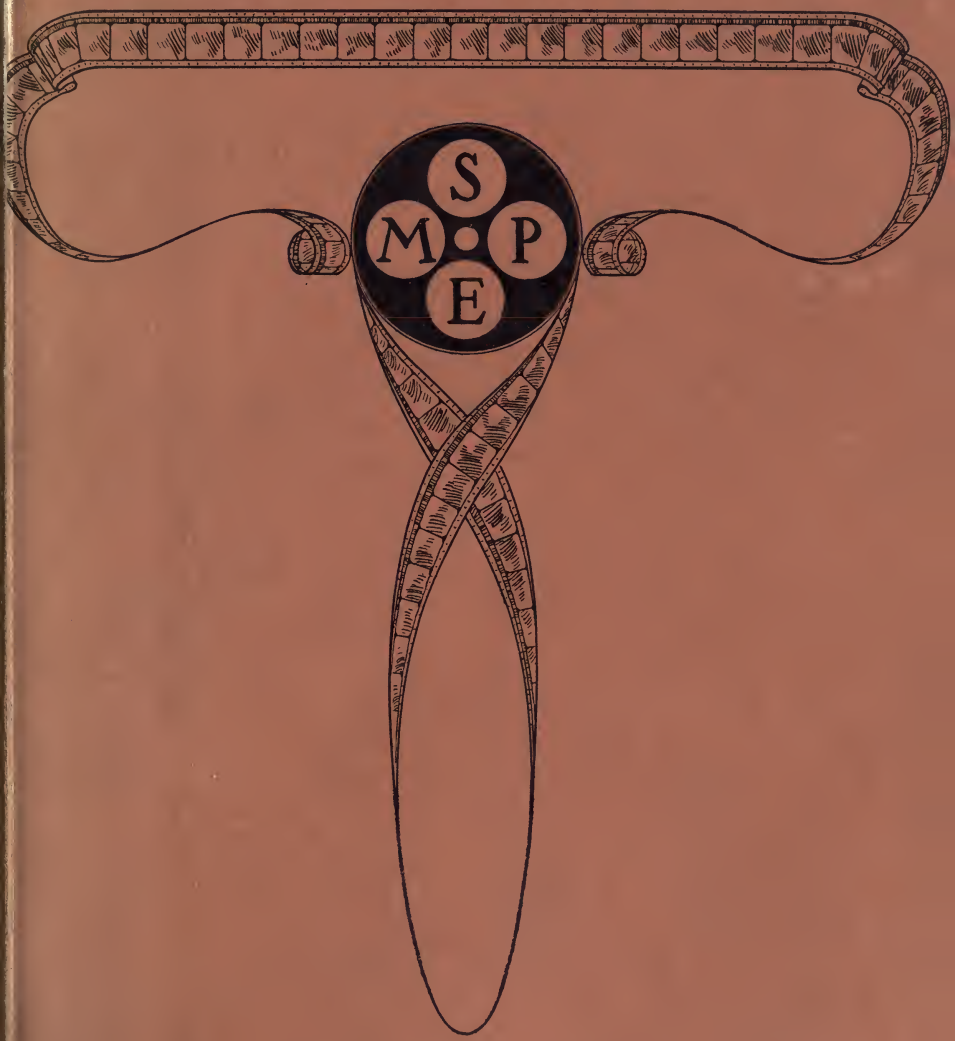
B. E. STECHBART

VOL. XVI NO. 1

JOURNAL

OF THE SOCIETY OF

MOTION PICTURE ENGINEERS



JANUARY, 1931

PUBLISHED MONTHLY BY THE
SOCIETY OF MOTION PICTURE ENGINEERS

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.

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OF THE SOCIETY OF

MOTION PICTURE ENGINEERS

SYLVAN HARRIS, EDITOR

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OF THE SOCIETY OF
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SYLVAN HARRIS, EDITOR

Published monthly at Easton, Pa., by the Society of Motion Picture Engineers

Publication Office, 20th & Northampton Sts., Easton, Pa.
General Office, 33 West 42nd St., New York, N. Y.

Subscription to non-members $12.00 per year; to members $9.00 per year; single copies $1.50. Order from the Society of Motion Picture Engineers, Inc., 20th and Northampton Sts., Easton, Pa., or 33 W. 42nd St., New York, N. Y.

Entered as second class matter January 15, 1930, at the Post Office at Easton, Pa., under the Act of March 3, 1879.

CONDENSER AND CARBON MICROPHONES—THEIR CONSTRUCTION AND USE*

W. C. JONES**

Summary.—Of the numerous microphones which have been developed since Bell's original work on the telephone, only two are used extensