing abstracts and reviews will be followed. Contributors to this issue are as follows: G. L. Chanier, E. M. Lowry, E. E. Richardson, Clifton Tuttle, and the Monthly Abstract Bulletin of the Kodak Research Laboratories.

Recording Sound on Disk. Nugent H. Slaughter. *Projection Eng.*, **2**, August, 1930, p. 7. A description is given of the various steps in the making of sound records: shaving of the wax disk, electrical recording of the sound, making of the matrix and finished disks. The electrical characteristics of the recorder and the reproducer are then considered, and there are a few words on the cutting of the picture. G. L. C.

Sound Recording Tubes. J. B. Zetka. *Projection Eng.*, **2**, July, 1930, p. 7. A description of a new glow lamp for variable density recording of sound on film and a discussion of the electrical characteristics of the lamp. E. E. R.

Kahn Completes New Sixteen Millimeter Sound Camera Mechanism. *Mot. Pict. News*, **41**, June 28, 1930, Section 1, p. 45. Announcement is made of an amateur standard sound-on-film portable camera and projector. The device may also be used for slow motion photography at 100 pictures per second. It is planned to manufacture the camera and sell it with a small microphone and amplifier.—*Kodak Abstr. Bull.*

Tone Compensator. *Ex. Herald World*, **100**, July 5, 1930, Section 1, p. 26. An announcement is made of an invention for improvement in controlling the input in recording sound pictures. Certain frequencies may be cut down or built up and stray noises may be eliminated. No technical details are given. The invention is credited to J. Aceves, an engineer, assistant to Prof. M. I. Pupin of Columbia University.—*Kodak Abstr. Bull.*

Accurate Check for Recorder Lights. *Cinematography*, **1**, July, 1930, p. 16. A photo-electric cell is so mounted that it can be adjusted easily on the side of the recorder in a position in line with a reflected image of the light valve. Readings of the reaction of the valve illumination on the cell are taken by means of a meter connected up with a tube amplifier. A microscope fitting permits the recorder to view the light valve after it is in place and make final adjustments if necessary. A similar apparatus has also been used in projection rooms for focusing light slits.—*Kodak Abstr. Bull.*

New Sound Head. *Ex. Herald World*, **99**, April 12, 1930, Section 2, p. 62. The head amplifier is built on a chassis with all integral parts enclosed. The cradle support for the amplifier is designed to filter out mechanical vibration regardless of projection pitch. A pre-focused exciter lamp is a feature of the equipment.—*Kodak Abstr. Bull.*

RCA "Type G" Reproducing Equipment. *Mot. Pict. Projectionist*, **3**, March, 1930, p. 16. "Type G" sound reproducing equipment was developed for the smaller theater and embodies many advances in the design of sound picture equipment. All power for the "Type G" equipment is provided by a three-unit motor generator set. The equipment has been supplied with sound heads for either Powers 6B projectors or Simplex projectors. A new type gate, known as the "impedance" gate, has been substituted and the viscous damping device has been removed. The optical system has been simplified while the disk mechanism differs considerably from that used in the standard Photophone disk attachment.—*Kodak Abstr. Bull.*

Modern Methods of Sound Reproduction in Kinematography. A. Kossowsky. *Phot. J.*, **70**, September, 1930, p. 420. The author begins with a review of the pioneering work in talking pictures from 1870 to date. This is followed by a mention of various types of microphones, and a short reference to amplifiers. All the other problems of sound pictures are then taken up from stage to screen: recording, variable area and variable density methods, emulsion characteristics, sound-proofing the camera, recording on disks, reproduction in the theaters, taking the pictures, scene design, acting technic, and difficulties due to musical instruments and the human voice. G. L. C.

Movie Camera as an Aid in Testing. *Sci. Amer.*, **143**, August, 1930, p. 136. In engineering tests it is often necessary to take simultaneously the reading of a number of meters. Several men are employed making it often difficult to coordinate the results, especially if the tests extend over a period of hours with frequent readings. Mr. L. B. Woodworth, a mechanical and electrical engineer of South Africa, advocates the use of a motion picture camera to register the readings. G. L. C.

Optical Principles of the Bifocal Lens. B. Rose. *Mot. Pict. Projectionist*, **3**, March, 1930, p. 31. A diagram shows a cross-section of the lens with patent specifications. The basic principles of the optical system are discussed and the characteristics noted. It is claimed that this bifocal projection lens is of high speed and is critically sharp for both focal lengths. Its effective aperture is said to be $f/2.5$.—*Kodak Abstr. Bull.*

Limitations of Modern Lenses. *Cinematography*, **1**, May, 1930, p. 9. A report is given of a paper by Warmisham, presented before the London Section of the Society of Motion Picture Engineers. Even with lenses brought to the best state of chromatic correctness, a secondary spectrum exists as an inherent result of the use of glass. Large aperture lenses were designed and introduced before the trade demanded them. The speaker predicted that an optical system will be produced in the near future for sound-on-film reproduction which will allow the omission of one stage of amplification and reduce electrical distortion. Finders are expected to be worked out which will give continuous survey of the film during exposure in the camera.—*Kodak Abstr. Bull.*

H. & C. Wide Film High Intensity Lamp. T. HALL. *Mot. Pict. Projectionist,* **3,** April, 1930, p. 21. The author describes a new projection lamp developed for use on wide film installations. The lamp is rated at 120 to 225 amperes. In order to stand up under this high current with its attendant high temperatures, the design of the lamps departs somewhat from standard lamp designs. The increase in illumination over present systems is said to be 45 to 50 per cent.—*Kodak Abstr. Bull.*

Effect of Colored Motion Pictures on the Eyes. D. LEVINSON. *Mot. Pict. Projectionist,* **3,** June, 1930, p. 38. The effect of concentration upon the same colors, red, green, and their complements, for long periods of time tends to produce eye strain and make those colors monotonous. Another source of eye strain is the effort required to make out the details of the picture.—*Kodak Abstr. Bull.*

The Application of Photography in Explosives Research. W. PAYMAN. *Phot. J.,* **70,** September, 1930, p. 409. This is a résumé of a lecture on the taking of pictures of rapidly moving phenomena, very often invisible, as pressure waves through the air. The pictures are taken on a film wrapped around a drum rotating at a high speed. The source of illumination is a powerful mirror arc lamp. The photographs constitute really a "photographic time-distance graph." Mention is made of the method called Schlieren photography in which the illumination is given by a very actinic electric spark of extremely short duration.

G. L. C.

BOOK REVIEWS

Cinematographic Annual 1930. *American Society of Cinematographers,* Hollywood, Calif. Edited by Hal Hall. 606 pp. $5.00. Thirty-eight authors, each noted for his ability in some branch of the motion picture arts or sciences, have contributed papers to this first annual of the A. S. C.

The reader is certain to be impressed with the diversity of the subject material presented in this volume. It is a text book for the motion picture worker designed to give a general education for the studio and laboratory personnel. Its content is divided equally among five subjects: (1) Artistic and dramatic features of production, (2) photographic theory and technic, (3) mechanical equipment used in the industry, (4) sound theory and production technic, and (5) amateur cinematography. Despite this diversity, only a few of the subjects suffer from a lack of detail. That the annual is intended as a reference text for the industry is evidenced by a thirty page section which gives useful tables and formulas. The value of the book for the reference shelf would be considerably enhanced by a classification of material into sections and by indexing.

C. M. T.

A Dictionary of Color. A. Maerz and M. Rae Paul. *McGraw-Hill Book Co., Inc.,* New York, 1930. 207 pp. In this work the authors present the results of an exhaustive investigation of the use of color words and the particular color sensations they identify. Not only have the names in common usage in the English language been given but, in so far as possible, the origins of these names are included. A bibliography of books dealing with color names is found on pages 20 and 22. The authors discuss the three attributes of color, which they have decided should be known as value, purity, and hue. Definitions of these attributes and of other color terminology are given on pages 10 and 11.

For the purpose of reproducing the color sensations associated with color names there are fifty-six color plates and each plate is divided into 12 rows and 12 columns. In these plates the colors are arranged in groups as follows: Red to orange, orange to yellow, yellow to green, green to blue-green, blue-green to blue, blue to red, and purple to red. Each group is presented in eight plates of which the first shows the color graded from its highest purity into white. The remaining seven plates of each group have increasing amounts of gray until the colors approach black. On the left-hand page facing each plate the color names in current usage are given in spaces which correspond to the color samples.

A brief history of color standardization is given which describes the work of Werner, Hallock, Dauthenay, Ridgeway, and others. The index of color names completes the volume which should prove valuable to those individuals who wish to know the relation between colors and the names by which they are identified in common usage.

E. M. L.

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LOYD A. JONES, EDITOR *pro tem.*

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INTERNATIONAL RELATIONS IN THE SOUND PICTURE FIELD

FRANKLIN S. IRBY*

The motion picture industry has passed through approximately three decades of growth—the first twenty years represented a period of continuous litigation over patent rights and licensing agreements. The next ten years, which would take us up to the entrance of sound pictures, was a period of tremendous expansion and growth unfettered by injunctions or restrictions.

In 1926, at the end of this period, the industry was "resting on its oars" if not actually slipping backward, and hoping for a new stimulus to lead it forward. This stimulus was provided by the introduction of sound pictures. This resulted in the development of a very complex structure of interlocking patent agreements and associated capital tie-ups both here and abroad. In tracing the history of this complex structure, we pass through three stages of development: first, the rise and fall of the old Motion Picture Patents Corporation; second, the development of radio and the first patent pooling agreement in the radio field; and third, the licensing agreements set up in the sound picture industry. The present economic structure has drawn into a closer relation the fields of electronics, such as phonograph disk manufacture, talking machine production, radio, and the sound picture industry.

It is rather significant that Edison, in his early experiments with the phonograph, should attempt to synchronize sound with the earliest projector. This phonograph idea persisted for years, in the development of the projection machine. Some thirty years later, we find the first successful electric recording of phonograph records a definite step in the making of sound pictures as we see perfected today. However, much water was to flow over and around the dam of progress in the motion picture art before a world-wide industry,

(Read before the Society at New York, October, 1930.)

* McGraw-Hill Publishing Company, New York.

based upon the research in other fields, was to build up the gigantic structure existing in 1930.

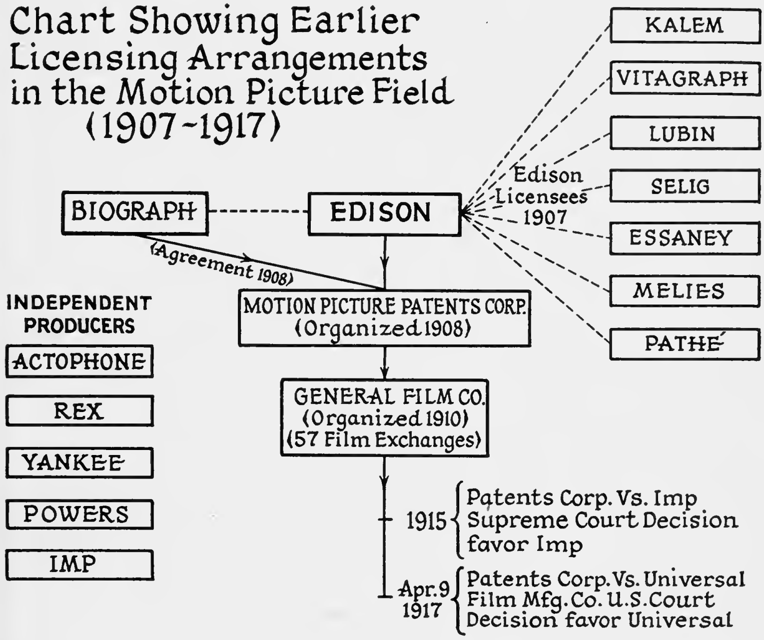
Litigation which was started in the earlier days of motion pictures led some years later to the first patent pooling agreements in this field. The first court action, that was to be the forerunner of many others, was started by Thomas A. Edison on December 7, 1897, when an injunction was sought in the United States Circuit Court of the Southern District of New York, against the International Film Company, claiming the Projectoscope of the latter firm was an infringement of the Edison machine. This case was followed by another suit of Edison's against the American Mutoscope Company, claiming infringement against Edison's camera patent. This was the start of one of the longest and most desperate patent fights in the history of the American industry. Ramsaye* has stated that there were no less than 202 major actions, involving patent litigations in the United States, with a list of approximately 300 replevins during the development of motion pictures. During this tempestuous period, many new names of producing organizations came forward, some of which can be traced directly down to the present. Among the latter may be mentioned the old Vitagraph Company; this was the result of a triumvirate formed with William Rock, J. Stuart Blackton, and Albert E. Smith, in 1899, which carried on for almost thirty years, down to the sale of the Vitagraph Company to Warner Bros. in 1925.

THE FORMATION OF THE MOTION PICTURE PATENTS CORPORATION

Up to 1907, every studio was a guarded stronghold; all the makers of pictures were hiding their methods for fear of being discovered in their infringements of the Edison patents. The industry up to this period was in a state of feudal war which was still far from being ended. On October 24, 1907, Judge Kohlsaat, in the United States Court in Chicago, handed down a decision holding the cameras used by Selig were an infringement of the Edison patent. This decision was followed by the first important pooling and licensing agreement in the motion picture industry, which included Kalem, Vitagraph, Lubin, Selig, Essenay, Melies, and Pathé. Under this agreement, all the producers were licensed under the Edison patent, in consideration of royalty payments. One important producer at this time, Biograph, did not join and demanded recognition on an equality

* TERRY RAMSAYE: "A Million and One Nights." *Simon & Schuster*, New York (1926).

with Edison. Biograph contended that its patents were as necessary to the art as Edison's. After ten years of litigation (at the end of 1907), Biograph was just beginning to fight. However, during the following year Biograph ran into certain financial difficulties, and with pressure of the bankers (which has happened more than once), finally joined the Edison group on favorable terms, the agreement being signed December 18, 1908. This agreement included Edison, Biograph, and all of those which Edison had licensed—Vitagraph, Selig, Lubin, Essanay, Pathé, Kalem, and Melies. They pooled



their patents, and the Motion Picture Patents Corporation was born. This was the beginning of the most powerful concern in the history of motion pictures.

This coalition was not, however, the end of litigation; the formation of new independents continued. Such companies as Actophone, Rex, Yankee, Powers, Imp, and others sprang into active life. The General Film Company was organized in 1910 by the Patents Corporation for the purpose of acquiring the principal film exchanges throughout the country, and thus controlling the output of films direct from the producer to the exhibitor. This company succeeded quite well, as by January 5, 1912, 57 principal exchanges had passed into its control. The grip of the Patents Corporation on the industry was getting tighter. The Patents Corporation had acquired every licensed exchange except that of William Fox. It was an injunction obtained by the latter, to obtain film from the Patents Corporation, that finally led to the dissolution suit against the Patents company in the Federal Court. The government's suit against the Patents company was started in 1913, and dragged through the courts for years, ending with a decision against the trust with the order to "discontinue unlawful acts." This decision came too late to have any effect, because the growth of the industry had been so rapid as to sweep aside the points involved. The end of the Patents company was not far off. One of the final stages resulted in a victory for the Imp Company against the Patents company before the Supreme Court in 1915, involving the "Latham Loop" patent. The Motion Picture Patents Company, the parent organizer of the General Film Company, came to the end of its active career on April 9, 1917, when the United States Supreme Court, in the case of the Patents Corporation *vs.* the Universal Film Manufacturing Company, held that the Patents' combine could not enforce the use of licensed film on patented projectors in the theaters. Thus were ended two decades of litigation and licensing arrangements within the industry. The next ten years were to see a tremendous expansion and growth of the industry freed from previous restrictions and court actions. New names of producing organizations came to replace the old, and the direct ownership or control of theaters by the larger companies became an accepted fact.

RADIO-AUDIO PATENT AGREEMENTS

As previously mentioned, the earliest development of motion pictures was associated with synchronized phonograph records, but no successful results were to be expected. This was due to the lack of loud speakers and vacuum tube amplifiers to operate them. The development of the vacuum tube and the growth of radio ran parallel to the successful rise of moving pictures. DeForest's original invention of the three-element vacuum tube occurred in 1906, and in 1908 this same pioneer broadcast a program by Caruso from the stage of the Metropolitan Opera House. While wireless communications existed since the turn of the century, it was some twenty years later before broadcasting became general.

The first pooling arrangements in the radio field occurred in 1919–21, when hundreds of patents, owned by General Electric, Westinghouse, A. T. & T. Company, Wireless Specialty Company, and the Radio Engineering Company of New York, were transferred to the Radio Corporation, which had been organized on October 17, 1919, by General Electric. These pooling arrangements have since been referred to generally as the radio-audio patent agreement. The number of patents, owned or controlled by these various companies bearing on radio apparatus at the time the agreements were made, are as follows: RCA patents—227, applications pending—65; General Electric Company patents—114, applications pending—110; A. T. & T. Company patents—337; Westinghouse patents—146, applications pending—16; Wireless Specialty Apparatus Company patents—68; and Radio Engineering Company of New York patents—144. Included in this list were some 121 patents, including important patents relating to the vacuum tube, of the DeForest Radio Company, which reserved the right to manufacture and sell under these patents.

This patent pool was organized long before sound movies came over the picture horizon, and specific mention of apparatus pertaining to this field was not to be expected. Some of the well-known patents included in this pool, involving circuit arrangements, are the Lowenstein Patent No. 1,231,764, issued July 3, 1917, covering the use of a negative potential in the grid circuit; DeForest Patent No. 1,377,405, issued May 10, 1921, covering the "grid leak;" and Langmuir Patent No. 1,282,439, issued October 22, 1918, covering a grid condenser. Other important patents included those covering the DeForest vacuum tube, the Langmuir high vacuum, Colpitt's grid modulator, DeForest oscillator, and others.

As mentioned previously, the motion picture industry was singularly free of licensing agreements after the passing of the old Patents Corporation, until the arrival of sound pictures. The licensing arrangements set up by Western Electric and RCA-Photophone with the leading producers of motion pictures in this country are well known. The organization of Electrical Research Products, Inc., RCA-Photophone, Pacent, General Talking Pictures, and other companies to handle sound reproducing equipment was the result of the successful exploitation of sound pictures. In this country the industry has been relatively free of litigation, although some interferences have come before the courts.

DEVELOPMENTS IN EUROPEAN COUNTRIES

A brief discussion of the development of the European companies in this field will be given. Klangfilm, Tobis, and Kuechenmeister groups represent the strongest interests in the European sound picture field. It is interesting to note that practically all the arrangements, either associated capital tie-ups or licensing agreements, have been made during the past two years. The Tonbild Syndicate, A. G., generally referred to as "Tobis," was organized in 1928 with a capitalization of 12,000,000 marks. Besides German and Swiss capital, considerable Dutch capital was represented in this organization. The well-known Tri-Ergon patents, which are the results of the research of three Germans, Englund, Vogt, and Massoelle, are included in the hundreds of patents acquired by this organization. It is understood that William Fox owns the exclusive right to the Tri-Ergon patents in this country. Tobis, besides building reproducing apparatus, represented the sound picture production interests. One of the earliest contracts concluded with the Deutschen Lichtspiel-Syndikat (German Talking Picture Syndicate), an organization of some 800 affiliated moving picture theater owners, for the sale of German domestic films and sound picture apparatus.

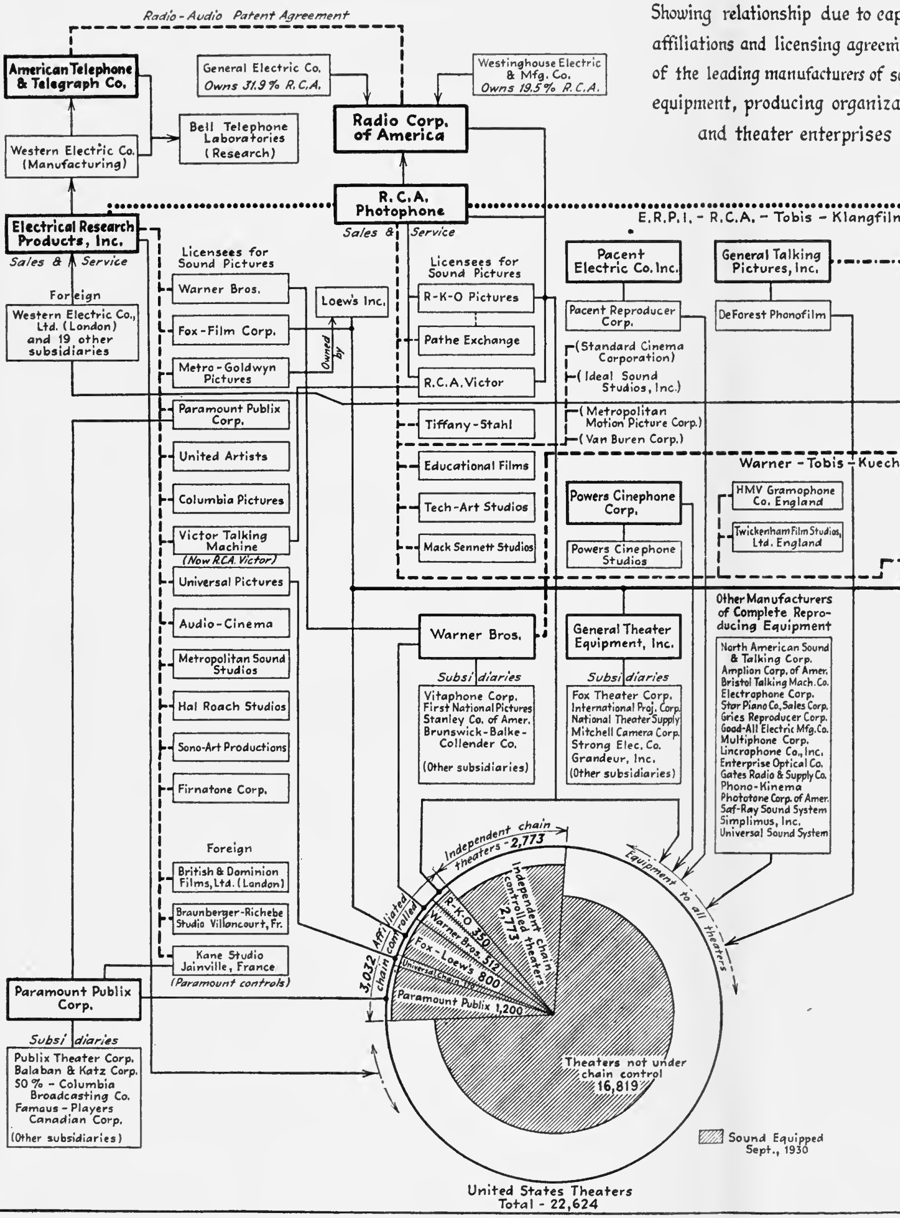
Almost simultaneously with the founding of Tobis, the well-known German electrical concerns, Siemens and Halske, and A. E. G., who had been carrying on research in the realm of sound films, came forward with the founding of Klangfilm, G.m.b.H., with a capitalization of 3,000,000 marks, in which Polyphon-Werke, A. G., holders of important phonograph patents, participated. The organization of Klangfilm was thus represented: Siemens and Halske, 45 per cent; A. E. G., 45 per cent; and Polyphon, 10 per cent. This organization, because of their foreign patent affiliations with the General Electric Company, constituted a strong threat to the Tobis organization. Patent litigation, which Tobis instituted against Klangfilm was, however, ended within a few months due to a settlement which provided total independence of both companies, continual coöperation, and complete patent exchange.

Tobis, in order to procure operating funds, and at the same time to place the sound picture business upon an international basis, sold the foreign rights in their sound picture methods to an international finance syndicate under the leadership of the Dutch banking house of Oyens and Sons. The latter, through the affiliation of the Kuechenmeister organization, made the Tobis patents the basis of a

CHART OF THE SOUND

UNITED STATES

Showing relationship due to cap
affiliations and licensing agreem
of the leading manufacturers of so
equipment, producing organizat
and theater enterprises



comprehensive international organization with the acquisition of other methods of electro-acoustics.

Kuechenmeister, a German inventor and promoter, was probably the first to recognize the importance of pooling the patents in the sound picture field. He had to turn, however, to Dutch bankers for support. Thus, at the time Klangfilm was organized, Oyens and Sons organized the N. V. Kuechenmeister Internationale Ultraphon, in October, 1928. This organization and other concerns represented in the fields of radio, phonographs, and phonograph disk manufacture, as well as sound pictures, embracing all the fields of electro-acoustics, were finally, in March, 1929, brought together under the N. V. Kuechenmeister Internationale Mij. voor Accoustiek, with a capitalization of 30,000,000 florins.

After the settlement of conflicting interests between Tobis and Klangfilm, N. V. Kuechenmeister Internationale Mij. voor Sprekende Films was formed with a capitalization of 10,000,000 florins, through which the Kuechenmeister group concentrated its film interests, and in which Tobis placed about one-third of its capital stock. The Dutch banking interests were also successful in acquiring about 26 per cent of the Tobis capital for the account of the Kuechenmeister Accoustiek, so that this organization, together with its Dutch financial allies, holds about 68 per cent of the Tobis capital. About 30 per cent of the Tobis capital is held by a German banking syndicate, under the direction of the Commerz and Privatbank. This explains the latter's participation in the recent Paris sound picture conference.

Shortly after its organization, the Klangfilm Company obtained a majority holding in Lignose-Hörfilm, Ltd., which owned the patent rights on the Breuning system of disk recording, and also controlled the British Phototone Company. This group, together with a sister company, the French Phototone Company, Ltd., and other film companies, were under the control of Count de Bosdari.

Klangfilm, Ltd. (Great Britain), was founded in London in May, 1929, to absorb and make use of the English Klangfilm interests. This new company was to take over the production of Klangfilm apparatus in England, to avoid payment of high English import duties. The coöperation with the British Phototone does not appear to have had the anticipated results, at least, not in the manufacture of apparatus.

British Talking Pictures Corporation was organized by a group headed by I. Schlesinger, who controlled the South African film and theater market through the Schlesinger-owned African Consolidated Investment Corporation, to which several African theater and film enterprises belong. The brother of I. Schlesinger, M. A. Schlesinger, is in control of the General Talking Pictures Corporation in this country. These companies control the Lee DeForest sound picture patents. British Talking Pictures later organized the S. A. Films Sonori in Rome (organizing capital 15,000,000 lire), with the support of the Italian Government, and by purchasing 40 per cent of the capital of this new company. Several large film concerns, such as the Ente Nazionale per la Cinematografia, Luce, and several music publishing houses are affiliated with Films Sonori.

The Associated Sound Film Industries, Ltd. (Asfi), with an authorized capital of 1,000,000 pounds, was organized in November, 1929, as a holding company for the Kuechenmeister group and General Talking Pictures Corporation. The interchange of capital stock of the founder organizers resulted in the pooling of patents involved in General Talking and Tobis groups for the British Empire.

The entrance of the Tobis-Kuechenmeister in France took place in February, 1929, when Tobis organized the Soc. de Films Sonores Tobis as its French producer. The French film market, which at first had the leading place in supplying the international film industry, is today under strong foreign influence. The Compagnie Générale de Télégraphie sans fil (capital 100 million francs) is a national producer of apparatus. It organized the Radio Cinema for the development of its system of sound recording.

INTERNATIONAL CONTACTS

Since the advent of sound pictures, there is to be observed a development toward concentration within the film industry, with still stronger international contacts. This is indicated by the number of foreign licensees for the recording of sound pictures, Western Electric now having three, and RCA-Photophone ten. The large American producers are also expanding in foreign fields, as indicated by the acquisition of the Gaumont British Pictures, a chain of some 300 theaters in Great Britain by Fox Films, and even more recently, the purchase of an interest in Hoyts' chain of 100 houses in Australia by the Clarke interests. The acquisition of the Kane Studio at Joinville, France, by Paramount, is another step in this expansion.

Because of strong consolidations built up in Germany, the Western

Electric Company was prevented by court injunction from installing their sound picture apparatus in Germany. American sound films were also prohibited from showing on German apparatus, all of which caused considerable havoc in this market. Warner Bros. Picture Corporation was the first American producer to obtain the right to show its pictures in Germany. This was accomplished by acquiring an interest in the patent and license agreements of the Tobis-Kuechenmeister group. This procedure on the part of Warner Bros., since it recognized the license claims of Tobis, which Western Electric were fighting, was in direct opposition to the position taken by the latter company. The move made by Warner Bros. was of such fundamental significance for the whole international sound film industry, that the Tobis group used it to introduce new negotiations with the American electrical companies.

This led up to the Paris Sound Picture Conference in July, between the German and American representatives of the film and electrical industries. The German companies involved in these negotiations were: A. E. G., the Siemens and Halske Company, and the Tobis group. American concerns were the Electrical Research Products, Inc., and RCA-Photophone, Inc. Preliminary negotiations were concluded July 22, 1930, as a result of which a memorandum was signed providing for the interchangeability of motion pictures in all countries upon all makes of licensed apparatus of the signatory parties. This memorandum also divides world territories into three sections, for the manufacture and sale of sound picture apparatus. The section which will be supplied solely by American manufacturers includes the following countries: United States, Canada, New Foundland, Australia, New Zealand, the Straits Settlement, India, and Russia. The countries reserved for German-manufactured apparatus include: Germany, Danzig, the Saar Basin, Memel, Austria, Hungary, Switzerland, Czechoslovakia, Holland, the Dutch East Indies, Denmark, Sweden, Norway, Finland, Jugoslavia, Rumania, and Bulgaria. The countries not included in either of the above two groups are open to products from either Germany or the United States, and include several European nations, among which are France, Great Britain, Spain, and Italy. The above agreement, as previously stated, apparently is applicable only to the signatory parties to this agreement.

We thus see that the entrance of the vacuum tube in the motion picture industry has built up the most complex corporate machine in the world, and in the place of relatively simple contractual agreements, we have a vast international network of inter-lacing patent agreements and licensees extending in its influence to 57,000 theaters serving hundreds of millions of people throughout the entire world.

Whether the end of litigation and patent wars is in sight for the industry is problematical, but as we enter the fourth decade in this development, we may expect greater stability, better financing, and more progress for the future.

MEETING SOUND FILM COMPETITION ABROAD

C. J. NORTH AND N. D. GOLDEN*

Last year, at your convention held in Toronto, I had the privilege of outlining to you in some detail the development of the sound film abroad. On that occasion, I tried to give you some approximate idea of what the potentialities of the foreign sound field were on the exhibition side, through a presentation of estimates of the number of theaters wired. I also endeavored to indicate what European producers were doing in the way of sound film production. It is my intention to pursue this thought today, stressing new conditions created by the displacement of silent by sound films, which in my belief are already beginning to create a severer competitive situation for American pictures abroad. And it is my further purpose to outline in a general way what our major film companies are doing, in an endeavor to retain their hold in the non-English speaking markets

First, however, I want to make a couple of general distinctions between the sound film situation abroad, as I outlined it a year ago, and as it is at present. Then, while talking pictures had certainly passed beyond the novelty stage, English dialog pictures were still being shown with a fair degree of success; theaters equipped with sound were still the exception rather than the rule; and as a necessary consequence of this, silent product still continued as the film fare of a startlingly larger proportion of theatergoers abroad. But now this situation has undergone a revolutionary change. Films in the English language stand little or no chance in most non-English speaking areas. The wiring of theaters has proceeded at an unprecedented rate of speed with the result that as in the United States any theater owner, if he wants to draw the crowd, will have to install sound, this movement to wire theaters being in turn due to the public demand for sound films. The silent picture is destined to die out

(Read before the Society at New York, October, 1930.)

* Motion Picture Division, Bureau of Foreign & Domestic Commerce, Washington, D. C.

abroad just as it has in the United States, and although silents still command more extended showings in foreign theaters than in our own, we already find exhibitors of silents hard up for product and forced in considerable measure to depend on re-issues or product of a year or two back. Whether the silent film is likely to show any signs of revival at a later date is a subject upon which I would not care to prophesy and is, besides, beyond the scope of this address.

This brings me to the second generalization. Last year at this time, only the first faint beginnings of sound film production had been made in foreign studios. True, a few talking pictures had been released by England and Germany, a number of studios abroad had installed or were in the process of installing recording equipment, and extensive plans were being laid for sound picture production. But the plans so laid were still largely in the paper stage. Within the past few months, however, England, France, and Germany, at least, have built up a record of talking picture releases which have established considerably greater box-office success than the general run of silent pictures previously put out by them. And for next year, announcements of product have been made which argue for considerably greater competition for American films in those countries than at any time previously. This competitive factor, which really forms the main theme of my talk today, will be treated in greater detail later on. All I want to stress now is that the demand of peoples for films in their own language plus the difference in technic between the silent and sound picture, is operating to increase competition for American films abroad.

Now consider with me for a moment or two the exhibition outlets for sound pictures abroad, by which I mean the number of theaters wired. Outside of Europe there are, excluding the United States, just under 10,000 theaters. Of these, again quoting in approximate figures, about 4000 each are to be found in Latin America and the Far East, 1100 in Canada, 750 in Africa, and 50 odd in the Near East. The number of wired theaters for this entire area, based on figures which we believe reliable but for which we cannot assume responsibility, now runs to about 1800, being divided about as shown in Table I. While this may seem a relatively small number out of the total, it must be remembered that the wired theaters include without exception all the largest and best equipped theaters, the ones, in fact, which supply the bulk of the revenue to the American picture companies. Of those remaining, many are being wired or soon will

TABLE I

Foreign Theaters

	Approximate Number of Theaters	Approximate Number of Theaters Wired
Europe	27,000	4950
Far East	4,000	900
Latin America	4,000	450
Canada	1,100	450
Africa	750	40
Near East	50	10
Total	36,900	6800

be, while an even larger number will have to choose between wiring or closing their doors, either from lack of patronage or as soon as the silent film supply becomes exhausted.

TABLE II

Increase in Number of Wired Theaters, 1929–30

	Theaters Wired as of Oct., 1929	Theaters Wired as of Oct., 1930
United Kingdom	400	2600
Germany	30	940
France	20	350
Spain	4	145
Italy	30	120
Netherlands	50	95
Sweden	7	90
Czechoslovakia	6	75
Hungary	5	70
Switzerland	3	65
Poland	0	60
Austria	0	55
Rumania	7	50
Denmark	18	45
Jugoslavia	13	35
Norway	2	30
Belgium	1	30
Greece	6	20
Finland	4	15
Portugal	0	15
Bulgaria	0	10
Turkey	2	10
Other European Countries	0	25
Total	608	4950

Turning now to Europe, which, after all, remains our principal revenue market, there are approximately 27,000 exhibition outlets. Table II will give you a clear picture of the situation. In it, as you can see, I have tried to indicate a comparison between theaters wired as of approximately this time last year and now, and it seems to indicate, more graphically than anything I can say, the manner in which the sound film is beginning to dominate the European scene. From less than 650 sound equipped theaters in the early autumn of 1929, wiring has gone ahead by leaps and bounds with the result that Europe (exclusive of Russia) now presents a grand total of around 4950 theaters. Indeed the number may be somewhat higher than this, because in a certain few countries it has been impossible to get completely accurate figures and in certain others our latest reports date back to the end of July. Again I want to point out, that, as in the case of Latin America and the Far East, the number of sound theaters may seem comparatively small when set against the total numbers, but the wired houses comprise all the biggest and best, which provide the overwhelming proportions of box-office receipts.

Even more striking does our comparison become in the case of figures from the individual countries. Note England, for example. Its total for this time last year is set at about 400 and this has now increased to 2600. France then had 20 sound equipped houses; now it shows nearly 350, and Germany with 30 sound houses, the patent dispute having kept down wiring there, now has nearly 950. Italy has increased from 30 to 120. There is no question but that within another year the European exhibitor will, in almost all cases, have had to choose between sound and closing his doors, particularly as silent product will be scarce, and such as there is, will command small attention.

The Motion Picture Division has endeavored at all times to supply the industry with authoritative figures. This, however, in the case of wired theaters, is impossible. Even during the course of this short talk it is quite likely that two or three more theaters somewhere in this world have gone "sound" and the change in totals from month to month is astonishing. It reminds me of the story told about the late Marcus Loew, who assured a visitor that the total number of theaters controlled by his organization was 118, but was promptly reminded by his secretary that he had given yesterday's figure and that the number was now 123. All we can do, and we are doing it now, is to furnish the figures supplied by our foreign offices, these figures undoubtedly being as accurate as is humanly possible when compiled, but which become approximations by the time we can make them available to the trade. And this state of affairs is bound to continue until the saturation point for theater wiring abroad is more nearly reached.

To return to the subject in hand, in the old silent film days the question of competition was largely academic. Indeed, the chief obstacle to American films lay in those countries which cut down the showings of American films by artificial restrictions. Foreign films there were, to be sure, some of them of considerable quality, but from a strict economic viewpoint, there were few cases where the local product was booked as against the American product in a strictly competitive sense. Now, however, two factors have arisen which will tend to make the American position less secure.

The first of these is the great difficulty, both from an economic and physical standpoint, in supplying foreign language versions to non-English speaking countries, which, as you know, are now insisting on films in their own language. Obviously, if there is any question that there will not be enough product from America to fill existing play dates, local exhibitors are bound to look with a more favorable eye to their own studios, and if these can fill their requirements satisfactorily, they may in future give them first choice. Secondly, there is a widespread feeling that European producers are adapting themselves more readily to sound than they did to silent film production. This has proved particularly true in the case of England, as I shall demonstrate in a few moments. Finally there has been a slight tendency for the public to flock to sound films from its own studios if only for the sentimental reason of seeing its own actors and actresses speaking its own language in familiar surroundings. For instance, *La Route est Belle,* one of the first French dialog films produced by a French company (Établissements Braunberger) had a phenomenal box-office success grossing 3,028,000 francs in a four months' run at a Paris boulevard house as against a high record of 1,965,000 francs for this same house over a similar period. It then did another four months' run in a Paris neighborhood house to the tune of 1,322,529 francs against a previous high for the house of 740,681 francs and concurrently with this, it was running a total of 62 weeks in 25 provincial cities. This, of course, is an exceptional case and may be partly explained, at least, on the ground of novelty.

It nevertheless contains food for thought as a possible subsidiary factor in connection with those already outlined.

Proof is not lacking that Germany, France, and England are now going rapidly ahead with sound and dialog film production. Table III indicates in a general way what they are doing. Naturally such

TABLE III

Production Schedules of Foreign Producers

Germany		France		England	
French Versions	40	English Versions		French Versions	15
English Versions	15	German Versions		German Versions	25
German Companies		French Companies		English Companies	
Ufa	40	Pathe-Natan	20	British International	25
Terra	15	Société des Films		British & Dominions	12
Hegewald	12	Osso	12	British Instructional	10
Tobis	10	Jacques Haik	9	Gaumont	8
Aafo	8	Cine Studio Con-	3	British Lion	6
Greenbaum	8	tinental	3	D & H Productions	6
Sudfilm	8	Vandal		Twickenham	4
Other Companies	34	Delac		Gainsborough	
		Braunberger		Piccadilly	
		De Veulo	26	A. S. F. S.	24
		Abel Gance		Raycol British Corp.	
		So Far		Patrick Heale Production	
		Others			
Total Production	135	Total Production	70	Total Production	95
		European Production	300		
		American Multi-Lingual Production	175		

production schedules as the individual companies indicate are subject to change, just as are those of American companies.

Germany, up to July 1st, released 24 dialog pictures and 10 sound synchronized. Of these, 20 dialog and 6 sound synchronized were released during the calendar year. Among them were several, notably, *The Blue Angel*, starring Emil Jannings, and *Hearts Melody*, to name only two, which achieved quite remarkable box-office success. English and French versions were made and enjoyed considerable showing in those countries. Now for the coming year, German companies announce no less than 135 sound features of which 23 have already been released. French versions of 40 of these, and English versions of around 15 are offered. Individual company programs are shown in the table. In this connection it is interesting to note that nearly all the Sudfilm production is in combination with companies from other countries, notably British International Pictures, collaborating in 3 productions, Pathe-Natan in 2, and an American company in one. There are, furthermore, arrangements for a few collaborations with Danish, Swedish, and Finnish productions units.

France during 1929 released only four sound pictures. Only one of these, curiously enough, *Le Collier de la Reine,* made by Aubert was actually the product of a French studio, the other three, *La Route est Belle* (mentioned above), *Le Nuit est a Nous,* made by De Venloo, both being produced in England, and *Les Troi Masques,* made by Pathe-Natan, being produced in Germany. All four enjoyed a greater measure of success than previous silent films produced in France, the popularity of *La Route est Belle,* as before indicated, being phenomenal. It should be understood that the list is in no way final and we may well find after the next playing season that the total is too low or too high. It does represent what is likely to occur. It has been impossible to get any clear-cut statement of the number of foreign versions of these films which France proposes to put out. The total is not likely to be very high. Nevertheless there is every probability that French sound product will attain a greater measure of popularity than ever before within the borders of France itself and is likely to furnish considerable competition.

Let us turn now to England.

It is a curious fact that in a country which is making such strenuous efforts to increase the quantity and quality of its film product there should be so little definite information as to how many pictures will be put out by British studios during the coming season. Such is the case, however, so what follows represents merely a piecing together of such scraps of data as we have been able to dig out. It represents though, we believe, a rough approximation of the situation.

As we implied above, England in such pictures as *Atlantic* and *Rookery Nook,* for example, is beginning to show a considerably greater degree of deftness in sound than in silent film production. During 1929 about 40 films were actually started of which around

35 were either dialog or sound synchronized. More than that have already been produced in 1930, while for the coming season somewhere between 80 and 100 films will probably be made. Table III gives the details of these, but it is interesting to note that four companies, British International with 25, British and Dominions with 12, British Instructional with 10, and Gaumont with 8, account for well over half.

The situation in England is somewhat confused furthermore with the production of quota films for American account and with tie-ups with Continental companies for multi-lingual versions. Several of these latter are being made by British companies.

Outside of the three countries just considered there is not much in the way of film production activity in Europe. It is interesting to note, however, that in Italy, Pittaluga has equipped the Cines studio in Rome for sound and has announced a number of multi-lingual features, the languages to be employed being English, French, Italian, and German. Austria, too, is embarking on sound film production through the Selenophon Company located at Schonbrunn, which has just announced a talking film to be entitled *Stormy Night*. Furthermore, the Sarcha Company of Vienna has made arrangements with the Berlin firm of Fellner and Somlo for joint production. Other similar projects have been announced in Holland, Denmark, Sweden, Norway, and Spain, and from far-off Athens comes news that Olympia Film, a Greek producing firm, is planning the construction of a sound film studio.

We find then that if these production plans are carried out there will be not far from 300 "made in Europe" sound productions on the European motion picture market. Granted that a large percentage of these may receive only limited showing, there is, nevertheless, material here to indicate a considerably greater measure of competition for the American product than heretofore. In addition to the fact that recent performance indicates better quality product from France, England, and Germany, we must remember that all three of these markets, which produce well over 50 per cent of our revenue from Europe, are hedged about by restrictions, which, at least in the latter two, give a material advantage to the local product. Germany's latest contingent law allows the showing of at most 110 foreign sound films up to June 30th next and the English quota is rising each year.

What then are the American companies doing to meet this competition? I refer here specifically to non-English speaking areas, for where there is no language problem the situation is in no way changed from silent film days. So far the American industry has met the problem in three ways: (*a*) writing captions on the screen in the appropriate language as explanation of the English dialog, (*b*) dubbing, (*c*) actually doing the picture in the appropriate language. The first is out so far as dialog films are concerned, but still may be employed on "musicals" where a minimum of dialog is used. The second is probably out at least to a large extent, though recent processes have perfected it to an almost unbelievable degree. I believe it can still be used in musicals and where the dialog is at a minimum, as the chief objection to it as straight dialog is the fact that it shows actors talking perfectly in a language of which obviously they have no knowledge. I wonder if any American producer has ever considered saying quite frankly to his foreign audience by means of an explanatory title, that while the actors do not speak the language in question, it was considered fair in the interests of realism to employ voice doubles, so that their favorite stars in the silent film days, could still be brought before them even though they could not speak the language. It might not work, but at any rate I pass the thought along.

This brings us to the method now employed by nearly all the companies here. For even though dubbing is still being carried on particularly for the less well-known languages, such as Portuguese, Hungarian, Rumanian and the like, the bulk of pictures destined for non-English speaking countries are actually done in the appropriate language with foreign casts. In the method of taking these, there seems to be two schools of thought, one which believes that the picture should be made abroad and the other that foreign versions can still be produced more profitably in Hollywood. I should not presume to render an opinion as to the relative merits of these contentions, beyond pointing out that both have obvious theoretical advantages and disadvantages too numerous to be given in any detail here. As both methods are being tried, time will tell, but the point to note is, that American companies are already successfully meeting competition with foreign versions already released in the major non-English speaking markets of the world and more are on the way.

For example, plans for the coming season embrace the following: One large American company has announced from its studio near Paris, production in 13 foreign languages embracing a total of 110 features. And to this may be added from ten to a dozen multilinguals at its studios in Hollywood and New York. Another company has planned versions in French, Spanish, German, and Italian, totaling 42 features. Another has under way 18 features, 6 in Spanish, 6 in French, and 6 in German. Two other companies contemplate half a dozen features each, with more to follow, dependent on the success of these when released. So far as I know, only two major companies are definitely remaining out of the foreign language field and even these will use dubbed versions of one or two of their outstanding productions.

I wish I could be more specific as to these foreign production plans of the companies, but many of them rather than announce a definite schedule are waiting to see the reception accorded to those now in production before going ahead too ambitiously. It can, I believe, be roughly calculated that American product will reach in the neighborhood of 150 in the three languages, German, French, and Spanish. Adding to this the foreign language versions made by foreign companies under contract for American companies, these being used in most cases for contingent purposes, I think we can consider the probability of 175 all told.

And there is no reason why these pictures should not act as more than an offset for the foreign productions offered. True they will lack some of the box-office names which have helped to popularize American films in bygone days, but fortunately Hollywood has quite a number of multi-lingual experts among its personnel and the American companies can and will build up new box-office names from actors and actresses already popular on the speaking stage or in the film world of France, Germany, and other countries. American scenarios, technic, and directorial ingenuity will remain, and while it is questionable whether we will again get as large a return from non-English speaking markets as in the silent film days, there is every prospect that we will more than hold our own even in the face of the foreign product.

PROGRESS IN THE MOTION PICTURE INDUSTRY*

Throughout the spring and summer of 1930 a gradual increase was noted in the efforts to establish the sound picture as a medium of good entertainment and lift it out of the realm of pure novelty. Many of the problems which faced the director and cameraman have been solved, and it has been possible for them to give more attention to the artistic and dramatic phases of the picture. Installations of unsatisfactory sound equipment made during the past two years in the studios and theaters were rapidly being replaced by standard reliable apparatus.

An encouraging sign of the times is the evidence of greater collaboration that exists between the producing organizations and the engineers in relation to the study of problems dealing with standard practice, such as camera silencing, release prints, and allied matters. The willingness of the producing companies to pool their knowledge and work with the technical committees of the Academy and this Society should result in a lowering of production expenditures when the knowledge gained is applied to practice.

Further progress has been made on the large picture problem, and, although final agreement still remains to be made on film width and picture shape, the engineering details have been settled and the outlook is hopeful for an early compromise on the remaining questions. In the meantime, most of the major producing organizations have made one or more pictures on wide film during the course of regular production and much valuable experience has been gained. One scheme that appeared to be gaining in favor was the plan of making the negative on wide film, printing by optical reduction on 35 mm. film, and projecting a large picture with a short lens.

Satisfactory international settlement of certain patent difficulties in European countries has encouraged the producers and exhibitors abroad to invest more heavily in sound equipment and installations were proceeding at a rapid pace. A marked demand was evident for pictures in various countries in native dialog.

(Read before the Society at New York, October, 1930.)

* October, 1930, Report of the Progress Committee.

Equipment such as cameras, lights, set materials, *etc.*, for making pictures has been rigorously examined by recognized committees, to determine their best design and composition for improving sound picture quality. Sound-on-film recordings appeared to be gaining in favor over disks as a result of better technic in recording the sound and processing the records, as well as the advantage of having sound and picture as an integral unit.

The use of two sound track records run simultaneously on "dummy" projectors apart from the picture projector has been given a satisfactory trial under regular performance conditions and is believed to offer a means of improving the sound quality of very loud sound effects. Special amplification and extra horns were used. The frequency range of loud speakers has been extended and one type, when used as an adjunct to the ordinary style, makes possible uniform reproduction of sound from 50 to 11,000 cycles.

Further data have been compiled on acoustics of theater auditoriums as well as on the sound characteristics of screens and special instruments devised for measurement of critical factors.

Interest in television has increased rapidly during the past few months in this country and abroad. Two public demonstrations were given as part of regular theater programs, one of which ran for a fortnight at a London variety house. Other showings were scheduled for this fall in Berlin and Paris. A leading experimenter has stated that television has now progressed to about the same degree of development as radio in 1915. Much is expected therefore from this new entertainment medium and authorities predict that it will be an asset rather than a liability to the motion picture industry.

Color as an adjunct to sound pictures appeared to have been over-sold to the public during the past year but steady improvement has been noted in the quality of pictures by subtractive processes which continued to have the chief commercial distribution.

Although a business depression prevailed in the world during the summer of 1930, total exports of film for the first six months of the year showed a 19 per cent increase over the same period in 1929.

Acknowledgment.—Valuable data have been contributed for this report by several members and friends of the Society residing in this country and abroad. L. Busch, Berlin, and S. A. Petterson, Stockholm, submitted comprehensive summaries of papers and useful commentaries on conditions in the industry in Germany and Scandinavia, respectively. H. A. C. Sintzenich prepared a résumé of

developments in India which is of sufficient interest to be included as an appendix to this report.

Several illustrations have been reproduced from the following publications, *Exhibitors Herald-World*, *Electronics*, *International Photographer*, *Bioscope*, *Kinematograph Weekly*, *Kinotechnik*, and *Cinematographie Française*. Other illustrations have been supplied through the courtesy of the General Electric Company, Schenectady and London, Baird Television Corporation, Ltd., London, Universal Pictures, Inc., Universal City, California, and W. Vinten, Ltd., London. A set of illustrations of Russian equipment was made available by L. Monosson.

Respectfully submitted,

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SUBJECT CLASSIFICATION

I. PRODUCTION

A. Films and Emulsions

1. New Materials
2. Manufacture
3. Miscellaneous

B. Studio and Location

1. General
2. Studio Construction
3. Lenses and Shutters
4. Cameras and Accessories
5. Exposure and Exposure Meters
6. Studio Illumination
7. Actors and Direction Technic
8. Trick Work and Special Process Photography
9. Methods of Recording Sound
10. Sets and Locations

C. Laboratory Practice

1. Equipment
2. Photographic Chemicals and Solutions
3. Processing Technic
4. Printing Machines and Methods

5. Editing and Splicing
6. Title Making
7. Cleaning, Reclaiming, and Storage

II. DISTRIBUTION

III. EXHIBITION

A. General Projection Equipment

1. Projectors and Projection
2. Sound Picture Reproduction
3. Projector Lenses, Shutters, and Light Sources
4. Fire Protection

B. Special Projection Methods

1. Effect Projection and Stage Shows
2. Portable Projectors
3. Stereoscopic Projection
4. Non-intermittent Projection

C. Theater Design and Installation

1. Screens
2. Theater and Stage Illumination
3. Theater Acoustics and Construction

IV. APPLICATIONS OF MOTION PICTURES

A. Education, Business, and Legal Records

B. Medical Films, Radiography, and Photomicrography

C. Telephotography and Television

D. General Recording, Miscellaneous Uses

V. COLOR PHOTOGRAPHY

A. General

B. Additive Processes

C. Subtractive Processes

VI. AMATEUR CINEMATOGRAPHY

A. General Equipment and Uses

1. Cameras
2. Projectors
3. Accessories
4. Scenarios and Amateur Clubs

I. PRODUCTION

A. Films and Emulsions

Plans for ultimate adoption of wide film have continued throughout the summer as several producers were known to be engaged actively in further experimentation. According to reports from production centers, negatives for several pictures have been made on wide film as well as on the usual 35 mm. width. Agreement has been reached among leading producers on perforation standards and sound tracks but there is still a division of opinion on total width and size of frame.[1] One immediate solution of the projector problem is to make the negatives on wide film and make reduced prints on 35 mm. for showing on the present standard projector fitted with a shorter focal length lens. Some of the advantages as well as limitations of this scheme were discussed by Finn.[2] Installation of large screens in several theater circuits has been undertaken as well as provision for such screens in the newly constructed houses. A survey indicated, however, that about 60 per cent of the theaters lack space for screens of more than 24 foot width.

The first of a series of conferences on wide film problems was held in Hollywood in September under the auspices of the Academy of Motion Picture Arts and Sciences. These sessions are devoted to the production aspects of the problem rather than to the engineering phases.[3]

According to Sponable,[4] the intensity range above ground noise will be increased with wide film. Since the running speed is raised from 90 feet per minute to 112, the frequency band will be raised from 9000 to 11,200 cycles.

Sound motion pictures in color continued to be used rather extensively although production of new feature color pictures appeared to slack up during the early summer. No new film emulsions, however, were known to be in use for color motion pictures and two-color subtractive processes were chiefly used. Two types of color charts have been made available on the European market for determining the characteristics of orthochromatic and panchromatic emulsions.[5]

An announcement was made in Great Britain of the construction of a new factory capable of making two million feet of raw film per week, chiefly for distribution through its own channels as production and exhibition plans were included.[6]

Reports on two new emulsions for motion picture work have been published in German trade publications.[7]

A transparent paper support which can be coated with either a positive or negative emulsion was placed on the market and the claim advanced that it was suitable for cinematograph film.[6] Another innovation was the introduction of a film containing a layer of aluminum foil 0.005 mm. thick.[8] A patent was taken out on film having a viscose support.[9] Two other patents related to emulsion manufacture[10] dealt with (*a*) a chromium metal surface for deposition thereon of cellulose derivatives and (*b*) a process for treatment of photographic negatives so that the images appear to be drawn.

Two patents were published describing methods of making films for color processes, with clear sound track areas.[11]

B. Studio and Location

The bulk of the leading studios of Europe had installed sound recording channels by July, 1930, one of the finest being located in a studio at Wembly, England. Services of American engineers were in demand by several Russian firms to assist in establishing an expansion program. Since a great many European theaters were installing sound equipment, particularly following the settlement of a patent controversy in central Europe, more pictures in native dialog were being requested of the continental studios.

American studios, having passed through their reconstruction period resulting from the advent of sound, were settling down to the steady business of regular production. One large studio was being constructed to house a color motion picture organization. The capacity of this studio was stated to be three million feet per week.[12] The Harvard Film Foundation was installing equipment for a complete studio and plant for the making of classroom films.[13]

Lenses and Shutters.—An English lens of 58 mm. focus working at $f/2$ is reported to be in use in Hollywood for wide film. A unique lens having a movable negative component has been described which makes it possible to keep the entire field in critical focus during each successive exposure.[14] Douglas has patented a lens comprising two movable parts by use of which objects in the picture appear to be moving to or from the camera.[15]

Cameras and Accessories.—A report was published during September giving the final results of a comprehensive survey of the methods used to silence cameras in the Hollywood studios. Eighteen types of equipment were tested.[16] One very interesting "blimp" was constructed of a cellulosic composition, the sections of which were so tightly fitted as to render the housing both air-tight and water-tight.

At the May, 1930, meeting of this Society, Howell and Dubray[17] presented data on wide film shrinkage and dimensional specifications which should be considered in designing equipment such as cameras, printers, projectors, *etc.*, for handling wide film.

Further data have been published on camera troubles as encountered by the Byrd Antarctic expedition on which over 150,000 feet of film were exposed.[18] Camera loading was extremely difficult and cameras had to be rebuilt in order to use them at temperatures as low as −70°F. The highest altitude motion pictures are believed to have been made in September, 1930, by E. Welch while flying at 39,000 feet near Bridgeport, Conn.[19]

Forch[20] has published a paper dealing with beater mechanisms which was commented on in another article published subsequently.[21] Seeber[22] has discussed pull-down mechanisms.

Pauder has reviewed the difficulties arising in the use of various types of camera finders.[23] The feature of both the reflex and regular models of cameras is claimed to be incorporated in a new camera.[24] This should be of interest to still cameramen as the device permits the user to watch the action on a ground glass at all times.

Numerous patents have appeared relative to improvements in cameras and accessories.[25]

Exposure and Exposure Meters.—A pocket size photometer resembling a short telescope with an eyepiece at right angles to the barrel is available on the market. Dials are twisted until a lamp filament becomes invisible, whereupon a reading indicates both exposure and stop to be used.[26] A portable actinometer of the sliding wedge type has been patented.[27]

Studio Illumination.—The investigation dealing with methods of silencing arc lights for sound motion picture work mentioned in the previous report of this committee has been continued and its results published. Data on tests made in 14 studios and reports from the Los Angeles Bureau of Power and Light are included.[28] With the better knowledge of the operation of sound pictures, the studios are utilizing old arc equipment as well as adding new apparatus. One improved type of arc lamp contains a special built-in choke coil which takes care of commutator ripple. The intermittent feed has been eliminated, non-grinding gears installed, and a new type of positive carbon used which does not squeak during feeding of the arc.[29]

Improvement has also been noted in high wattage incandescent lamps. Such lamps must necessarily be subjected to rough usage and it has been a problem to make them sufficiently strong for such service. A new system of bringing the current into the bulbs of 5 kw. and 10 kw. lamps has greatly increased their strength, reduced their heating tendency, and permitted the introduction of any amount of current. In the method used, the glass does not come in contact with current-carrying parts.

A novel method of lighting uniformly large sky backings on sets consists in using sand blasted, porcelain enamel domes as reflectors behind 5 or 10 kw. lamps. A high intensity spotlight is capable of giving an illumination of 8500 lumens at 125 amperes. It is fitted with automatic control of spot, heat resisting shutters, and a quickly adjustable aperture.[30]

For special effect work, a photo-flash lamp of German origin is being manufactured and distributed by an American firm. The light consists of a bulb (with the usual screw socket base) filled with very thin aluminum foil and oxygen. It is ignited by a paste covered low voltage filament. Advantages as a flashlight are absence of noise, smoke, and odors.[31]

Incandescent lamps are in almost universal use in sound studios in England. For overheads and banks it is general practice to use 6 to 12 lamps (1500 watt) in a fan cooled single aluminum reflector. The average illumination of a set is 400 foot candles. Detachable parabolic, faceted, or aluminum mirror reflectors are used with spots. To prevent bulb blackening of the 5 or 10 kw. lamps, for sun effects, a blast of air is used. The use of tungsten powder for cleaning is not generally favored.

Patents issued deal with shaded lamp bulbs and reflectors for use with mercury vapor lamps.[32]

Actors and Direction Technic.—According to reports from the

Motion Picture Division of the U. S. Bureau of Foreign and Domestic Commerce, the demand is increasing in foreign countries for sound pictures in native languages. The plan of dubbing foreign lines in pictures made with English speaking actors is being discouraged. A few American producers are making plays over, using a foreign cast or the same actors if they speak well in the tongue required. A school has been established by one producer for teaching actors foreign lines.[33]

Trick Work and Special Process Photography.—Trick process shots, which for a time were largely eliminated, have come into extensive use again. The sound picture, therefore, is rapidly attaining the flexibility that the silent picture possessed. Four patents have been noted dealing with trick photography.[34]

Sound Recording.—A conference held in Paris in July, 1930, between American and German interests resulted in an agreement on territorial distribution of sound motion picture equipment. The agreement is stated to provide for complete interchange of American and German patents and manufacturing and technical information. Equipment manufactured under the new agreement will be suitable for showing sound films of either German or American origin.[35]

Manchee[36] has written on his experiences in making production sound records in the Arctic regions of Labrador and Newfoundland. A news reel camera was converted into a recording camera and connected by a flexible drive with the picture camera. Microphones and light valves were stored in air-tight compartments, when not in use, to keep them dry.

Sound film records made in England at the Wembly studios are identified by photographing at intervals on the film, a lantern slide carrying the scene and shot numbers. Each half minute, figures up to 10, in Morse code, are printed on the side of the film opposite the sound track. Corresponding figures are recorded on the picture negative in the space reserved for the sound track.[36]

Vogt[37] has published details on the transfer of sound-on-film to sound-on-disk records according to the Tri-Ergon method.

In a lecture on studio damping before the London branch of this Society, Capt. West pointed out that in recording, echo can be combined artificially in the required degree.[38] Glover[39] has discussed the acoustics of studios in a series of articles in which are included tables of sound absorption coefficients of a very wide range of materials. Data are given on construction materials used in several

English studios. Studies on absorption values of several sound absorbing materials have also been published by Meyer and Just.[40] Hanson[41] at the May, 1930, meeting of this Society showed that reflecting surfaces near the sound sources in a motion picture set may introduce interference that may cause distorted sound quality.

By controlling the ratio of direct sound to reverberation, Maxfield states that the true illusion of nearness or distance of the speaker can be secured. There is a critical range of 50 steps of the total 120 sensation units within which sounds may be reproduced pleasantly in theaters.[42] Smiley[43] has treated the subject of audio-frequency gain measurement, for which he states the requisites are an oscillator of exceptionally pure wave form and a measuring system such as a vacuum tube voltmeter. Recorder lights may be checked easily by mounting a photo-electric cell on the side of the recorder in line with a reflected image of the light valve and taking readings on a meter connected with the tube amplifier of the reaction of the valve illumination on the cell.[44] Various types of galvanometers for use in sound recording have been described by Dimmick.[45]

The causes of feed-back in amplifiers have been reviewed by Schroeder[46] who states that it may be avoided by using proper filtering devices. Goudy and Powers[47] have made a very interesting study of sound recordings on both disk and film, treating the relation between needle diameter and frequency, needle pressure, pick-up distortion, slit-width *vs.* frequency, and a comparison of film and disk records. Considerations affecting the design of phonograph needles were discussed by Friebus at the Washington meeting and a method of shadowgraphing the points described.[48]

An improved type of flashing lamp has been devised by Zetka[49] which is stated to have fifty times the life of older types and to be of much sturdier construction. Recordings of nearly 25,000 feet have been made. Glauber[50] has given complete design data for a high gain quality amplifier using screen grid tubes and Thompson[51] has described a new power amplifier with a positive grid-bias. The characteristics of the power pentode tube have been discussed by French.[52]

At a sectional meeting of this Society, Cook presented a mathematical analysis of the effect of the finite size of recording and reproducing slits as well as the effect of lens aberration on aperture width.[53] A beam microphone which may be focused on one speaker has been perfected by a Hollywood sound director. It consists of a parabolic metal reflector about 5 feet in diameter with the usual condenser microphone placed at the focus. A cylinder of felt is placed around the outer edge. The device has proved of special value for outdoor recording where it is desired to eliminate extraneous sounds.[54] Balantine[55] has studied the effect of cavity resonance on the frequency response characteristic of the condenser microphone. Two effects causing increases over the uniform response of condenser microphones are: (1) increase of pressure on the diaphragm, and (2) acoustic resonance in the cup-shaped recess of the ring stretched over the diaphragm. A modified design without the cavity suitable for spherical mounting is described. West[56] and Hartman[57] in papers on this same subject arrived at similar conclusions.

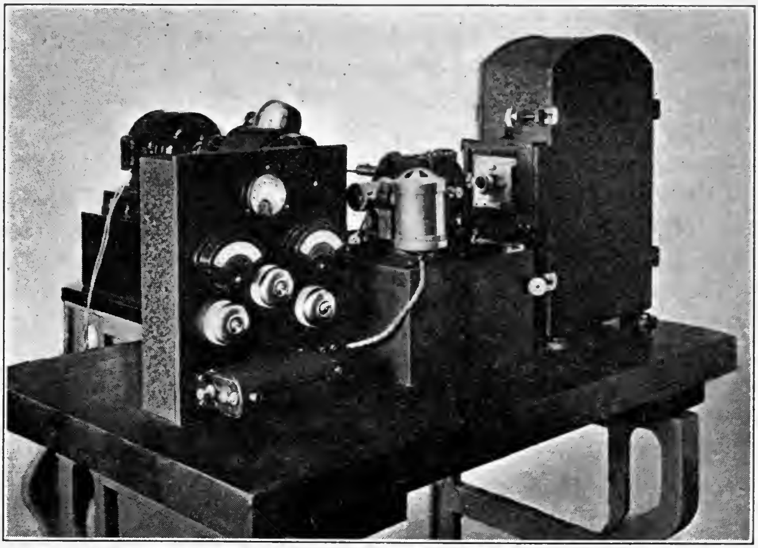
Besides the variable width and variable intensity methods of sound recording on film Cauda[58] states there is a third method available in which the time of exposure of the light sensitive emulsion is made the variable. It is shown that the density variation on the film is proportional both to intensity and frequency. Tasker[59] has presented a useful analysis of the causes of ground noises in disk and film records.

At the 1930 spring meeting of the Society, Evans[60] gave a summary of the advantages and limitations of disk and film records. His conclusions were that, although film recording is theoretically superior, its advantages are not realized as readily in practice. Nevertheless, many of the large companies appeared to be encouraging the use of film records. Two large equipment manufacturers during the summer of 1930 announced lower prices on sound-on-film equipment and the option of purchasing the general installation without the disk. One producer who supplied disk records exclusively began early in the summer to supply sound-on-film features as well.[61] It is considered by some exhibitors that film records "wear" better than disk records and have noticeably less of a metallic note when played. Projectionists are also a bit careless in replacing old needles and distributors occasionally do not supply new disks quickly enough to replace worn ones. Loss of parts of the film cannot be eliminated from the disk and the picture is thrown out of synchronization. There are 3500 theaters, however, equipped only for disk records and it will undoubtedly require at least two years to effect a complete change-over.

A revision of the National Electric Code is reported to be in progress affecting requirements as to wiring for sound recording and reproduction.[62]

A system of recording being developed in Russia employs an oscillograph with one thread and is stated to be suitable for either variable width or variable density recording (Fig. 1). Another sound-on-film process utilizes a sound print having the record engraved in the edge of the film. A sapphire roller pick-up device is employed in the reproduction. A roll of clear celluloid is engraved in preparing the master record and this record is then transferred to the sound print. No stages of amplification are said to be necessary in reproduction.[63]

Lüschen[64] has contributed data on electric filters for use in damping and phase correction of recording and reproducing units.



Reproduced by courtesy of L. Monosson, N. Y.

FIG. 1. Sound recording apparatus for either variable width or variable density records (Shorin System—developed in U.S.S.R.).

Numerous patents taken out on sound recording devices[65] include among others: (1) a method for cutting sound records into the film with a stylus, and (2) the use of a continuous belt of discrete particles embedded in a matrix carried by a base for recording the sounds magnetically.

Sets and Locations.—A report was published the latter part of May, 1930, and a second report in September, 1930, giving the results of extensive tests made on acoustic materials for set construction. The work was conducted by a subcommittee of the Academy of Motion Picture Arts and Sciences. For the tests the materials were mounted to wooden studding braced vertically and horizontally and faced over a 3 inch layer of rock wool between the room wall and the studding. Reverberation times were measured with the new materials as against times for an empty room. The greatest absorption coefficient was found with Zonolite plaster brushed $^1/_{16}$ to $^1/_8$ inch thick over burlap or chicken wire.[66]

A complete description of the sound-proofing and acoustic treatment of the RKO stages has been published by Ringel.[67] According to a trade note, six French studios at Joinville had been wired for sound work and production has been started.[68]

A description has been printed of the lighting equipment used in an English studio set for lighting "fog scenes."[69]

C. *Laboratory Practice*

A committee made up of representatives from the Board of Fire Underwriters, the New York Bureau of Fire Prevention, and the Motion Picture Producers' Association has drawn up a code on studio and laboratory practice, the exchange, and the theater. It gives specifications for the handling of film from its development to the delivery of finished print. A description of a new film processing laboratory in New York has been published. The developing rooms are equipped with both negative and positive machines and sensitometric measurement is utilized.[70]

Equipment.—Sandvik[71] has designed three instruments for precise analysis of photographic sound records, namely, a microdensitometer, a sound track densitometer, and a variable slit sensitometer. Data obtained with these will be published subsequently. Further information has been published on the Hunter-Pierce developing machine which was mentioned briefly in the previous report.[72] The machine consists of horizontal tanks arranged one above the other with a vacuum system drying compartment on top. It processes 12 separate strands of film simultaneously at the rate of 10 feet per minute and has a capacity of about one million feet of film per week. The film is fed into and taken off the machine from the same end. During processing the film is twisted constantly and is so exposed that any breaks can be repaired very quickly. It is said to be capable of handling either positive or negative film of any width in commercial use. Lasally has also published a description of two development machines, those of A. Debrie, Paris, and of Geyer-Werke A.-G., Berlin.[73] The former apparatus is a twin machine, each part of which works independently. The developing and fixing end is located in a dark room, the washing, dyeing, and drying end in a light room. Film passes in loops through the various baths at the rate of 1600 feet per hour. The Geyer machine is of somewhat similar design.

Patent protection has been taken out on a few types of motion picture processing equipment.[74]

Photographic Chemicals and Solutions.—A slowly growing appreciation of the value of sensitometric control in motion picture film development has been apparent since the advent of the sound motion picture. This is true abroad as well as in the United States. The value of duplicate negatives has also been realized and it is understood to be a general practice in the larger laboratories to make duplicates of the bulk of negatives as finally edited.

No radical changes have been introduced in the methods of developing sound motion picture film during the past six months. Development has become a matter of detail refinement. A slow working MQ developer containing glycerin has been suggested by Leitner[75] to minimize graininess on 35 mm. negatives. Of practical as well as theoretical interest is Dundon and Ballard's observation that with partial exposure of emulsions, most of the iodide remains in the undeveloped portion of the emulsion but with very full exposure, most of it becomes leached out by the solution. The small quantity of iodide which accumulates in a used developer is a very important factor in diminishing its fogging action.[76]

An exhaustive investigation on chrome alum stop baths and fixing baths has been published by Crabtree and Russell[77] who give data for compounding these solutions and reviving them during use.

Processing Technic.—At a meeting held in May of the newly formed Deutsche Gesellschaft für Photographische Forschung, Eggert described a method for rapid testing of the characteristics of any film emulsion. It consisted in exposing a strip of film under a step wedge, and, after processing, placing it (in a counter direction) beside a standard step tablet on a viewing box. By examination and reference to a scale, several factors could be determined.

From a study of the effect of photographic treatment on the volume range and high frequency response of variable width sound films, Maurer[78] has concluded that best results are achieved when the negative densities lie between 1.0 and 1.6 and the positive is about 1.3. Nicholson[79] has studied the effect of varying the time of development, of both the negative and positive, in processing of variable density records. Measurements of "sound reproducer" density of variable density sound films have been published by Tuttle and McFarlane.[80]

Printing Machines and Methods.—Brandt[81] has recommended more scientific printing in laboratories and advanced suggestions on the use of sensitometric data. A triple adjustment sound printer attachment permits masking the picture or sound area for either forward or reverse printing, collectively or separately.[82] A method has been

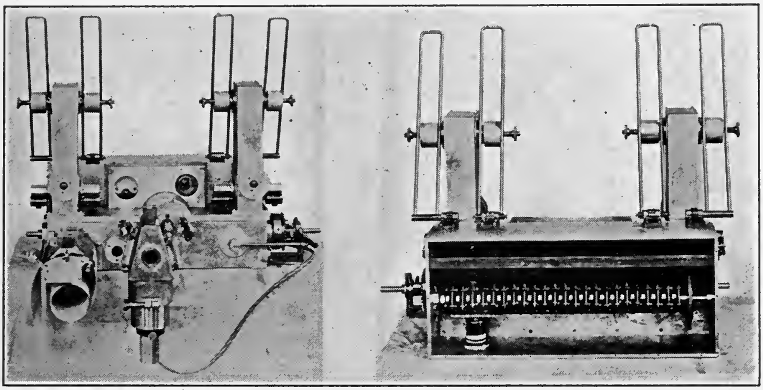


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FIG. 2. Continuous printer with automatic light change. Left: front view showing fiber platen strip; right: back view showing light change mechanism.

suggested for making a photometric test of the brightness of an actor's face in a studio and subsequently reproducing this brightness proportionally on the screen.[83]

A new continuous printer has been designed for sound film records which works at 120 feet per minute. Contact is established by a curved gate with a flattened aperture through which the films are pulled at the correct tension. The printer may also be equipped with an automatic light change attachment (Fig. 2). A strip of thin fiber with perforations on its edges (corresponding to scene changes in the negative) is fed into a special gate attached to the front of the machine. The fiber strip is moved forward at a slower rate than the film and as each hole passes over a contact (of which there are 20) a light change is effected. Changes may be made for scenes as short as 6 inches. It is not necessary to mark the negative in any way by this system.[84]

Although requiring great care in printing and developing, duplicates of sound film negatives can be made, according to Wake, of quality equal to or better than the originals.[85]

An optical printer for reduction printing was constructed from two Arri printers. A high aperture lens in a helical mount forms the objective.[86]

Patents issued deal principally with printers for use in printing sound records.[87]

Editing and Splicing.—Specifications have been drawn up by a subcommittee of the Academy of Motion Picture Arts and Sciences on a standard release print including leader, run-out, and cues. It applies to either silent or sound prints. The specifications will be distributed throughout the country under the approval of the Motion Picture Producers and Distributors of America and the Film Boards of Trade.

A diagonally cut splice of a sound-on-film record is stated to produce less disturbance in reproduction than a frame line splice.[88] When perforations are torn out of a piece of sound film, without injuring the picture area, a narrow strip cut from the edge of another film may be cemented over the damaged area, thus avoiding insertion of black leader.[89]

Patents on film editing devices include inspection apparatus, a new type of splicing block, means for shrinkage measurement, and a humidifier which blows the moist air against the film during rewinding.[90]

Title Making.—According to a French patent, titles are inscribed on cellophane or other non-inflammable film, and then by a pseudo-lithographic process, are printed from the cellophane upon the film. This method is recommended when insertion of foreign language titles is required.[91]

Cleaning, Reclaiming, and Storage.—A modified type of film waxing machine has been described by Crabtree and Ives for applying a thin line of a 10 per cent solution of paraffin wax in carbon tetrachloride to the center of the perforation area of motion picture films.[92] A method of treating films has been announced which is claimed to make subsequent cleaning easier and to preserve their moisture content.[93] Only one patent on a film cleaning device has been noted.[94]

The problem of safe storage of cellulose nitrate motion picture film has been an important one for many years. In the event of a fire, it is desirable to avoid destroying or damaging all other rolls of film stored in the cabinet vault if possible, while attempting to extinguish the fire. A method of storage which insures maximum protection to all film stored in a vault and minimum danger from spreading of the fire has been devised by Crabtree and Ives. It consists of a series of metal drawers of 1000 foot capacity, contained in fire-resisting wood cabinets. The back end of each drawer is vented into a large flue pipe leading out of the building. Fire tests have shown that one roll can burn up completely without damaging any other rolls in the cabinet.[95]

II. DISTRIBUTION

Stringent rules relating to film handled in the exchange maintenance department of a well-known producing company have been published. All film must be handled from the edges using white cotton gloves and no rings are to be worn at any time. Detailed instructions on splicing are provided.[96] The adoption of a standard leader and run-out, as noted previously under *Editing and Splicing*, would do much to simplify and standardize the work of film exchanges. Faulkner[97] has presented valuable practical comments on maintenance of sound film in exchange operation as well as on the degree that sound reproduction is affected by continued use of sound track film.

III. EXHIBITION

According to trade reports orchestras which were discharged upon the installation of sound equipment have been returned to a few theaters in this country and South America. An inventory of several leading theaters on the Pacific coast reveals, however, that certain houses appear to have a patronage who wish orchestras and shows, whereas others have a patronage who prefer a first class selection of pictures. It appears to depend, therefore, largely on the type of clientele a theater enjoys.

In the readjustment from silent productions to sound productions, the average producer had so many technical problems to consider that many traditional considerations of both production and showmanship were forgotten. The bulk of the large technical problems has now been solved and routine production is under way. Greater attention has, therefore, been given to planning entertainment for different ages and particularly the youth of the nation as it is realized that these sections of the patronage later grow to become the mature sections.

Sound motion pictures have introduced certain fundamental changes in the previous order of motion picture programs. Overtures played by an orchestra have largely been eliminated, the value of the news reel enhanced, the value of comedies lessened, but greater importance has been given to cartoons. Short subjects which were merely used to introduce a vaudeville team, though at first popular, are fast losing appeal, perhaps because vaudeville has limited appeal at the present time. The general length of program remains one of approximately two hours' duration.

A. General Projection Equipment

Descriptions have been published of several foreign makes of projectors. The Ernemann projector now uses a more powerful light source and has moved the shutter blades near the film, somewhat as used in the Simplex.[98] A new projector built by Bauer has incorporated several improvements.[99] Joachim[100] has dealt with the development shown in projector design during the past ten years.

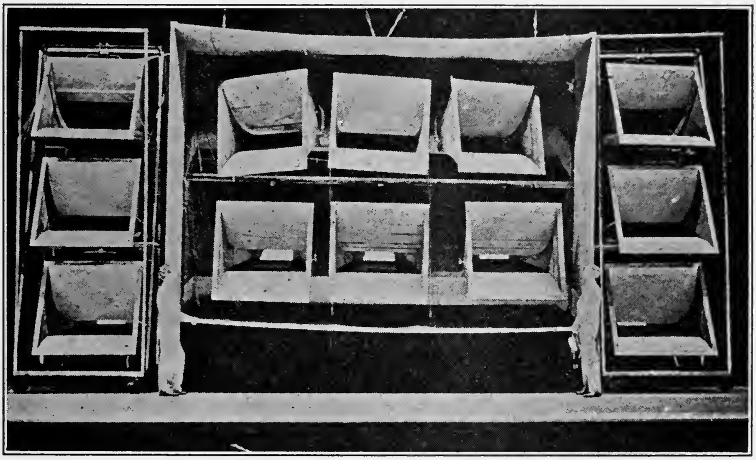
Ozaphane film is stated to be finding use in France in theaters which as yet do not have projectors for standard film. It is claimed that such film may be projected over 3000 times without appreciable wear.[101]

Several patents have been granted on improvement in projector design,[102] which describe, among others, (*a*) a means for splicing on a new reel during the projection of one film, thus eliminating the necessity for two projectors, (*b*) a method and apparatus for releasing an odor or odors in the theater especially associated with the visual images of the picture, and (*c*) a projector which is quickly adjustable for either amateur or professional standard motion pictures.

Sound Picture Reproduction.—About one-third of the motion picture theaters of the world had been equipped by September, 1930, for sound reproduction of either the synchronous or non-synchronous types. In proportion to the total number of theaters, Canada leads the list of countries with 70 per cent sound installation, and the United States is second with 55 per cent, Great Britain, third, with 47 per cent. Trade reports from the Motion Picture Division of the U. S. Department of Foreign and Domestic Commerce indicate that European theaters are rapidly converting their old equipment over for use with sound pictures. Contracts for wiring of 1000 theaters in Soviet Russia have been announced and 50 sound pictures are stated to be scheduled for 1931 in Russian production centers.[103]

Equipment difficulties are slowly being eliminated in theaters, one firm reporting that 88 per cent of their installations were giving satisfactory quality at the horn mouth, according to a survey completed in August, 1930.[104]

The prediction made by Edgar[105] that projection rooms in major theaters will be equipped with extra dummy machines for handling film with sound records only, has been realized in the showing of the



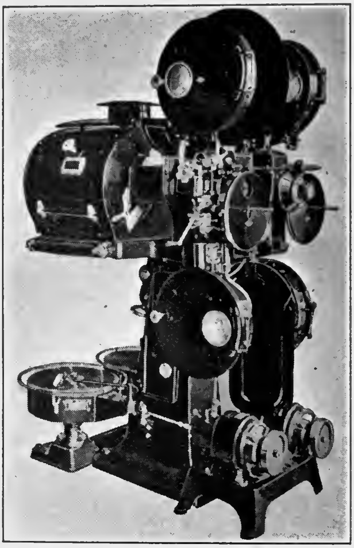
Reproduced by courtesy "International Hollywood"

FIG. 3. Horn installation for use with twin sound track reproduction on dummy projectors as used in Chinese Theater, Hollywood, California.

feature production, *Hell's Angels*, at the Chinese Theater, Hollywood. Volume with less distortion, elimination of troubles from heating of the film, and a lowering of projector vibration are some of the advantages cited by Edgar. Three dummy projectors connected in parallel were used in the Chinese Theater demonstration so that two sound tracks could be played at the same time. Six reels of "Magnascope" film were included in the picture which was projected on a 24 by 37 foot screen and 9 extra loud speakers were added to the regular installation which consisted of three horns (Fig. 3). A special amplifier system was installed to accommodate the 12 horns, which made possible an increase in volume equal to five times the normal volume of the regular sound installation.[106]

Sound motion picture equipment for rear projection has been installed in an Indianapolis theater.[107] The Powers portable Cinephone has been added to the group of portable sound projectors. An amplifier for an audience of 500 persons is used and a $4^1/_2$ by 6 foot screen.[108]

In the British Thompson-Houston apparatus, the exciting lamps in the sound head are supported in a pre-focusing triple holder so arranged that one can be substituted quickly for another. All parts of the optical system and sound head are easily accessible.[109] A full



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La Cinématographie Française
FIG. 4. Twin projector assembly on single rigid support (Nalpas).

description has been published of all the types of technical and commercial sound apparatus on the French market.[110]

One of the most interesting innovations in projection equipment of foreign origin is the French Nalpas double projector (Fig. 4). Two complete sound-on-film or disk assemblies are mounted compactly on a single rigid support.[111] The smaller British theaters which have not been equipped for sound pictures are to have the sound brought literally to their doors. Mobile, five ton trucks carrying a standard set for sound projection, including power generators, are being developed so that a silent theater can be fitted up temporarily for sound projection in one or two hours. Screens, loud speakers, and technical staff are supplied.[112]

Peek[113] has presented an interesting analysis of practical problems encountered in sound picture projection and states that less reverberation is desired in the case of reproduced sounds as recordings have already been affected by the reverberation present in the studios. A "live" stage is, therefore, satisfactory if the auditorium is made dead. A new sound head for a motion picture projector is fitted with only one small roller and side buffer which insures correct positioning of the film at all times.[114]

A resynchronizing device of British origin consists of a footage counter and a dial graduated into 16 sections, each of which corresponds to a frame. The device is attached to the 90 feet per minute spindle by a flexible shaft. The footage counter is set to correspond with the edge number on the film and the dial hand is moved to zero. The exact foot and frame passing the aperture can be detected at once, during projection.[115]

The frequency characteristics of a sound film recording and reproducing system have been discussed by Browne[116] with a view to producing a level combined frequency response. A recording system producing a twin wave track variable width record was described. By forming the aperture before the light slit, by the tangential approach of the circumferences of two rotating rings, the problem of keeping the slit clean is claimed to be solved.[117] Wolf and Sette[118] have analyzed the factors governing the power capacity of sound reproducing equipment in a paper presented before the New York Section of this Society.

A power level indicator has been announced for reading the signal amplitude in voice transmission circuits; levels from minus ten to plus thirty-six decibels can be measured.[119] A monitor has been developed to meet the needs for accurate indication of volume levels from power amplifiers in sound reproducing equipment.[120] According to Aceves,[121] amplifiers may be given desired characteristics to compensate for deficiencies in processes of recording and reproducing and an amplifier having such properties is described.

In a new type of sound-on-film reproducer, mechanical parts in the optical path have been substituted for a cylindrical lens which illuminate only 0.0005 inch of the film area, thus eliminating the usual slit.[122] Nason[123] has dealt with the application of photo-cells in projection work. Characteristic curves published for the gas filled type of photo-electric cell compared with the vacuum type show the former to have nearly five times the sensitivity but the gas filled cell requires more critical adjustment of operating voltage.[124] A new ultra-sensitive vacuum tube has been developed in which the grid current is reduced to a very low value for measurements as low as 10^{-17} amperes. Such a tube will indicate a flow of 63 electrons per second.[125]

One of the weak points of sound motion picture reproducers has been the limited reproducible frequency range of such apparatus. Within recent months, marked improvement in speaker design has extended the range. A new 72 inch dynamic cone speaker and directional baffle have been announced which is claimed to deliver clear mellow low frequency (50 cycle) sounds and high frequency (7000 cycle) sounds. The sounds "*s*," "*f*," and "*th*" can be distinguished clearly.[126] Another type described by Bostwick[127] utilizes a moving coil piston diaphragm in conjunction with a 2000 cycle cut-off. By using this speaker as an adjunct to the ordinary type, it is claimed that uniform reproduction of sounds from 50 to 11,000 cycles may be obtained. A brief notice has been published of a new sensitive valve for exponential horns which regulates the flow of compressed air into the small end of the horn and greatly multiplies its effectiveness.[128] A description has been published of a new super power speaker of German origin which, it is claimed, can be heard clearly at a distance of 15 miles.[129]

Bull[130] has published data on methods of measuring loud speaker efficiency. Good horn type speakers used in theater installation are said to have an efficiency of 35 per cent; ordinary commercial speakers only 1 to 6 per cent. A specially designed audio frequency generator of the heterodyne type was used by Barnes as a means of studying loud speaker performance.[131] Wolff and Malter[132] have shown that the way in which a loud speaker distributes sound energy is a measure of its performance. Speakers for home use should radiate uniformly throughout a hemisphere; those for theaters should possess a characteristic, the limits of which are defined sharply by the edges of the audience. Data have been published by Malter on the characteristics of a large number of directional baffle loud speakers as well as several commercial types.[133]

A disk record containing several hundred grooves to the inch will play for 72 minutes. Fox suggests that shipping problems for disk records would be simplified if these records could be impressed on a light weight support permitting them to be packed with the film or mailed in an envelope.[134] A new type of record which is said to withstand scratching and other maltreatment is reinforced with an inner layer containing rubber and shellac.[135]

By means of stroboscopic synchronization, the sound from a sound motion picture shown in a theater was transmitted by radio for a showing of a silent print of the same picture at a disabled veterans' hospital. Although exact synchronization was lost at each change-over, it was estimated that the synchronization was within 0.2 sec. for 85 to 90 per cent of the time.[136] Sound pictures have been shown successfully on an ordinary day coach attached to a passenger train, two portable projectors being used.[137]

At a meeting of the Société Française de Physique, Dundoyer described a new type of light bulb for sound reproducing equipment. A rectilinear filament is arranged parallel to a flat plate fused in the bulb and a microscope objective used to produce a greatly reduced image of the filament on the film.[138]

Sound reproduction patents issued dealt chiefly with methods of synchronizing the sound and the picture change-over from sound-on-film to sound-on-disk, synchronization of motion pictures and sound transmitted by telegraph or radio, and means for the determination of the particular record groove engaged by a phonograph pick-up at any time.[139]

Projector Lenses, Shutters, and Light Sources.—Joachim[140] has reported on tests regarding suitable condenser lenses, mirror arrangements, *etc.*, for projectors. Naumann[141] has treated the problem of the diameter of projector lenses. An optical device has been patented which serves to shift the projected images to the center of the screen and to spread the images laterally to cover the entire screen.[142]

A projection lamp of novel construction is designed so that the upper part of the bulb is spherical, whereas the lower part narrows to a cylinder, near the base of which is the filament. The leads are brought in at the top. Convection currents carry the tungsten vapor to the upper part of the bulb where it deposits.[143] Greater screen illumination is said to be secured from a new lamp of American manufacture. It is rated at 20 volts—$12^1/_2$ amperes—and, when used with a transformer, may be operated at 115 volts. A 25 per cent increase in illumination is possible over any other type lamp of similar wattage. The nature of the light source has been shown by Naumann[144] to influence greatly the contrast of the projected picture. Mirror arc lamps were shown usually to be less contrasty than arc lamps using condensers. Patent protection has been granted for a projector illuminating system which serves two projectors.[145]

Fire Protection.—Nuckolls[146] has published valuable data on ignition temperatures of nitrate and acetate films, the type of decomposition, and the products of combustion. A number of patents have appeared describing various means of closing projection room ports, disconnecting electrical circuits, directing currents of air on the film, and using fire screens.[147]

B. Special Projection Equipment.

Effect Projection and Stage Shows.—Methods of using wide-angle lenses to project a much enlarged picture on the screen have been employed in several of the large theaters for certain scenes of such pictures as *Old Ironsides, Trail of Ninety-Eight, The Hollywood Review,* and *Hell's Angels.* In one process, a movable screen was utilized which traveled downstage as the growth of the picture occurred. These methods all tend to over-accentuate the graininess of the picture. The same defect holds if too large a picture is attempted with wide film, tests having shown that a width of 50 feet is the maximum permissible before such effects begin to appear.

An expanding screen developed by an English firm is claimed to be particularly effective for emphasizing the climax of a picture.[148] When space is at a premium back stage, the public address system with outlets over the proscenium arch, has been utilized quite successfully as a substitute for the usual horns during presentation of shorts, such as song cartoons.

A new model of effect projector incorporates as features a pre-set adjustment for effects or slides, and a lens assembly of 10 to 32 inch focus mounted so as to permit rapid change to any one side.[149]

Portable Projectors.—An advertising projector supplied by an English firm projects a 1000 foot reel of film in the form of an endless band. When nearly all the film has passed onto the take-up spool, a mechanism causes the take-off and take-up spools to change places and the projection continues as if the reel had been rewound.[150] Another advertising projector, uses a daylight screen and slide film accommodating from 24 to 320 pictures.[151] Film of 16 mm. width is used on a small, compact advertising projector which projects continuously on a $11^1/_2$ by 15 inch translucent screen.[152] A few patents have been noted disclosing improvements in portable projector design.[153]

Stereoscopic Projection.—One of the most successful artifices adopted for imparting a stereoscopic effect to motion pictures is to move the camera while the optical axis is made to pass through a central point of interest in space. DeLassus has announced a device by which the optical axis is directed automatically, whatever the displacement of the camera.[154] Ives[155] has given his analysis of a method of stereoscopic photography invented by Bessiere. It uses a large lens, greater in diameter than the interpupilary distance. It is claimed that the relief cannot be exaggerated by this method. Three patents dealing with stereoscopic motion pictures have been published; two of them are concerned with the preparation of two films with pairs of images; the third with a projection device.[156]

Non-intermittent Projection.—The Holman continuous projector was demonstrated at the Washington meeting of this Society and a paper describing its operation was presented. The mechanism consists chiefly of a pair of lens wheels rotating in opposite directions. These act as the two intermediate elements of the projection lens when driven at the proper speed.[157] Apparatus for manufacturing the lens wheels has also been described.[158] The well-known Mechau projector has been fitted with sound reproduction attachments.[159]

A novel portable non-intermittent projector for educational use has been made available by Gaumont. It consists of a folding metal case, hinged at the top. When opened the take-off reel is located in the top. Film moves continuously around a hollow sprocket containing a stationary prism. Light from a source on the front of the projector is directed toward the rear through a condenser system and then through the film, where it strikes the first prism. At this point, it is reflected onto the second prism and thence through the rotating lens drum, and is directed finally through a suitable lens system onto the screen.[160]

Thun has presented an optical and mathematical analysis of the errors encountered in motion picture projectors utilizing the principle of optical compensation.[161] Only a few patents have appeared disclosing improvements in methods of obtaining non-intermittent projection.[162]

C. Theater Design and Installation

Screens.—A number of theaters throughout the United States have increased the size of their screens anticipating the advent of the wide screen picture. Practically all the theaters in one circuit on the Pacific coast have installed larger screens.

According to Hopkins,[163] sound is transmitted through a screen in three ways: by diaphragm action of the screen, by transmission through air passages, and by wave propagation. A total area opening of 5 per cent was found satisfactory acoustically and did not materially alter the light reflection properties. A silk fabric coated with glass beads has been used to make a screen which is claimed to be suitable for sound motion pictures.[164] Two types of daylight screens, prepared with small vertical fins before their surfaces, have been made available. One of these, of French origin, has a frame holding the fins or blades supported in front of the screen, which, it is claimed, cast shadows on the screen.[165] Fins 0.02 inch high are used for the other screen but the angle of visibility for the spectator is rather limited.[166] Two patents were issued disclosing methods for the construction of screens.[167]

Theater and Stage Illumination.—There has been a tendency in recent years to retain a faint lighting of the auditorium during projection of a picture. Emergency lighting of auditoriums is about one foot candle, intermission lights, four to five foot candles, screen brightness about thirteen foot candles.

One patent has been noted on an improved method of theater illumination.[168]

Theater Acoustics and Construction.—An announcement has been made of the establishment of a huge amusement center in New York City which will occupy three city blocks. It will include a sound motion picture theater seating 5000 people.[169] The large ballroom in the Atlantic City Pier Auditorium has been equipped for showing sound motion pictures and required one of the largest installations ever made.[170] A social center motion picture theater has been completed in Newark, N. J. It contains a theater auditorium seating 436 persons, a ballroom, billiard room, ping pong room, coffee and cigaret counters, card room, and indoor golf facilities, all decorated in modernistic fashion. The auditorium screen is 20 by 25 feet in size, but may be enlarged to 35 by 40 feet.[171]

A New York theater installed a folding roof during the past summer which may be closed or opened quickly.[172]

Lindahl and Waterfall[173] have reported on extensive tests made by acoustical engineers in redesigning theaters. They regret that more opportunity is not given this group of engineers in planning new theater acoustics. Chrisler and Snyder[174] reported on sound absorption measurements in a room where persons dressed in different types of clothing were seated in various kinds of chairs. The values ranged from 2.3 to 4.8 at 512 cycles depending on whether or not coats were worn. Audience absorption is one of the most important factors in determining reverberation times in a theater. Eyring[175] has shown that an auditorium, to have a single optimum reverberation time, should not only be free from echoes and have the proper amount of damping, but the absorbing material should be fairly uniformly distributed, resonating bodies eliminated, and a condition for diffusing sound should be assured. A time bridge for measuring reverberation times in enclosed spaces has been designed by Olson and Kreuger.[176] MacNair[177] has suggested that the rate of decay of loudness sensation is a better criterion for the arrangement of damping material in auditoriums than decay rate of sound energy. A more general equation for determining optimum absorption of any size room than the formula of Sabine has been developed.

The results of measurement of sound transmission by various types of wall insulation materials have been reported by Sabine.[178] Maximum intelligibility of speech occurs at a level above 70 decibels above the noise level according to Knudsen,[179] and for good results should not fall below 50 decibels. The reverberation time for speech is noticeably different from that for good reproduction of music.

IV. APPLICATIONS OF MOTION PICTURES

A. Education, Business, and Legal Records

Schober[180] has reported that there are 14 permanent theaters devoted to scholastic motion pictures in Vienna and 46 throughout Austria. The Scholastic Cinematographic League, a subsidiary of the schoolmasters guild, is producing experimental films. It is planned to preserve copies of leading films. A group of 15,000 photographs and 500 film placards have been catalogued in the National Library. A film culture group was organized in Italy for the purpose of providing technical and artistic training in motion pictures and their applications.[181] Motion pictures are finding increasingly greater use in time study work in industrial plants, according to Mogenson.[182] Time recording is accomplished either by (*a*) photographing a special time-clock simultaneously with the subject being studied, or (*b*) using a constant speed camera operated at 1000 frames per minute.

Several colleges are planning to institute a cultural course on photo play appreciation during 1930–31. This course was presented first at the University of Southern California.[183] Arrangements have been made to release the negatives of outstanding historical pictures made several years ago, for re-editing for educational purposes.[184] New York University is reported to be giving a survey course in business which consists chiefly in viewing industrial motion picture films.[185]

A series of sound pictures are to be produced by the U. S. Army,[186] which has three open-air theaters for showing such pictures as well as many small lecture rooms in various camps. The projection room at one of the "airdomes" is constructed on an auto truck chassis so that it can be moved to any point and made ready quickly for a show.[187] A Cinema Salon has been organized in Paris under the Ministry of Fine Arts where a series of daily lectures will be given illustrated with films to encourage greater public interest and support of the motion picture industry.[188]

To correlate efforts being made in different countries on the production of educational films, Will[189] has advocated that the International Cinematographic Institute (League of Nations) prepare a statistical record of the demand for such films. A central agency should be established which could supply information on the existence of films, and rent them at a low cost. A plan, for the preservation of American historical films having the endorsement of the President of the United States, was announced by Hays at the Washington meeting of this Society.[190]

Motion pictures will be made from hidden viewpoints of all public events in Vienna in which the police take part; the films will be used later for police instruction.[191] Eighty per cent of the workers in a silicate factory in Russia are claimed to have been taught to read by means of sound films.[192] Motion pictures of actual fire scenes are being collected by the Paris Fire Department to be used in instructing firemen.[193]

B. Medical Films, Radiography, and Photomicrography

A method of analyzing the mechanism of speech by photography of the vocal cords was described and illustrated by Russell and Tuttle[194] at the May, 1930, meeting of this Society. Illumination of 250 foot candles was secured by means of a quartz rod and a special camera was devised to make the film record. A dissection requiring six weeks to complete was photographed on two reels of amateur standard film, after which a synchronized sound record was made on a disk.[195] Ten reports presented at the Sixty-Sixth Meeting and Clinic of the Chicago Dental Society were illustrated with amateur standard films.[196] Tuttle[197] has described equipment for making color motion pictures of surgical operations. A brief account of the use of such equipment for photographing a skin grafting operation was published by Baker.[198]

Gottheiner and Jacobsohn[199] have reported on improvements in their technic in X-ray cinematography. In this type of work, the difficulty in the past has been to get sufficient exposure to make pictures without over-dosing the patient and working the X-ray tube over its capacity. A new lens of $f/1.25$ was used, constructed of two spherical cemented elements. A camera equipped with a shutter admitting more light, an improved X-ray tube, a fluorescent screen, and a highly sensitive film were employed. With this equipment it was possible to take pictures for as long as 25 seconds at a time, whereas 2 to 3 seconds was the maximum exposure which could be used with older apparatus.

An inexpensive motion picture apparatus for photographic work has been described by Woodhead[200] which makes possible the photography of biological subjects. A movable stage is used and the camera and microscope are stationary. At the Washington meeting of this Society, Rosenberger[201] described several types of equipment, and especially 16 mm. apparatus for cine photomicrography.

C. Telephotography and Television

Developments in television have progressed rapidly during this year both in this country and abroad. From an examination of trade publications and technical journals, it is evident that the interest in this newest method of picture transmission is world wide and acute. An International Institute of Television was founded in Brussels, Belgium, which will deal with results of researches in connection with the broadcasting of pictures.[202] Eighteen companies were reported to have twenty-two stations in operation in the United States for television experimentation. No license is granted by the Federal Radio Commission, however, unless evidence can be shown that the work represents legitimate research.[203]

A three-day test, made in September to transmit televised signals across the Atlantic ocean, failed and was abandoned. The German expert, Karolus, was in charge of the experiment and was assisted by members of the staff of RCA and the General Electric Company.[204] A permanent equipment installation for two-way television was set up in April between the Bell Laboratories and the American Telephone and Telegraph Company's offices, which are about two miles apart. Speakers face a screen and talk into a microphone just back of it so the entire face is visible for scanning. The loud speaker is placed carefully to avoid reaction with the microphone in each booth. A 5000 element picture is transmitted requiring a transmission band 40,000 cycles wide.[205]

Television images transmitted by radio were shown as a part of one regular performance at the Procter Theater, Schenectady, N. Y., on May 22nd. A loud speaker system was used to transmit the voices of the actors who performed before a "television camera" at the General Electric plant, about one mile distant. A 48 hole scanning disk covered the subject twenty times per second. Four photo-electric tubes responded 40,000 times per second to the impulses reflected back from the subject. The images were transmitted on a wave-length of 140 meters; the voices on 92 meters. At the theater, the light impulses were reproduced first on a small monitor "Teloptikon," then transferred to a light valve where the light was broken up by a 48 hole scanning disk to reproduce the images which were projected on a screen six feet square set under the proscenium arch. Heads and shoulders of the subjects were reproduced in a black and white picture showing gradation of tones. The system was developed under the direction of Alexanderson.[206] Richardson[207] has published a detailed description of the optical system used in the Alexanderson television projector.

Marked progress has also been made in England in the development of television in the hands of Baird Television, Ltd. Experimental transmissions were initiated in conjunction with the British Broadcasting Corporation from Brookman's Park broadcasting station on Sept. 30, 1929. Simultaneous sound and vision transmissions were begun on March 31, 1930, sight being transmitted on a wave-length of 261.3 meters; sound on 356.3 meters.[208] A play was televised July 14, 1930.[209] On July 1, 1930, a demonstration of television was made before press representatives on a 3 by 6 foot screen. Screen brightness was insured by using 2100 ordinary metal filament lamps instead of neon tubes and Kerr cells as in earlier experiments. Commutator contact switches, turning on one lamp at a time, sweep the entire bank of 2100 lamps in one-twelfth of a second. The receiving outfit on a portable truck was installed in the London Coliseum and demonstrated as a part of their regular variety program three times daily from July 28 to Aug. 9, 1930 (Fig. 5). A talking film made on Friday, Aug. 8th, was televised as a special feature of the program on the closing date of Aug. 9th.[210] The Baird Company also

Reproduced by courtesy of Baird Television, Ltd., London

FIG. 5. Coliseum Theater, London, showing Television demonstration as part of regular program, July 28–August 9, 1930.

markets a commercial television outfit for home use, ready for attachment to any good radio set.[211]

Replogle[212] has described the problems encountered by the Jenkins Television Corporation in establishing their regular broadcasting presentations. A special disk scanning system is used with a mercury vapor lamp for illumination. In another television system, patented by Lieut. Wold of the Quartermaster Corps, U. S. Army, mechanical scanning is said to be rendered unnecessary by the use of a lamp house having a lattice work of filaments, different junctions of which become luminous successively.[213] A means of keeping the receiving televisor in synchronization with the transmitting device has been described consisting of a phonic motor designed to operate on the strong 720 cycle scanning frequency component.[214]

Schroter[215] has presented data on reproduction and amplification in television work and Rhein[216] has treated the difficulties associated with the televising of motion pictures.

According to one patent specification, pictures to be transmitted by television are recorded on a film which is both light sensitive and fluorescent. This film is processed as usual and then passed between a cathode ray tube and a light sensitive cell. At the receiving station, the signals influence a pencil of cathode rays which oscillates in two dimensions to reproduce a picture on a fluorescent screen, or in one dimension so that the emergent rays affect a photographic film.[217] Another patent protects a method of recording telegraphic impulses.[218]

D. General Recording

An attempt to make a motion picture record of the moon's shadow from an airplane during the total eclipse of the sun on April 28, 1930, was partially successful. Clouds obscured the earth below the plane which flew at an altitude of over 18,000 feet, but the shadow bands were photographed on the cloud layer. A special sound recording camera fitted with an $f/1.4$ lens and hypersensitzed panchromatic film was used. Radio time signals received by the plane were recorded.[219] On the ground, at another point in the totality region, cameramen from the American Society of Cinematographers, working with Nicholson of the Mt. Wilson Observatory, photographed the bands which were clearly visible on a 6 by 8 foot screen set at 20 feet above the ground.[220] Accurate timing records made on a reel of sound film by Pettit during the eclipse showed it to be 1.7 seconds earlier than calculated.[221]

A small motion picture camera with an electric clock timed mechanism giving one exposure per minute has been used to record the smoke evolution of chimneys.[222] A camera of special design enclosed in a non-magnetic container was employed to detect the direction of drift of an oil drill. A picture of a combination compass and spirit level is made every $3^3/_4$ minutes by a clock work mechanism.[223]

Two electrically synchronized motion picture cameras located, one at an aircraft battery, the other a measured distance away on the flank, have been used to record all shell bursts about a target.[224] The dark bands produced by application of a load to a phenolite model were photographed with a motion picture camera. According to Zuki,[225] stresses may be calculated more accurately from these records.

An apparatus similar to the Recordak has been patented which is suitable for copying documents and other printed matter.[226]

V. COLOR CINEMATOGRAPHY

According to plans announced during the summer of 1930, positive prints made by the additive Herault Trichrome process have the three successive frames dye tinted. Projection is made with a Continsouza-Combes non-intermittent projector which at 24 frames per second is said to suppress flicker. This projector does not use mirrors or prisms, only spherical lenses. The Wolf-Heide process is said to use a similar projection method.

A color process using a three color mosaic screen has been developed by the Danish inventor, Larsen. The color intensity of the particles can be increased after exposure and prior to projection.[227]

The Horst system of additive color cinematography utilizes a prism system in the camera so arranged that three pictures may be exposed simultaneously through primary filters. In the positive each frame carries three images, each corresponding to one of the color separation images of the negative. No details of the method of projection are included.[228]

Baker has published a series of articles dealing with systems of color photography.[229]

Patents issued on three color additive processes disclose among others, methods for making multicolor screen mosaic films, shutters for color cameras, optical projectors, the use of tri-pack films, and projection in a special sequence of tri-color records.[230] Only one patent was noted describing a color process using embossed film.[231]

A new two color additive process is reported to have been used in making *The School for Scandal,* shown during the early part of October, 1930, at the Plaza Theater, London.[232]

A few patents relating to improvements in two color additive processes have been issued.[233]

Subtractive color film processes continue to enjoy the greatest commercial application, although quite a few poor quality color prints were released during the past year when the demands of the producers for color became so great that it was difficult to supply enough color prints to satisfy the orders. Several of the leading color motion picture firms have kept their standards high, however, and productions released late in the summer of 1930 were of much improved quality.

Sound prints by the Technicolor process have been released commercially with a silver image sound track having a contrast or gamma of unity, having been printed from a negative having a similar contrast or gam a of unity. This procedure was that originally recommended for handling variable density sound track, but a compromise was necessary generally in connection with black-and-white picture technic, which is unnecessary in color prints by this process. The advantages of the original method are said to be greater ease of control, and somewhat greater latitude in volume control. The feature picture *Whoopee* is the first to make use of this improved procedure.

A new plant for the Multicolor process, being constructed in Hollywood during the summer and fall of 1930, will require 200 men and will have a capacity of 3,000,000 feet of film per week. A school for color cameramen is being conducted.[234] A comedy short in color by the Sennett color process was shown at a Broadway theater in October, in which underwater photography was reported as being quite natural.[235] The negatives are made by running two films through the camera simultaneously, the upper film acting as a filter for the lower. Prints are on double coated stock and are toned with inorganic salts.[236]

A description has appeared of the Photocolor laboratory and of its process. Two negatives are made with a twin-lens camera and dye toned prints on double coated film.[237] A well-known German optical firm was reported to be supplying projection lenses of wider diameter for use with mirror arc projectors for color motion picture projection.[238]

A new method of making color stills for lobby display purposes has been announced in the English trade press. The details of the process were not revealed.[239]

Patent disclosures on subtractive processes describe printing machines for making two color prints on double coated film, the compounding of color images by dye toning and metal toning methods, and the making of three color film records, by printing on opposite sides of one-half of a double width, double coated film, and on one side of the other half and folding the film lengthwise.[240]

VI. AMATEUR CINEMATOGRAPHY

A. General Equipment and Uses

Amateur Cameras.—Comparatively few new cameras have been introduced within recent months. The Bell and Howell Company has adapted many of the features of their Filmo 70 to the design of a new Eyemo model, their professional spring driven camera using 35 mm. film. The model includes a built-in turret head, variable speed adjustment, relative exposure indicator and a governor making overcranking impossible.[241]

Two new Cine Kodak models, M and K, were introduced in August. Both are fitted to take 100 feet of film at one loading and are smaller and lighter than previous models taking this footage of film. Each camera is fitted with a half speed attachment. Model M is equipped with an *f*/3.5 lens and K with an *f*/1.9 lens.[242]

The English camera, Super-Kinecam, represents an addition to the British market. It is equipped with a lens turret holding *f*/2.6 and *f*/1.5 lenses of one inch focus. The camera may be run at five different speeds.[243]

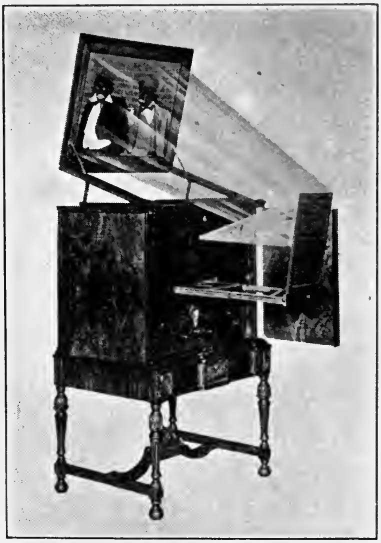
Another new spring driven camera called the "Piko" has been announced for 16 mm. work. The camera is a vertical design with one reel above the other. A double claw pull-down is used.[244] An inexpensive camera having a new shape has been announced. It is called the "Moveo" and is designed with the feed reel displaced behind, above, and to one side of the take-up reel. It is spring driven, has an *f*/3.5 lens, a shutter opening providing $^1/_{28}$ second exposure, as well as other usual fittings.[245]

One patent on amateur cine cameras describes a claw-type pull-down; two others deal with types of motor drives.[246]

Projectors.—According to Irby,[247] it has been estimated that over 200,000 home motion picture projection sets in one form or another have been sold. Interest during 1930 appeared to be centering in the development of sound motion picture devices for use in the home. To date these have all been of the type requiring disk turntables, and range from simple models to very elaborate ones. Putting sound records on 16 mm. film beside the picture is a difficult problem because of the narrow space available and the delicate equipment required for recording the sound.[248] Holslag[249] has made a number of useful suggestions on the handling of available sound apparatus.

At the meeting of this Society held in May, 1930, Bristol[250] described and demonstrated improved synchronizing apparatus for 16 mm. film with disk records. A small high speed synchronous motor has been developed and the size of the synchronizers reduced.

The DeVry sound projector uses a 16 inch turntable rotating $33^1/_2$ times per minute. The amplifier employs one No. 224 screen grid tube, one 250 amplifier tube, and one 281 rectifier tube.[251] Bell and Howell Company has developed a turntable and amplifier for use with their projector.[252]



Reproduced by courtesy of "Electronics," N. Y.

FIG. 6. Combined radio, phonograph and amateur projector (Visionola, N. Y.).

Visionola is a radio-phonograph and motion picture instrument in which any combination of the three units is attainable (Fig. 6). The image from the projector may be reflected onto a 2 by 3 foot screen mounted at the top and back of the cabinet or it may be focused directly on a larger screen. Two loud speakers are included, one static and one moving coil, the former being mounted behind the smaller screen.[253]

A new type Agfa projector is fitted with an anti-flicker shutter, a variable speed drive, and a ventilating fan.[254] A demonstration has been made of a new non-intermittent amateur standard projector which utilizes a moving aperture and a reciprocating lens.[255]

A few improvements in projector design were noted in patent specifications.[256]

Accessories.—A compact mercury vapor lighting unit has been made available for amateur use, designed as a portable studio unit with a power rating of 450 watts.[257] A studio lamp called the "Photomirenta" was made available for amateur use. It consists of a 500 watt gas filled bulb having half the inside silvered to act as a reflector. The "Duo-Photolamp" is fitted with a switch in the base which enables one to have either white or red light.[258] A series of three long focus Meyer $f/3$ Telecine lenses have been made for use on the Pathe Moto-Camera. They give magnifications of four, six, and eight diameters, respectively, and are interchangeable with the regular $f/1.5$ lens on this camera. Similar sets are available for use on other amateur standard cine cameras.[259] Dallmeyer has also issued a new telephoto lens of $f/2.9$ aperture which is stated to give a linear magnification of three diameters. It is supplied only in 3 inch focal length.[260] The $f/0.99$ lens made by this firm has been withdrawn from the market. The new Dist distance meter is calibrated to work at distances as low as fifteen inches. It gives a single brilliant image, the barrel being rotated until the image is sharply focused.[261] Dutton[262] has devised a unique method of making amateur cine titles which consists in setting small ball bearings on a piece of blackened zinc, perforated to hold the balls, the camera being set up above the device.

A complete line of sound pick-up devices, including an inexpensive one-button carbon microphone, have been made available for the sound minded cine amateur.[263] A combined reel and humidifier can is supplied which consists of a flange that clips over the circumference of an unperforated reel.[264]

A patent for a remote control apparatus for amateur cameras has been issued.[265]

Scenarios and Amateur Clubs.—Suggestions on the choice and arrangement of properties for standard and miniature motion picture sets have been published by Webber.[266] There has been a marked rise in the number of amateur film clubs in England during the past six months, about one hundred of which are reported to be operating.

In spite of the club facilities available, the vast majority of amateurs are lone workers.

Films and Film Processing.—A new orthochromatic negative film of 16 mm. width has been introduced on the English market. The purchase price includes the making of one positive print.[267] An apparatus has been made available for processing small lengths of 17 feet or less of amateur film. It comprises three circular tanks, a film container drum, and a transparent apron for co-axial winding of the film.[268]

Patent protection has been granted on the use of an automatic printing device for exposure of cine film, after bleaching and before development, when treating such film by the reversal process.[269]

Cleaning and Editing.—An automatic film cleaner has been marketed which consists of an arm attachment for the Filmo and other projectors. The film runs between two moistened tapes and is wound on the projector reel. The tape is supplied on rolls so arranged that clean surfaces may be moved into place by turning a knob.[270]

A brief description has appeared of a viewing device of German origin for editing amateur standard film. Twelve times magnification is secured.[271] Bennet[272] has written a series of articles on editing and titling which contain many valuable hints for the amateur.

B. Amateur Color Processes

Ives has published a description of an interesting device for color photography called the "Chromolinoscope." It was invented by his father, F. E. Ives. It is suggested that this apparatus offers a simple means of viewing single frames of embossed films such as Kodacolor film and also that it may be utilized to make copies from such films.[273]

An additive color process called "Moviecolor" has been announced which is stated to be adaptable to all existing models of Victor cameras and projectors. Complete technical details have not been published.[274]

VII. STATISTICS

About eighty per cent of the amateur scenarists have been eliminated because of their inability to write dialog for sound motion pictures.[275]

According to an estimate made by Menefee, a million and a half dollars were expended in the production of industrial films during 1929 which indicated a great gain in the popularity of such films. One-third of the amount was devoted to the production of sound films.[276]

Theaters in the province of Szechwan, China, on the border of Thibet, exhibit American as well as Chinese pictures. There are 27 theaters with a seating capacity of 115,000. As this is an average of more than 4000 seats per theater, some of the theaters compare favorably in size with several of New York's big cinema houses. The population of the province is 60 million, however, so that only a small per cent can attend at one time. Only silent pictures are shown to date.[277]

Average daily attendance at 18 of Broadway's leading theaters with a seating capacity of 37,000 has been estimated as 100,000.[278]

During the first six months of 1930, nearly 145,000,000 feet of motion picture film valued at over $4,000,000.00 was exported from the United States, compared with approximately 122,000,000 feet valued at $3,300,000.00 in the same period in 1929. The 1930 exports were divided as follows: 2,788,000 feet of silent negative film; 3,292,000 feet of sound negative; 53,472,000 feet of silent positive film; and 85,378,000 feet of sound prints.[279]

According to a report on conditions in Scandinavian countries the Nordisk Tone-Film, invented by Jensen, is being used in several theaters in Denmark. Copenhagen has 40 theaters, of which 8 are wired for sound. All theaters in Norway were taken over by municipalitie sin 1921–22. The number of sound installations is increasing rapidly. The Svensk Filmindustrie studios at Rasmüda in Sweden represent the oldest establishment for producing pictures. Of the 100 odd theaters in Stockholm, many are sound equipped. Industrial and advertising films are used considerably.

There were 430 cameras and 1218 projectors for 35 mm. film exported from the United States during the first six months of 1930 compared with 419 cameras and 702 projectors for the same period in 1929. A decrease was noted in the exports of 16 mm. cameras and projectors for the first six months of 1930 as compared to 1929.[280]

A valuable series of reports on business conditions was issued by the Motion Picture Division of the U. S. Department of Commerce, dealing with São Paulo, Spain, Brazil, Central Europe, Bulgaria, Hungary, and the results of two international congresses held in Europe.[281]

VIII. PUBLICATIONS AND NEW BOOKS

One new publication has been noted in recent months, *Amateur Films,* which is published in Great Britain. *Cinematography* has been discontinued and combined with *International Photographer.* As a result of a new policy adopted this year by the German publication *Filmtechnik,* every alternate issue is devoted to technical and artistic problems, respectively.

New books which have appeared are as follows:

1. *Motion Picture Almanac—1930.* Edited by the staff of the *Exhibitors Herald-World.* Quigley Publishing Company, Chicago, Ill., 1930.
2. *Director's Annual and Production Guide—1930. Film Daily,* New York, 1930.
3. *Cinematographic Annual—1930.* Edited by the American Society of Cinematographers, Hartwell Publishing Co., Hollywood, Calif., 1930.
4. *Recording Sound for Motion Pictures.* Edited by the Academy of Motion Picture Arts and Sciences, McGraw-Hill Book Co., N. Y., 1930.
5. *Photocells and Their Application,* by V. K. Zworykin and E. DeW. Wilson, Wiley and Sons, N. Y., 1930.
6. *Sound Film* (*Der Tonfilm*), by H. Umbehr and H. Wollenberg, Lichtbildbühne, Berlin, 1930. This is Vol. 4 of *Bücher der Praxis.*
7. *Through a Yellow Glass,* by O. Blakeston, Pool, London, 1930.
8. *Photography—Theory and Practice,* by L. P. Clerc. An English edition translated by G. E. Brown of the comprehensive French text, *La Technique Photographique,* Pitman & Sons, Ltd., London, 1930.
9. *Film Hazards,* by C. A. Vlachos, Vlachos & Co., N. Y., 1930.
10. *Television Today and Tomorrow,* by S. A. Mosely and H. J. B. Chapple, Pitman & Sons, N. Y., 1930.
11. *Photographing with the Leica* (*Photographieren mit der Leica*), by C. Emmermann, W. Knapp, Halle, 1930.
12. *Film Problems in Soviet Russia,* by M. Bryer, Pool, London, 1930.
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APPENDIX

THE MOTION PICTURE INDUSTRY IN BRITISH INDIA, SEPTEMBER, 1930*

H. A. C. SINTZENICH**

There are approximately fifty producing companies in the Indian Empire, including Burma, making purely Indian pictures. The principal producing center is Bombay, which has nineteen companies, the remainder being dotted around the Empire.

In production technic, India is at least ten years behind the times, but a great deal of credit is due to the producers, in so far as they are self-taught, copying by trial and error methods what they have seen in foreign made productions.

Pictures are abnormally long, principally on account of the uneducated masses having no imagination or picture sense. Fade-outs as lapses of time are not understood and all the action that would intervene must be clearly shown. Another cause is the language difficulty. There is no *lingua franca* for the whole of India. There are over 30 languages and about 150 dialects. An Indian film has to have titles in the familiar vernacular of the locality in which it is shown, hence the necessity of printing the titles in four and sometimes six vernaculars as well as English. As mentioned before, the majority of the population is illiterate, and it is the custom of those who can read to repeat the titles aloud for the benefit of the others. In Burma, pictures run to forty reels and families go to see them in relays and on their return home explain what happened for the benefit of the absent members.

Mythological and historical stories are most favored, with a decided leaning toward the former. There being no social life among the Indians outside the larger cities, dramas and comedies of this order are rarely seen.

Love themes as in American and European productions are not understood for the simple reason that it is not part of the Indian's life. Neither the man nor the woman have anything to say about whom they marry, it all being arranged by their parents. The recently passed Sharda Act raised the marriageable age for girls to thirteen. Previously, more often than not, the ceremony

* A contribution to the work of the Progress Committee.

** Kodak (India), Ltd., Bombay, India.

took place while they were infants. It was not uncommon for men of forty and even sixty to marry young girls of from nine to twelve years of age.

The art of scenario writing, continuity, and direction is sadly lacking. Their greatest advance has been in photography, but even this, with a few exceptions, is not as good as was done in America fifteen years ago.

The majority of the proprietors of the producing companies are absolutely in the hands of their employees, as they know practically nothing of the technical side of the business.

Production is practically at a standstill for the months of June, July, August, and September owing to the monsoon (rainy season) when the rainfall averages 100 inches in Bombay. During these four months and the month of October following the monsoon, the relative humidity registers a high point, with a minimum of 72 and a maximum of 91 per cent. Under these trying and extreme climatic conditions, manufacturers for years found it increasingly difficult to ship and stock sensitive photographic materials and keep them in good condition. This trouble has now been overcome, however, by the use of tropical packings which are proving eminently satisfactory.

Studios.—Studios are of the open-air type with overhead cotton diffusers. There are four studios only with glass roofs. Dark studios with artificial light are unknown. One Calcutta and two Bombay companies are utilizing artificial light combined with daylight, but their total amperage does not amount to more than 300 to 400 amperes each.

Sets are constructed in the main of painted canvas flats which shake and flutter in the breeze. These defects, however, are not objected to by the audiences. The artists who are naturally dark, all make up white, to represent the European complexion, and the effect is quite startling and humorous.

Scenes in the studios are photographed in continuity, the cameraman moving up and back to take long, medium, and close-up shots just as they are to appear in the finished production. This idea is to conserve negative film and to facilitate editing and cutting.

Rehearsing is not practiced; the director explains the situation and leaves it up to the artists. Their expressions are mostly a blank and all their emotions are in their voices.

Cameras.—There is no lack of good and expensive equipment. Bell and Howell cameras predominate, with Debries also in favor. Obsolete models of Williamson and Moy cameras are also numerous.

Laboratories.—This is undoubtedly the worst side of motion picture production in India. It is a forlorn hope and next to impossible to get an Indian to change his method of working. When once he has learned one way to do a thing nothing will induce him to change, no matter how old and antiquated it may be. He is deadly afraid of trying anything new.

Processing is accomplished by antiquated methods throughout India. Film racks have a capacity of 100 feet and developing and fixing is done in open, flat, oblong wooden trays. Temperature of solutions averages 75° to 80°F., and cooling is accomplished by adding ice to the solutions. Wash water, in many places at a premium, averages 90°F., and washing is accomplished by coolies squatting on their haunches, rapidly lifting frames up and down in a tray on the floor. Drying drums have a capacity of from one to two thousand feet and are turned by hand. Printing machine equipment is mostly good, being either Bell and Howell or Debrie. Only one producer has a modern up-to-date laboratory and this is located in Secunderabad. Six copies is the maximum number of positive prints made from any one negative, the average being about three. A model laboratory and projection room in Bombay is maintained by a large industrial firm as a service gratis to Indian producers, cameramen, laboratory men, and traveling foreign companies.

Theaters.—According to latest government figures, there are 310 motion picture theaters in India including Burma. Taking India's estimated population of 248,000,000, there would be only one theater for every 802,589 of the population, whereas America with a population of 120,000,000 has 20,500 theaters or one for every 5853 of the population. The total seating accommodation of the theaters in India is approximately 222,000. If the average attendance per day be taken at 200 at each of the 310 theaters the average daily attendance would be only 62,000.

The reason for the small number of theaters is found partly in the poverty of the people, also the fact that the greater part of the population live in small villages where a theater would not be a paying proposition.

Of the 310 theaters, 64 are devoted to the exhibition of imported American and European pictures only. Of the remaining theaters, these show both Indian and imported films in varying degrees. A large majority show only Indian films and only resort to imported films when they cannot obtain Indian.

The type of imported films which are most popular with all classes and communities are the spectacular productions, featuring Douglas Fairbanks, Charles Chaplin, and Harold Lloyd. The most popular film ever shown in India so far was *The Thief of Bagdad,* with its Oriental settings.

Sound.—Up to date there are 28 theaters in India wired for sound; these are divided as follows: Bombay 5, Calcutta 5, Rangoon 4, Colombo 2, Karachi 2, Bangalore 2, Lahore 2, Mussoorie 2, Madras 1, Simla 1, Poona 1, and Delhi 1. Of these theaters twenty-five are Western Electric and three RCA installations.

At the time of making this report, September, 1930, no Indian producer has yet started recording sound either on film or disk, but there are indications that there will be two in Bombay and one in Calcutta before the year is out.

One unit of Fox Movietone News has been in India for the past year, covering topical incidents connected with the present political disturbances.

Films—Processed and Raw.—There is a wide choice of raw stock, both negative and positive, on the market in India, being imported from America, England, Germany, Belgium, Italy, and France.

That the industry is in a healthy and expanding state will be seen by the following official government figures of imports of raw stock, both negative and positive, for the past eight years:

1922–23	520,429 feet
1923–24	1,451,655 feet
1924–25	3,194,760 feet
1925–26	6,258,199 feet
1926–27	7,715,632 feet

1927–28	12,372,093 feet
1928–29	19,161,293 feet
1929–30	21,500,579 feet

The following are the official figures of imported American and European productions (finished pictures) for exhibition:

1922–23	1,790,000 feet
1923–24	5,750,000 feet
1924–25	6,250,000 feet
1925–26	7,661,000 feet
1926–27	9,767,032 feet
1927–28	10,372,288 feet
1928–29	10,792,341 feet
1929–30	10,247,051 feet

It will be observed that the last three years show the imports of foreign finished pictures as reaching the saturation point with the theaters available, whereas the Indian producers as shown by their imports of raw stock are holding their own and expanding.

Education.—The Imperial as well as the Provincial Governments maintain motion picture departments in their various institutes, such as the Provincial Hygiene Institute, Lucknow; the Kala Azar (Black Water Fever) Commission, Assam; the Hafkin Institute, Bombay; the Central Publicity Bureau, Delhi; and the Imperial Agricultural Department, Delhi.

Amateur Cinematography.—Amateur cinematography combines both standard and sub-standard film and is very popular among the wealthy classes. In Bombay, an amateur cine club is being formed.

Sub-standard film is also being used for commercial advertising. Tire, tobacco, and fertilizer manufacturers, *etc.*, demonstrate their goods as used and applied to conditions in India.

Conclusion.—The present political unrest and disturbances have affected the industry as a whole, theater receipts having fallen off considerably, especially among the Indian picture houses.

At a meeting of the Indian Producers and Exhibitors Association, a resolution was passed boycotting all British films for exhibition, raw stock, and chemicals.

THE PROGRESS OF SOUND MOTION PICTURES

HAROLD B. FRANKLIN*

The moving picture is a modern industry, not only in being contemporary, but in conducting its business along the most enlightened and up-to-date lines. When the time comes, and it will, that ushers in the next development of the motion picture art, the leaders of our industry will again be prepared to startle and please millions of patrons with added improvement. Instead of being off-guard when sound came, the industry, in a large degree, was acquainted with its findings as well as with its flounderings. The experiments and conclusions of engineers, producers, distributors, and managers form a body of fact which has been of great advantage to all of us.

Let us, in a few short minutes, review the development which leaders have been following for half a century.

In 1894 a new era in mass entertainment was born, when a machine called the Kinetophone introduced a series of photographs viewed through a slot, which, when turned by means of a crank, appeared to be in motion. A few years later moving pictures were shown on a screen. Thus were moving pictures introduced to the world.

Pictures as a symbol came with our earliest civilization. As a means of expression they were used before writing. In this may be recognized a fundamental appeal to the subconscious mind, which may account for the popularity of motion pictures. The modernization of pictures through motion intrigued many brilliant minds. Roget, the author of the famous *Thesaurus*, is said to be the first actual experimenter on record, and while he and others gradually visualized the possibilities of moving pictures through the persistence of vision theory, others applied themselves to the further development of photography.

America, however, brought the practical motion picture to the

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* Fox West Coast Theaters, Hollywood, Calif.

world. The first successful experiment of a moving picture was introduced by Leland Stanford, who, through the use of photographs taken by a series of cameras, showed that all four feet of a running horse were off the ground at the same time. It was Edison, however, that presented the first actual motion picture through the use of flexible film.

When motion pictures became a reality, they were welcomed by an eager public everywhere. The first motion picture theater was opened in 1895. A few years later the first nickelodeon was opened to the public in Pittsburgh; within a few years there were thousands of such amusement places, and these formed a nucleus of what is today the motion picture industry. At present there are over 22,000 motion picture theaters in the United States, with an approximate seating capacity of eleven million. Over sixteen million persons, virtually in every community in the country, attend motion pictures daily.

With the development of sound synchronization came a turning point in the motion picture industry. Though first regarded skeptically by many, within a year the future of the new medium was assured. The talking picture had arrived and received great public support. Almost everything which can be seen and heard may be introduced through this new medium.

The transition from silent motion pictures to sound is one of the most interesting chapters of business development. The rapidity with which the requirements of the new art have been met is something to marvel at. A new technic had to be evolved, studios were virtually rebuilt, players had to be trained, technicians developed, and all of this was accomplished within the period of a year, and to the credit of the industry, with financial profit to practically all of the important organizations who participated. No type of entertainment has ever made so rapid a progress as sound motion pictures, and no innovation in the entertainment field has been as graciously welcomed by the public.

Great technical progress has been made in not alone the recording but in the reproduction of sound, until today defects are the exception rather than the rule. All elements of the industry coöperated to bring about present-day standards.

The making of sound motion pictures has passed the stage of mystery. Those who engage in the business of making such pictures are now familiar with the medium. There is now a feeling of confidence about the studios that was lacking in the beginning. Technicians and players are available in sufficiency who have a full realization of the sound screen possibilities and are equipped to use their knowledge to advantage. They have learned that the entertainment and artistic value of the silent picture need not be sacrificed in the adaptation of sound. Under the new conditions, it is likely that fewer productions will be made than in the past. It is a comparatively easy thing to turn out a number of silent motion pictures that require only titles to hold a story together. But when a story depends on intelligent and continuous dialog, the richest capabilities of writers of drama will be taxed. It is difficult to imagine anything as inept as meaningless dialog. Where the silent motion picture left something to the imagination of the audience, the dialog picture, to be acceptable, must absorb the full attention of the auditor. Good writers will become more important than in the past and good story material will be the most important requisite for the dialog motion picture, because a picture is never better than the story it tells.

A new musical interest has been added because of sound motion pictures. Music adroitly arranged, that interprets each situation, has added considerable entertainment value. But the art of scoring motion pictures under the new order of synchronization has scarcely begun, and important strides may be expected in this connection within the next few years. But even at the present writing, one may say that music, as synchronized, is in closer unity with the situations pictured than was the case in former times. There is not, moreover, the distraction caused by the close proximity of musicians to the screen. The small towns, where inadequate orchestras used to render their ineffectual accompaniments to the silent pictures, have reaped the special benefits of musical synchronization. Music of the best caliber becomes available to every type of theater.

The sound motion picture has met with greater success in theaters of a seating capacity of between 2500 and 3500 seats, and this fact may have a marked effect upon the design of newer theaters; for, while satisfactory reproduction has been attained in theaters of huge seating capacities, yet the problem in such houses is so formidable as to require constant and minute supervision. Auditoriums, in the future, will be specially designed with the greatest regard to acoustical conditions, and we may well expect—except in theaters located in the very largest communities, where stage entertainment may be expected at some time to be a part of the program—to see the elimination of the present size stage with its lofty gridiron. Projection booths have already become the subjects of special study by theater architects and engineers. In some of the more recent Fox West Coast Theaters, which have been built under my direction, a special observer's box is provided in a balcony close to the projection booth, so that the projectionists may see and hear everything just as it comes to the audience.

Accomplishments have been effected in connection with color photography, motion picture cameras, laboratory equipment, illuminants, projection room equipment, stereoscopic pictures, and television. No one can doubt that with the development of sound, science has entered the entertainment field. It is only to be expected that the great electrical organizations will take an ever increasing interest in the future of the industry and will make available to the public the results of their experiments. In view of such resources the possibilities of motion picture entertainment may be said to have scarcely been scratched. Newer methods and revolutionary improvements will come in direct ratio to the scientific facilities applied to them. This should eventually mean the solution of other possible riddles, such as stereoscopics and the further development of natural color. The possible future of the motion picture screen, with animation, sound, color, third dimension, and screen magnification, gives unbounded play to the imagination. Already we have sound, color photography, and the large screen and while it is doubtful that either of these improvements have brought any additional revenues to the box-office, yet they have in some instances enhanced some of the possibilities of production and eventually may be used to decided screen advantage.

The highest technical perfection, however—stereoscopics, or the third dimension—is still lacking, although many important minds are concentrating on the development of the feature. So far as the projection of still pictures is concerned, this can already be accomplished by any one of a great number of devices placed at the eye; for the essential of stereoscopic vision is the existence of two images corresponding to what each eye sees, and the segregation of each image to its proper eye. There have been some claims of stereoscopic features in connection with the introduction of the double-width screen. However, although such screens are of value in reproducing larger images and securing larger area, they do not, up to this writing, include any stereoscopic advantages.

Dr. Herbert E. Ives of the Bell Telephone Laboratories has evolved a plan wherein a spectator at one side of the theater sees a different side of a certain object than is viewed by another spectator on the opposite side of the room. Thus he gives the illusion of solid objects in space instead of flat images on a flat surface. The apparatus necessary to attain the desired effect, however, is both cumbersome and costly. To obtain the result, the projectors are placed behind a transparent screen, and the spectator is seated on the opposite side of the screen. Both sides are blanketed with grids of alternate opaque lines and open spaces that pass the light in narrow parallel bands. The projectors behind the screen are arranged in a semicircle. All of them render, simultaneously, views of the same scene taken at one time by a battery of cameras arranged to focus on their objective from different angles. Using the present motion picture camera, it is necessary to take sixty images each from a slightly different angle; the procedure requires fifteen cameras with four moving lenses, each photographing about eighty pictures a second—more than four times the ordinary rate of speed. The sixty images taken are then all condensed upon a single film. Dr. Ives knows that photographers will say that the obstacles are insuperable, but insists that if sufficient diligence and the same kind of financial backing and facilities that have been given to similar developments are given here, the difficulties of simplifying the taking and projection may be overcome. The experiment is particularly interesting in view of the fact that Dr. Ives has to his credit the origination and the present progress of television as developed by the Bell Laboratories.

The dialog motion picture is also likely to have an interesting effect on the theatergoing habits of its public. While it has meant nothing, until now, to drop in on a picture after it started and to pick up the threads of the story as it progressed, in the case of the talking picture it becomes more important for the audience to be present from the beginning. If the talking motion picture follows the technic of construction in play-writing, the earlier part of the action, in a measure, will establish the premise for the story that is to come. If this is missed, it is obvious that the picture will not be as enjoyable as though it were seen from the very beginning. Hence it is likely that, in neighborhood theaters, managements will establish definite schedules for the feature portion of the program and try to regulate the attendance of patrons. The problem is of importance in connection with downtown or *de luxe* theaters that depend to some extent on transient patronage. Conspicuous posting of schedules and advertising of the starting time of the various units of the program will help the public to view the talking motion picture from the beginning.

The dialog picture has already worked a change in the attitude of moving picture audiences in regard to applause. Observations would indicate that audible pictures are more likely than silent ones to move audiences to applause.

A question has been raised as to what will happen to the *de luxe* type of entertainment, where stage presentations have become an important part of the programs. It is safe to assume that the same patronage that made necessary a different type of entertainment for the high priced downtown theaters as compared with those that play pictures subsequently will continue to demand it. Therefore theaters of large capacities in key points, and charging higher prices of admission, will in all likelihood continue the stage type of entertainment regardless of the success of sound motion pictures. Such stage presentations will always improve in quality and will keep pace with public expectation.

Dialog motion pictures have renewed the vexatious question of censorship. Enforced censorship of sound motion pictures in different communities would bring to the industry serious problems in the physical handling of film. Changes required by local censor bodies cannot be made as readily as in the case of the silent picture. Although correcting scenes in the silent version to meet the demands of the censor boards is a simple matter, the problem is a big one when it is applied to sound. A title can be either rewritten or eliminated; a scene can be cut out; a title can be substituted to explain the deleted action. Such methods are not possible in films that are synchronized with dialog. They mean a return to the studio and a fresh production. The cast and the set must be recalled to retake the action. In some instances members of the cast are not available when needed for such retakes, so that the effect on general releases in censored territory is virtual obstruction.

The potentialities of sound have opened a greater field for the motion picture than ever before. The future of the screen is brighter from every artistic and economic point of view. The future, with its greater plans, greater now than in any previous period of the business, brings to us the vision of the greater responsibility that is ours. The industry has a long, broad road to travel.

X-RAY CINEMATOGRAPHY

S. RODWELL*

The value of the X-rays in the study of medical and surgical problems would be greatly enhanced by the addition of cinematography and, in fact, many medical men impatient with X-ray stills—at best records of single phases only—have begun to ask for new methods of attack along cinematographic lines; in short, for "moving pictures" of the internal organs of the body at work, *e. g.*, the heart beating, the digestive tract dealing with food, and so on.

Some pioneer work has already been done. In Germany, before the War, Dr. Friedrich Dessauer, and later Dr. Franz Groezel, and in America, Dr. Ruggles have each achieved a measure of success in recording the action of the heart. More recently good work has been done in the Grace Hospital, Detroit, Michigan, where "Cin-ex" studies of the *tracheo bronchial tree* have been obtained.

In England experiments are being made by British Instructional Films, Limited, represented by Mr. Stanley Rodwell in collaboration with Dr. Barclay of Cambridge University.

For the benefit of those unacquainted with X-ray methods, it may be as well to mention that the X-ray picture is produced by the invisible rays falling upon a specially prepared screen (usually 12 × 10 in.) which, according to the various degrees of transparency to the rays in the object under examination, and through which the rays are passing, fluoresces in correspondingly various degrees to form the X-ray picture. The picture is in fact a shadowgraph and is, of course, full size or larger. The picture remains only so long as the X-rays are passing, though a permanent record can be obtained by using a photographic film in place of the screen or in contact with it.

The problem is to photograph the screen with its fluorescent shadowgraph 16 times a second (or if talkies are to be included) 24 times a second. At first sight this might appear to be simple, but in

(Contributed by the author, October, 1930.)

* British Instructional Films, Ltd.

fact the difficulties have been found to be very great. To begin with, the screen must be photographed by its own direct "light"—such as it is—for the "light" emitted by the fluorescence is sadly deficient in actinic rays. (The experiments are of course carried out in darkness.) Further, in order to produce fluorescence of sufficient intensity to photograph at all, a very high voltage electrical discharge must be used for the X-rays. A voltage in the neighborhood of 120,000 has been employed, but—and this is a very great difficulty—so harmful to living tissues are the X-rays produced under these conditions, that 5 or 6 seconds is the very utmost to which a human being can be subjected without serious risk of burning.

It is essential that exposures should be the absolute minimum. Even with a discharge of this intensity, the fluorescence is so poor in actinic light value that normal cinematographic exposures are far too short to produce a negative of reasonable printable density.

The lens aperture must, of course, be the maximum possible, (commensurate with definition) and Mr. Luboshez, a Paris experimentalist, has used a lens of his own manufacture, working at about $f/0.75$ which he says he cannot repeat owing to difficulties with the glass. He uses 16 mm. film and has perhaps been more successful than anyone else up to the present—probably due to his enormous lens.

In all these experiments, the X-rays used were continuous, the camera exposures being, of course, intermittent. Dr. Barclay has suggested synchronizing an intermittent flash X-ray discharge with the intermittent camera exposures, and indeed, has practically completed an apparatus for bringing this about. It appears that there is a certain amount of lag in the fluorescent screen, and he thinks that with a very large instantaneous X-ray discharge, this lag will be sufficient to give the necessary exposures.

This synchronization of the shutter with the discharge from the X-ray tube will not only minimize the danger of burning the patient under examination, but also will lessen to some extent another difficulty presented by the fluorescent screen, *viz.*, that exposed for too long a period, say, 5 seconds, it becomes, as it were, "tired" and photographically inactive.

As to the film used in the camera, from the results so far obtained, it looks as if a specially prepared color base negative stock rendered supersentitive to the particular rays emitted by the fluorescent screen will have to be employed. Perhaps also, the screen itself can be improved to give a fluorescence richer in actinic light. The screens so far used have differed very widely in this quality.

Experiments showed that orthochromatic film stock gave a denser negative than panchromatic. Of the many light filters used with the latter, a red filter gave the densest negative. It must, however, be clearly understood that even the best negative so far obtained is too thin to be satisfactorily printable.

With regard to the camera, the Maltese cross movement shutter appears to be the best as its more rapid pull-down of the film between exposures enables a longer exposure to be given. It is advisable to utilize the quarter circle to enable just sufficient time to obscure the subject while the film is passing through the gate.

It is essential to have the front part of the camera which faces the fluorescent screen covered with lead leaf (with the exception, of course, of a small aperture for the lens) in order to prevent fogging of the film by X-rays.

The developer, which has given the best results in the laboratory so far, is the metol-hydroquinone formula, with the addition of 50 per cent above normal of both sodium carbonate and sodium sulfite.

The electrical equipment necessary to produce X-rays of sufficient intensity presents further difficulties, for transformers, condensers, *etc.*, will not stand up for long periods at a stretch to such a high voltage. During the experiments, one always feels that a serious breakdown is imminent. The idea of a series of pictures lasting even for a few minutes is at present out of the question.

One more obstacle is the enormous cost of the apparatus. This is a very serious item even for a well endowed research laboratory, and to a firm run on a commercial basis, it is practically prohibitive.

Nevertheless, such are the benefits to medicine and surgery—to mention only two sciences—which would undoubtedly follow from the perfection of the "Cin-ex" Camera that those experimenters already at work are straining their resources to the utmost to reach the goal.

Wherein lies the solution of this intricate problem? Is it in the improvement of the fluorescent screen to enable a comparatively harmless X-ray to give a picture sufficiently actinic to be photographed? Will it be in the manufacture of a camera lens of unheard-of aperture? Or in the cinema film supersensitized with a dyestuff as yet unused or perhaps even undiscovered? Or in all these things?

REPORT OF STANDARDS AND NOMENCLATURE COMMITTEE*

This committee was organized in January of this year and a report of the meetings held during the spring was presented at the Washington meeting of the Society in May and appeared in the August, 1930, issue of the JOURNAL. As indicated in that report, the work of this committee may be summarized under the following headings: Preparation of Booklet, Nomenclature, Standard Practice, and Wide Film Dimensions.

PREPARATION OF BOOKLET

A booklet entitled "The Dimensional Standards for Motion Picture Apparatus and Recommended Practice" has been prepared by Mr. L. A. Jones, a member of this committee and the editor *pro tem* of the JOURNAL. This booklet contains all the standards adopted by the Society up to the time of the Toronto meeting in 1929. It was submitted to the American Standards Association under the *proprietary standards method* and subsequent approval was obtained on September 20th as A. S. A. standard Z22-1930. The booklets have been distributed to each member of the Society and additional copies may be obtained from the secretary of the Society or from the American Standards Association.

NOMENCLATURE

The subcommittee on nomenclature, consisting of Messrs. Carson, Dubray, Powers, and Rayton (*Chairman*), has held two meetings during the year to consider a revision of the glossary that was published in *Transactions* No. 37 of the S. M. P. E. It is proposed to publish a revised glossary every year in order to keep it up to date.

The proposed revisions of the glossary include the dropping of certain terms that have become obsolete or that have become part of the English language and are to be found in any good dictionary. They include also the correction of definitions that were in the old

(Read before the Society at New York, October, 1930.)

* October, 1930, Report of the Standards and Nomenclature Committee.

glossary and the addition of many more terms that have come into use since this glossary was published. The subcommittee has in its possession a list of definitions prepared by the Academy of Motion Picture Arts and Sciences, which has been of considerable assistance to the committee. The revised glossary will appear in a later issue of the JOURNAL.

Work has been continued on the compilation of a list of foreign equivalents of the terms defined in the glossary. This has not advanced far enough, however, for publication and it is recommended that the work be continued by the succeeding committee.

STANDARD PRACTICE

A subcommittee, consisting of Messrs. Farnham, Hubbard, Mitchell, and Rackett (*Chairman*) has met during the summer to formulate certain recommendations which are presented below for consideration by the Society. The policy of the subcommittee has been to sponsor only those practices which have not only all the features that qualify them as practical working specifications but have as well the support of at least a majority of those who use them.

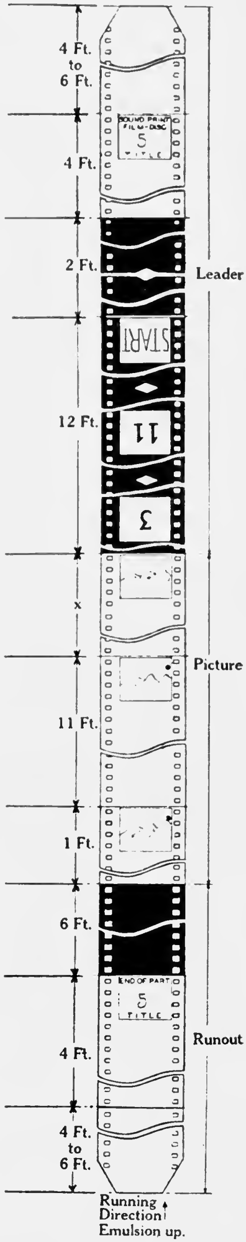
(1) *Projector Speed.*—It is recommended that a nominal projection and reproducing speed of 90 ft. per minute be adopted for all 35 mm. films. This replaces Item 8 and Item 15 of the current recommended practice.

(2) *Camera Speed.*—It is recommended that a nominal photographing and recording speed of 90 ft. per minute be adopted for 35 mm. films. This replaces Item 9 and Item 14 of the current recommended practice.

(3) *Standard Leaders for 35 Mm. Release Prints.*—This committee has been in close touch, through interlocking memberships, with the work of the Technician's Branch of the Academy of Motion Picture Arts and Sciences. We are very pleased to recommend the adoption by this Society of the Academy's specifications for standard leaders to be used with 35 mm. motion picture release prints. The detailed plan of release prints is given below. It is felt by this committee that the general adoption of these recommendations will avoid much of the mutilation of release prints that is now current.

(4) *Screen Brightness.*—The subcommittee has under consideration the formulation of limits for screen brightness and is seeking to arrange for a coöperative effort with the Academy of Motion Picture

ACADEMY SPECIFICATIONS FOR 35MM. MOTION PICTURE RELEASE PRINTS



PROTECTIVE LEADER

Either transparent or raw stock.

When the protective leader has been reduced to a length of four feet it is to be restored to a length of six feet.

IDENTIFICATION LEADER (Part Title)

Shall contain not less than 32 frames in each of which is plainly printed in black letters on white background, type of print (see nomenclature), part number (arabic numeral not less than $1/4$ of frame height), and picture title.

SYNCHRONIZING LEADER

First section shall be opaque.

Start mark shall be one frame in which is printed START (inverted) in black letters on white background $1/2$ of frame height.

A white line $1/32$ inch wide upon which is superimposed a diamond $1/8$ inch high by $3/8$ inch wide shall be printed across the picture and sound track area at a point exactly 20 frames ahead of the center of the start frame.

Beginning 3 ft. from the first frame of picture, each foot is to be plainly marked by a transparent frame containing an inverted black numeral at least $1/2$ frame height. Footage indicator numerals shall run consecutively from 3 to 11, inclusive.

This section shall be opaque and contain frame lines throughout entire length which do not cross sound track area.

At a point exactly 20 frames ahead of the center of each footage numeral frame there shall be a diamond (white on black background) $1/8$ inch high by $3/8$ inch wide.

PICTURE

It is recommended that picture action start and finish on fades wherever possible, otherwise significant sound should be kept at least five feet from the start and finish of the picture.

MOTOR CUE

Shall be circular opaque marks with transparent outline printed from the negative which has had four consecutive frames punched with a serrated edge die 0.094 inch in diameter. The center of these holes is to be halfway between the top and second sprocket holes 0.281 inch from the right-hand edge of the film with heads up and emulsion toward the observer.

CHANGE-OVER CUE

Shall be same as motor cue.

RUNOUT TRAILER

Shall be opaque.

IDENTIFICATION TRAILER (End-of-Part Title)

Shall contain not less than 32 frames in each of which is plainly printed in black letters on white background: End of part, part number (arabic numeral not less than $1/4$ of frame height), and picture title.

PROTECTIVE TRAILER

Same as protective leader.

Arts and Sciences for the ultimate standardization of this important factor in motion picture projection.

(5) *Screen Color.*—With the increasing use of color films, the standardization of screen color is as important as the standardization of screen brightness. Due to the difference in spectral quality of incandescent lamps, low intensity and high intensity arcs, the color of the projection light varies from a yellowish-white to blue. In addition, projection screens vary considerably in their color. Under existing conditions, it is impossible to realize the full value of color prints. The subcommittee will undertake a number of coöperative investigations in an effort to improve this situation.

(6) *Theater Sound Intensity.*—One of the most important factors in the presentation of talking motion pictures is the level of the sound intensity in the theater. It is obviously bad practice to delegate the regulation of sound intensity in a theater to one person because his individual preference may not be in accord with general public approval. Also, this individual is often located of necessity at a point where his observations are of little value. For these reasons, the committee feels that the establishment of an optimum sound level, preferably with mechanical means for its indication, is highly desirable. The Projection Committee of the S. M. P. E. has this problem under consideration and it is hoped that a standardization of practice may be brought about through coöperation both with this committee and with other organizations.

(7) *Negative Notching.*—An investigation of negative notching practice is being undertaken with the hope that the principal features involved may be standardized. This undertaking, like those outlined above, is being launched in coöperation with other organizations.

WIDE FILM DIMENSIONS

This committee has felt that the standardization of wide film dimensions was the problem of prime importance before it, and the subject has been considered at great length at three meetings of the entire committee and at seven meetings of a subcommittee consisting of Messrs. Davee, DeForest, Evans, Griffin, LaPorte, Spence, Sponable, and Batsel (*Chairman*).

It is quite generally agreed that placing the sound track on the present 35 mm. film results in a picture with undesirable proportions. When these proportions are corrected by masking the height, the smaller area of picture requires a greater magnification of the film to cover the same size of screen. As the magnification has already been pushed close to the limit set by the graininess of the film and its unsteadiness in the projector, the utilization of a portion of the film for the sound track has made the projection of pictures of even moderate screen dimensions not altogether satisfactory. Simultaneous with the general introduction of sound has come a desire on the part of the industry for a larger projected picture that would include more action. Although several methods have been suggested for the realization of large screen pictures with the present 35 mm. film, this committee feels that none of these methods offers a permanent solution to the problem and that, at the present time, the only satisfactory method of obtaining a large screen picture seems to be through the use of a wider film.

There are many obvious advantages to wide film. It not only permits a sound track of more satisfactory width than in use at present, but it makes possible large screen pictures having a greater variety of composition and more action without exceeding a practical limit of magnification. In considering a new standard for motion picture film, this committee has been guided not alone by engineering principles but by considerations of the cost to the industry of a new standard and of the necessary transition period. It is obvious that any practical recommendation must involve the ratio of screen width to screen height that is already established within reasonably narrow limits by both the proscenium arch and the balcony cut-off in existing theaters. An investigation of this subject shows that, whereas a few of the larger theaters can use a ratio of width to height as great as 2 to 1, the ratio for the smaller theaters is usually less. After careful consideration of this subject, this committee recommends the adoption of a 1.8 to 1 ratio of width to height as the best compromise. This ratio seems to be not out of line with prevailing sentiment among members of the Academy.

During the deliberations of the subcommittee, it became increasingly evident that the adoption of release prints with a width in the neighborhood of 65 or 70 mm. would be economically impracticable for a large proportion of theaters. It seemed desirable, therefore, to give consideration to a film size intermediate between these dimensions and the present 35 mm. standard. We are working on a layout that will permit the use of the 1.8 to 1 ratio and that will provide for a wider sound track and more suitable margins. We are attempting to assign dimensions to this film that will permit the most economic use of existing 35 mm. equipment.

While the specification of the release print dimensions is the problem of most importance, this committee has under consideration a negative of such proportions that it can be printed by optical reduction on the new intermediate film size or by contact on a larger film for the *de luxe* houses.

M. C. BATSEL	R. E. FARNHAM	G. F. RACKETT
W. H. CARSON	H. GRIFFIN	W. B. RAYTON
L. W. DAVEE	R. C. HUBBARD	V. B. SEASE
A. DEBRIE	L. A. JONES	T. E. SHEA
L. DEFOREST	N. M. LAPORTE	J. L. SPENCE
J. A. DUBRAY	G. A. MITCHELL	E. I. SPONABLE
E. W. ENGSTROM	W. P. POWERS	L. T. TROLAND
P. H. EVANS		A. C. HARDY, *Chairman*

TREND OF LAMP DEVELOPMENT AND OPERATION IN MOTION PICTURE PROJECTORS EMPLOYING 16 MM. FILM

V. J. ROPER* AND H. I. WOOD**

We have had to alter our conception of the application of the non-professional projectors employing 16 mm. film. It was formerly felt, that due to inherent limitations in illumination, these small units could only be recommended for use before a handful of people. However, due to their portability, comparatively low cost, and low film cost, they have become increasingly popular. While one of their major applications is in the home, they have become an important sales aid in the business field and find increasing use in the school classroom.

The increasing use of this equipment before larger groups, in rooms not totally darkened, and the projection of color films have led to demands for higher illumination. Naturally, in looking for higher illumination one first thinks of the light source. Unfortunately motion picture projection is one of the few fields of illumination wherein higher levels of lighting cannot be obtained at will by increasing the wattage of the source, or by increasing the number of sources. The optical system imposes a practical limit of one source of light, and definitely limits the source area which may be effectively utilized. Back testing 16 mm. optical systems shows the maximum effective light source size to be a rectangle with rounded corners approximately 8 mm. long and slightly less high. Different lens systems of course accommodate sources of different size. Naturally any part of the light source extending beyond the area which can be utilized is wasted as far as contributing to screen illumination is concerned.

To obtain the highest possible screen illumination with an incandescent lamp, the problem becomes that of providing the most hot

(Read before the Society at New York, October, 1930.)

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tungsten within the usable area. Perhaps a logical first thought would be, why not employ a solid band of tungsten, a tungsten sheet or ribbon? The obvious advantage of such a source is offset by the fact that it operates at a lower temperature than that of a coiled filament, for the same lamp life. There are several contributing factors to this situation. A ribbon or sheet of tungsten presents relatively greater surface for evaporation, hence the temperature and therefore brilliance must be lowered to keep down the rate of evaporation. Due to the fact that the ribbon of the needed area is necessarily a very low voltage, very high current source, great end losses are encountered. That is, the large lead-in wires conduct heat away so rapidly that only the center of the filament operates at the critical temperature. It is true that the length of the ribbon may be increased to compensate for this, but the resulting wattage becomes unreasonably high. Another disadvantage of a flat ribbon is the absence of "black body effect" or internal reflection of light between filament coils. Hence its apparent operating temperature and therefore brilliance suffers still further in comparison with the coiled filament. Ribbon filaments are also less uniform in operation due to necessarily greater tolerances in manufacturing.

The tungsten coil has then the advantage of higher operating temperature and greater brilliance. It offers a further advantage in that the efficiency of light utilization may be increased through the use of a spherical mirrored reflector to mesh a filament image between the filament coils.

Inasmuch as the filament length is proportional to the voltage, for a given wattage a low voltage filament may be coiled within a smaller area than a high voltage filament, or for a given area, a higher wattage, low voltage source may be used. This requires comparatively high current and larger wire size, but the increased space taken by the larger wire is more than compensated for by the reduced filament length. And the larger tungsten wire may be operated at a higher temperature or brilliance since it presents proportionately less surface to the gas for evaporation. There is a low limit beyond which further reduction in voltage and increase in current becomes disadvantageous due to the increase in end loss, that is, heat conduction by the larger lead-in wires. Very high current lamps also present difficult manufacturing problems such as that of bringing the high current leads through a glass stem of limited size.

Fig. 1 shows some of the many filament forms investigated. The greater end cooling effect of the shorter coils is clearly indicated. Figs. 2 and 3 present graphically some of the illumination results obtained through this investigation. It must be noted that the ordinates are initial screen lumens. These data disregard bulb size, and are all on an equal life basis. Fig. 2 indicates the advantage of low voltage sources and also the disadvantage of too low a voltage. Fig. 3 shows the optimum voltage for 250 watts. The pronounced hump in the curve at 20 volts is occasioned by a change in filament

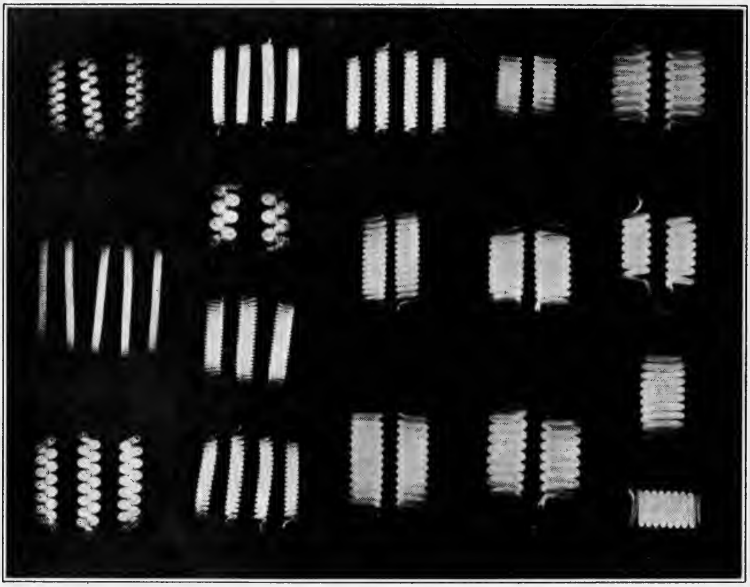

FIG. 1. Various coil forms ranging from 115 volts at left to $12^1/_2$ volts at right.

construction to the 2-segment source made feasible at 25 volts and lower. Below 20 volts, end cooling losses mount rapidly and account for the rapid drop in illumination. An optimum lamp for the system would have a voltage somewhat higher than 20, chiefly to compensate for the greater end losses of the higher wattage, higher current filament, and present indications are that its wattage would be around five hundred.

Present equipment designs limit the bulb size to the T-10, a tubular bulb $1^1/_4$ inches in diameter. This in turn definitely limits the wattage. Aside from the fact that excessive wattage would cause bulb failure, the chief limitation is that of bulb blackening. It is well known that as an incandescent tungsten filament operates, metallic tungsten is deposited on the bulb in the form of a black coating. The resulting thinning of the filament due to this evaporation eventually causes the lamp to fail, and for a given bulb size, the higher the wattage, the greater the rate of deposit. You may wonder why we don't place tungsten abrasive powder in these small lamps and scrub off the blackening periodically as in the case of

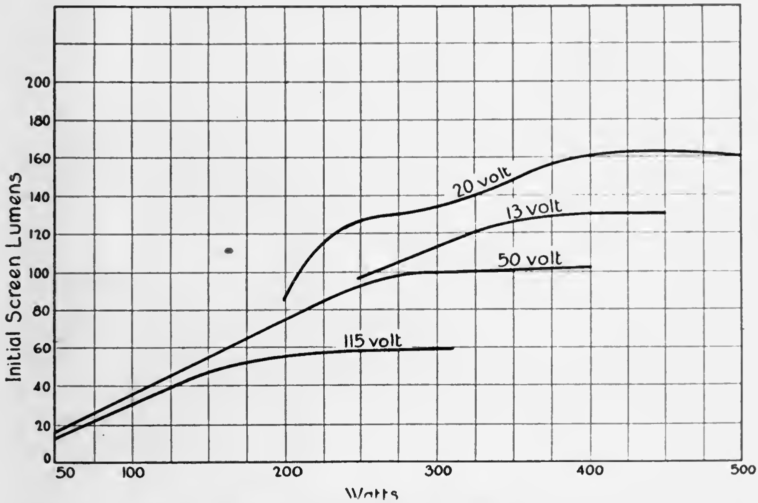

FIG. 2. Relation of screen illumination to watts and volts with coiled filament Mazda lamps in a 16 mm. optical system.

the large lamps used in studio illumination. The reason is that in the case of the T-10 bulb, the filament is so close to the glass that the tungsten deposit is burned into it. Water cooling of the lamp would permit cleaning off the blackening in this manner, but would involve auxiliary apparatus that would increase the bulk of the projector, as well as its expense.

Fig. 4 shows typical candle-power maintenance curves for different wattages in the T-10 bulb. From this it can be seen that the candle-power maintenance of a 250 watt T-10 bulb lamp is none too excellent. Higher wattage in this bulb causes the illumination to fall off so rapidly that the lamp performance cannot be considered satisfactory.

At 250 watts, the 20 volt rating gives highest illumination results as is indicated in the curve of Fig. 3. No further advantage is obtained by a lower voltage, higher current rating at this wattage, chiefly because of end cooling losses.

Table I gives screen illumination values obtainable from lamps now available for this service. These data were taken without a rotary shutter in the path of the light beam. As is shown in Fig. 2, higher illumination can be obtained than that with the 250 watt

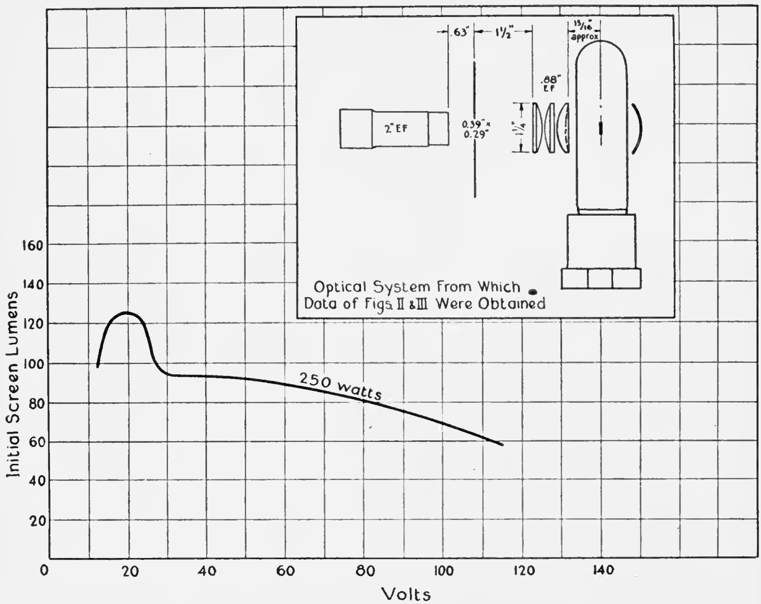

FIG. 3. Relation of screen illumination to volts with 250 watt lamps in a 16 mm. optical system.

20 volt rating, approximately 30 to 40 per cent more, but the filament to give it must be housed in a larger bulb.

The use of low voltage, high current lamps practically necessitates transformer operation. Aside from the poor economy of great wattage loss in a rheostat, dissipation of the heat would be a major problem. Since d.c. districts are sometimes encountered, it may be found necessary to provide projectors equipped for transformer operation of a low voltage lamp with a change-over switch which would disconnect the socket from the secondary of the transformer, connect it directly to the line, disconnect the primary of the transformer, and thus permit the use of a 115 volt lamp on direct current. This feature would be required only on those equipments which are

TABLE I

Initial Screen Illumination Values in Two 16 Mm. Optical Systems

Lamp	Screen Lumens	Screen Lumens
	Spherical Condensing System $1^1/_4''$ in Diameter with 0.88″ EF	Aspheric Condensing System $1^3/_4''$ in Diameter with 1.055″ EF
50 watt, 115 volt, T-8 bulb	15	22
100 watt, 115 volt, T-$8^1/_2$ bulb	32	45
200 watt, 115 volt, T-10 bulb	58	76
250 watt, 50 volt, T-10 bulb	14	132
250 watt, 20 volt, T-10 bulb	125	172

Data are with spherical mirrored reflector and without rotary shutter in path of light beam. Aperture—0.39″ × 0.29″; objective—2″ EF, having rear opening of 0.79″, front opening of 0.97″.

to be transported about the country. Another advisable precautionary measure with transformer equipment is that of providing a fuse in the circuit to the primary of the transformer which would insure against transformer burn-out in case of accidental connection to a d.c. circuit.

To meet variations in circuit voltages, transformers may be designed to supply the correct secondary voltage for the lowest circuit voltage one is likely to encounter. A small variable rheostat in the primary can correct for the higher circuit voltages encountered. The range to provide for is about 100 to 125 volts. Provision of primary taps is of course another means of taking care of the range of circuit voltages. To guide the adjustment to the particular circuit voltage, it is best to provide a voltmeter across the secondary terminals of the transformer. The voltmeter should preferably be so marked that when the needle exceeds the lamp voltage, it falls on a warning of the consequences, that is, more light, but at the expense of lamp life. A similar warning below the voltage of the lamp could indicate that light is being sacrificed.

The relation between voltage and lamp life is often not appreciated by users of the non-professional projectors. Projector lamps are designed for an average life of 50 hours. An over-voltage of five per cent cuts the life in half, and an over-voltage of 10 per cent approximately quarters the life. The low voltage, high current lamps operate at a temperature which is close to the melting point of tungsten. Therefore over-voltage is more apt to cause trouble. These facts also emphasize the importance of providing a voltmeter, and a variable rheostat or primary taps with transformer operated equipments.

Before concluding a paper on this question we feel it would be very pertinent to include some thoughts about the optical system apart from the lamp itself. Equipment manufacturers naturally

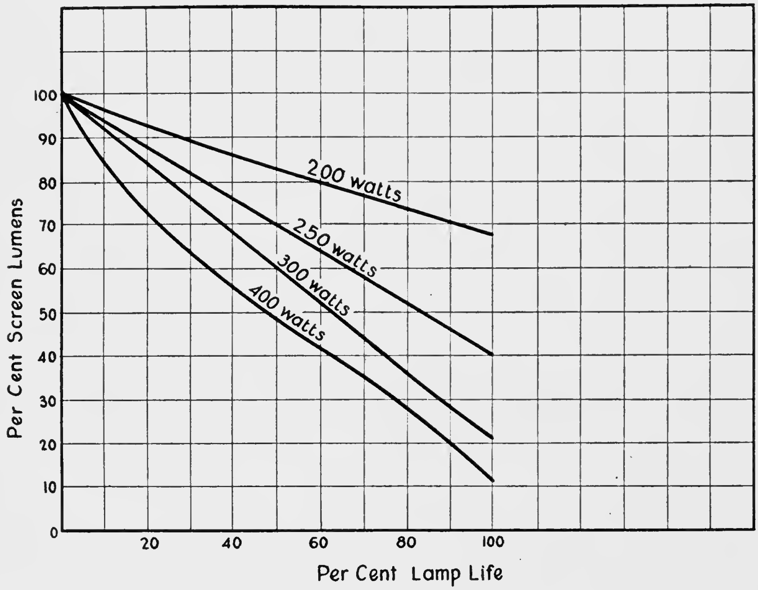

FIG. 4. Typical candle-power maintenance curves showing variation in screen illumination throughout life with T-10 bulb lamps in a 16 mm. optical system.

look to the lamp for improvement in illumination; however, to our knowledge, no commercial equipment employs the optimum optical system. The best optical system we have encountered, that using a small aspheric condensing system designed for 16 mm. projectors, utilizes 2.6 per cent of the total light emitted by the source of the 250 watt 20 volt lamp. Some commercial systems use considerably less than one per cent of the light from the lamp. Therefore great illumination improvements may be made with no change in lamps. Before making available an optimum lamp, a higher wattage type than any at present employed for this service, and which of itself necessitates a change in optical system design due to its larger bulb, we hope to have the coöperation of equipment manufacturers in building the best possible optical system around that lamp.

ABSTRACTS

The Editorial Office will welcome contributions of abstracts and book reviews from members and subscribers. Contributors to this section are urged to give correct and complete details regarding the reference. Items which should be included in abstracts are:

Title of article
Name of author as it appears on the article
Name of periodical and volume number
Date and number of issue
Page on which the reference is to be found

In book reviews, the following data should be given:

Title of book
Name of author as it appears on the title page
Name of publishing company
Date of publication
Edition
Number of pages and number of illustrations

The customary practice of initialing abstracts and reviews will be followed.

The Abstracts in this issue are taken from the Monthly Abstract Bulletin of the Kodak Research Laboratories.

Limits of Luminous Yield in Motion Picture Projection. H. Joachim and H. Schering. *Sci. ind. phot.*, **1**, March, April, 1930, pp. 115, 153. For several years attempts have been made to increase the radiation reaching the screen because of the larger screen used and because of the smaller percentage of reflecting surface of the sound screens. Increased illumination has been accomplished partly by concave mirrors and lenses without an increase in current to the arc, and partly by increasing the current itself. The efficiency increases with increase in the solid angle subtended by the condenser, provided the image just fills the projector aperture. With reflecting mirrors it is necessary to decrease the effect of the shadows cast by the carbons. The objective should make use of all the light coming from the condenser.—*Kodak Abstr. Bull.*

Disk Development: Micro Recording on Durium. *Bioscope* (*Mod. Cinema Technique*), **84,** July 2, 1930, p. iv. Sound records on Durium, a new synthetic resin,invented by Professor Bean, of Columbia University, will shortly be available as a result of experiments carried out in conjunction with Warner Brothers. Advantages claimed include pliability, excellence of tone, and good wearing qualities. The micro disk is a record with several hundred grooves to the inch. A 16-inch record will play for one hour and twelve minutes. A special pick-up has been designed.—*Kodak Abstr. Bull.*

Application of the Principles of Television in Roentgenology: The Radiophot. A. Dauvillier. *Amer. J. Roentgenol.*, **24,** July, 1930, p. 111. (From

Fortschr. a. d. Geb. d. Röntgenstr., **40,** 638, October, 1929.) A lead scanning disk rotates between the Roentgen source and the object to be examined, and the rays traversing the small holes in the disk are received by a large sensitive ionization chamber serving as a detector. The ionization current amplified, controls the intensity of the light transmitted through an optical scanning disk and thereby reproduces in ordinary light the original Roentgen ray image.—*Kodak Abstr. Bull.*

Progress of X-Ray Motion Pictures. V. GOTTHEINER AND K. JACOBSOHN. *Kinotechnik*, **12,** June 20, 1930, p. 336. Motion pictures of the human chest, throat, and mouth by means of X-rays, have been made possible by a special fluorescent screen, a special camera, a special objective lens, and a highly sensitive film. Although the objective operates at $f/1.25$, it is made from only two cemented elements to reduce losses by reflection and absorption. It is said to give pictures sufficiently sharp for the purpose. The X-ray tube permits pictures tó be taken for as long as 25 seconds at a time.—*Kodak Abstr. Bull.*

New Photoelectric Cell. *Amer. Projectionist*, **8,** May, 1930, p. 9. This cell is the invention of Dr. B. Lange of the Kaiser Wilhelm Institute for Silicate Investigation, Berlin. The new cell consists of a layer of copper oxide between two layers of metallic copper, one of which is so thin as to be almost transparent. The light falls on one of the thin copper layers and the electrons given off pass through the very thin copper oxide layer, and on reaching the other layer of copper, an electric current results. It is said that the cell operates with very little lag, does not show fatigue as does the ordinary type, and can be operated indefinitely without loss of efficiency and much greater sensibility to the infra-red waves.—*Kokak Abstr. Bull.*

New Training Device. *Bioscope* (*Mod. Cinema Technique*), **83,** June 11, 1930, p. vii. The Western Electric Company is training its engineers to detect the lack of certain frequency bands in sound reproductions. A sound film is projected on the screen and the instructor by means of a key system operates a filter which cuts out a frequency band and simultaneously indicates on a board the frequencies lacking. After experience the engineers are required to estimate without the help of the indicator board exactly what frequency bands are absent in a test audition.—*Kodak Abstr. Bull.*

Photographing Sound Conditions. P. B. BRAYTON. *Ex. Herald-World*, **99,** May 10, 1930, p, 39. The contour plan of the theater auditorium, walls, or ceiling is laid out with a flexible strip of metal, about one-half inch wide, on a white table top. A light source is placed in a position representing the stage or screen. The camera is positioned vertically above the table. Reflections show up as white streaks and are stated to simulate sound waves. Non-reflection surfaces are produced by blackening the metal strip and partially reflecting surfaces by covering with a non-reflecting grating.—*Kodak Abstr. Bull.*

Apparatus for Photographing Growing Plants in Their Natural Color. H. C. RICKER. *Amer. Phot.*, **24,** July, 1930, p. 352. Use is made of the amateur standard motion picture in connection with Kodacolor film for photographing growing plants and microörganisms. For stop motion pictures, the camera and lights are controlled automatically by means of a timed contact disk which, through a relay, operates a master rotary switch, thereby turning on light and tripping the camera.

The camera speed is eight frames per second. When used for stop motion work, the individual frame receives about twice as much exposure as when running continuously. This extra time given the first frame serves well in Kodacolor work, and for black and white pictures the lens can be stopped down two points, affording the use of a x4 filter. The light used is a 500 watt incandescent with a reflector. Illustrations are given.—*Kodak Abstr. Bull.*

BOOK REVIEWS

See and Hear. W. H. Hays. New York, *Motion Picture Producers and Distributors of America*, 1929, 63 pp. In this small book is presented a concise and yet quite complete story of the growth of the motion picture industry from the days before the advent of the "nickelodeon" through the introduction and acceptance of the sound picture. A review is included of the departmental activities of the Motion Picture Producers and Distributors of America. Credit is given the engineer for his contribution of devices which have made possible the sound motion picture. A closing chapter predicts a greater expansion and further perfection of sound in conjunction with pictures, and the ultimate adoption of a larger screen giving more realistic perspective to the projected picture.—*Kodak Abstr. Bull.*

Sound. A. James and J. A. Archer, editors. New York, *Ex. Daily Rev.*, $2.00, 210 pp. Several well-known executives and technical workers have contributed short articles to this special edition of the Exhibitors' Daily Review and Motion Pictures Today. Subjects discussed include among others: an historical review of commercial sound picture production, problems of the sound director, recording difficulties, sound news reels, theater installations and acoustic problems, make-up of the program, and fundamentals of projection. One author feels that the universal appeal of the motion picture will be lost with the production of sound, unless the vital parts of plot action are not spoken, but are expressed in pantomime. Greater experience in the use of sound in theaters with improved acoustic conditions is considered by another authority, before the best from sound pictures will have been fully realized. An outline is given of the new laboratory technic required in the development of variable density sound films. Lists of theaters wired for sound pictures in 1929, features released, names of studio personnel, and description of new equipment are included in this volume.—*Kodak Abstr. Bull.*

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PRESIDENTIAL ADDRESS*

The rapid rate at which time flies has been brought home to me more forcibly than ever during the past year. Starting out with many objects to achieve, even by working overtime with a crew of willing workers, it has been possible to accomplish only a fraction of those which I had in mind when I became chief executive of this important technical Society.

The change-over from the publication of our quarterly *Transactions* to a monthly JOURNAL was effected smoothly under the capable editorship of Mr. L. A. Jones. This was a distinct milestone in the progress of the Society because it permitted a more prompt publication of papers of immediate interest, and likewise the publication of papers not presented at our conventions, while our members have been kept in closer touch with the activities of the Board of Governors and the various sections through the medium of the "Society Notes."

The main reason for the existence of our Society is the advancement of knowledge and interchange of ideas by publication. The JOURNAL is the backbone of our Society. Our value to the Industry and mankind is in direct proportion to the quality and quantity of the contents of our JOURNAL and upon the wideness of its distribution.

As measured by this yardstick, the Society is progressing in a creditable manner. The size of the October issue of the JOURNAL was about 50 per cent larger than that of the January issue and its circulation is about 1000 copies, 180 of which are for non-member subscriptions. Our membership continues to grow in a satisfactory manner and has increased from 600 to 800 in the past year as a result of the energetic efforts of the Membership Committee under the chairmanship of Mr. H. T. Cowling.

As the Society has grown, however, the burden of work involved in conducting the offices of the Secretary and Treasurer and of editing the JOURNAL has become such that the Society can no longer expect to receive this work from any individual as a labor of love.

* Read before the Society at New York, October, 1930.

The labor involved in carrying out the activities of many of the committees is tremendous and realizing this, your Board of Governors decided to appoint a paid officer with headquarters in New York City to supervise the editing of the JOURNAL, conduct the routine work incidental to the offices of Secretary and Treasurer, assist the various committees and, in fact, coördinate more closely the various activities of the Society.

The Solicitations Committee acquired sufficient additional income through the medium of sustaining memberships to justify the Board's proceeding with the appointment. The position was advertised in the JOURNAL and trade papers and over 60 applications were received which were reviewed by a special committee which reported to the Board of Governors. The Board hopes to be in a position to make a definite appointment before the conclusion of our sessions.

Our finances are in a sound condition, thanks to the watchful guardianship of our treasurer, Mr. W. C. Hubbard, but unfortunately the Board was unable to persuade him to accept nomination to this office for the ensuing year. The Society is greatly indebted to Mr. Hubbard for his untiring efforts for many years in the interests of the Society.

The various sections of the Society in London, New York, Hollywood, and the recently formed section in Chicago are performing a valuable service in providing means for local discussion on technical matters and contributing papers to our JOURNAL. The London Section with 100 members has been the most active and has held biweekly meetings throughout the season. The enthusiasm and efforts of the London Section are reflected in the high quality of some of the recent films turned out by the British Studios. There is some danger of duplication of effort on the part of the Pacific Coast Section and the Technical Bureau of the Academy of Motion Picture Arts and Sciences and plans are in progress between the two organizations for a closer coördination of effort.

The standing committees have worked consistently, especially the Convention, Progress, Standards and Nomenclature, and Projection Committees. The report of the Progress Committee is recognized by the trade as one of the outstanding contributions of the Society and is eagerly published by the press. The Standards Committee has published a booklet of standards adopted and recommended practice which contains dimensional standards for 35, 28, and 16 mm. film, sprockets, splices, aperture plates, dimensions of sound track, *etc.* These have been approved by the American Standards Association. This committee has also made a Herculean effort to arrive at a standard for wide film and a detailed account of this work will be presented to you at this session.

There are mountains of work ahead with many avenues leading to greater service to the Industry. With the establishment of a centralized office and paid managerial and editorial assistance whereby the officers of the Society will be relieved of burdensome details, it will be possible to devote more time and thought to ways and means of extending the usefulness of the Society to the Industry, to foster the work of the sections and the various committees, to conduct the paper programs at the conventions with more showman-like precision, to publish and circulate abstracts of papers and committee reports in advance of the meetings, to expand the distribution of the JOURNAL, to establish coöperative relations with other organizations whose field of interest adjoins ours, to arrange for organized speakers' service for our sections, and to induce the universities to establish courses of instruction in motion picture engineering.

During the past year the Society has lost by death two of its outstanding members, Professor William H. Bristol of the Bristol Studios and Mr. John J. Lyng, Vice-President of the Electrical Research Products, Inc. Their deaths are not only a loss to the Society but to the entire Industry.

In conclusion, I wish to express thanks to the Secretary, Treasurer, the various committee chairmen, the Members of the Board who have given unsparingly of their time and energy in conducing the business of the Society, and to all those who have labored without glory.

SOCIETY NOTES

Local Sections.—None of the sections have held technical meetings during the past month.

Meeting of the Board of Governors.—At the Board meeting held at the Hotel Pennsylvania, New York, N. Y., September 22nd, a large number of business matters were transacted including the following:

(1) Resolved that the resignation of the chairman of a local section from the Board of Governors can only become effective upon resignation as chairman of the section.

(2) Replying to an invitation from the London Section to hold the fall convention of 1931 in London, it was resolved that this would be impossible since the Board has recommended that the Society meet in Hollywood during the spring of 1931 and it would not be desirable for the Society to meet in two such widely separated localities during the same year.

(3) Resolved that the By-Laws should be changed to permit of a quorum consisting of a majority of the elected members of the Board. There are now four Board members who obtain their positions automatically by virtue of their election as section chairmen. In view of the frequent impossibility of attendance by section chairmen, it has been difficult invariably to insure a quorum of eight members. Under the new ruling a majority of the Board would consist of six elected members.

(4) Resolved that Section 3, By-Law 7, be changed to read: "Nine dollars of the members' dues shall be applied for annual subscription to the monthly publication." This is a formality to conform with the requirements of the Post Office Department to insure second class postage privileges in connection with the JOURNAL.

(5) Resolved that if any member of the Board objects to an application for the grade of Active membership the Board must then be re-circulated at which time these objections should be clearly outlined to each Board member and a new vote taken. If the vote shows that a majority of the Board approves of the applicant's qualifications, he is thereby elected to membership.

(6) Resolved that all non-member authors of papers appearing in the JOURNAL shall be given, free of charge, three copies of the issue in which their paper appears.

The Board received the report of the special committee appointed to investigate the various applications for the position of editor-manager of the Society but no definite appointment was made at that time.

The President appointed a committee to report on the location of suitable headquarters for the Society in New York City.

At the invitation of the President, Mr. Cowan, Manager of the Technical Bureau of the Academy of Motion Picture Arts and Sciences, outlined some of the technical activities of the Academy in Hollywood and discussion followed regarding ways and means for closer coördination of the efforts of the Academy and the Society.

At Board meetings held on October 19th and October 23rd, respectively, at the Hotel Pennsylvania, New York, N. Y., the following matters were transacted:

(1) A number of prospective candidates for the position of editor-manager of the Society were interviewed and by a unanimous vote of the Board Mr. Sylvan Harris received the appointment at a salary of $6000 per year.

(2) A committee consisting of Secretary J. H. Kurlander and Mr. M. W. Palmer was authorized to engage office space in the Aeolian Building, 33 West 42nd Street, New York, N. Y., at terms of $1800 per year for three years for 600 square feet of space.

(3) The Secretary reported that second-class mailing privileges for the JOURNAL had been secured from the Post Office Department.

(4) It was resolved that a section of the JOURNAL be devoted to technical activities of the Academy of Motion Picture Arts and Sciences. The President was authorized to communicate with the Academy, asking their collaboration in the way of supplying the editor-manager with an official record of the activities of the Academy.

(5) No action was taken on a communication from the Historical Committee recommending that honorary membership be granted to Messrs. Eugene Augustin Lauste and Jean Acme LeRoy.

(6) Resolved that the booklet "Standards Adopted by the Society of Motion Picture Engineers" be distributed gratis.

(7) Resolved that the Society take up membership in the American Standards Association and the National Fire Protection Association.

The Editor-Manager.—Mr. Sylvan Harris, the newly appointed editor-manager of the Society, was formerly in the Research Department of the Fada Radio Corporation and before joining the Fada Corporation was managing editor of Radio News and served for several years as director of radio research for the Stewart Warner Corporation.

He is a member of the Radio Institute of Engineers, American Institute of Electrical Engineers, American Physical Society, Optical Society of America, and Radio Club of America, and is a graduate in Electrical Engineering from the University of Pennsylvania.

Mr. Harris' chief duties will be to edit the JOURNAL and carry on the routine work of the offices of the Secretary and Treasurer. He will be located at the Society headquarters.

New Headquarters for the Society.—Official headquarters of the Society are room 701, 33 West 42nd Street, New York, N. Y. When in New York City members are invited to visit the Society headquarters and call upon Mr. Harris for any information relating to the activities of the Society.

The Fall Meeting.—The fall meeting of the Society was held at the Hotel Pennsylvania, New York, N. Y., October 20th–23rd, inclusive.

The convention was called to order on Monday morning, October 20th, and the members welcomed by Major Edward J. Bowes, Managing Director of the Capitol Theatre, New York, N.Y. An extensive and interesting series of technical papers was presented during the four days' sessions which were well attended.

Some of the outstanding features of the papers sessions were open discussions on "Methods of Securing a Large Screen Picture" and "Advantages and Disadvantages of Placing Sound and Picture on Separate Films." A complete record of these discussions will appear in a future issue of the JOURNAL.

On Monday afternoon examples of the following color processes were projected: Sennettcolor, Multicolor, Harriscolor, Photocolor, and Colorcraft. This demonstration was arranged by Mr. W. V. D. Kelly, chairman of the Color Committee.

Excellent facilities were available for the projection of sound films made possible through the courtesy of the Electrical Research Products, Inc. Mr. H. Griffin was in charge of projection and the services of the projectionists were donated by Local No. 306 to which the Society is indebted.

On Monday evening, October 20th, a motion picture entertainment was presented for the benefit of members and guests of the Society. The feature pictures were: *Play Boy of Paris*, courtesy of the Paramount Publix Corporation, and *The Big Trail*, courtesy of the Fox Film Corporation.

The banquet on Wednesday evening, October 22nd, was in honor of the producers. President Crabtree outlined the aims and accomplishments of the Society and introduced Dr. A. N. Goldsmith, Vice-President of the Radio Corporation of America, and Mr. H. B. Charlesworth, Vice-President of the Bell Telephone Laboratories, Inc., as member engineers representing large research organizations. Mr. Will Hays, President of the Motion Picture Producers and Distributors of America, Inc., then introduced the various producers, including Messrs. J. Lasky, J. E. Otterson, C. J. Ross, H. G. Knox, L. E. Thompson, Paul Gulick, and L. I. Monosson. The Russian director, Mr. Serge Eisenstein, and the star of *The Big Trail,* Mr. John Wayne, also spoke briefly.

On Thursday, October 23rd, the technical sessions were held in the auditorium of the Bell Telephone Laboratories and the members were given a demonstration of two-way television. On Thursday afternoon special trips through the laboratories were arranged, including demonstrations of binaural hearing, automatic call announcing, *etc.*

President Crabtree donated a prize to the author making the most effective paper presentation during each day of the convention. The winners were Mr. James McGuiness for his paper entitled "Scenarios for Sound Pictures;" Dr. A. N. Goldsmith for his description of "An Entertainment City;" Mr. J. B. Taylor for "Some Observations on Stereoscopic Projection;" and Mr. F. F. Lucas for his description of "The World's Most Powerful Microscope."

An amendment to By-Law No. 7, Section 3, was approved by the membership to read as follows: "Nine dollars of the dues shall apply for annual subscription to the monthly publication."

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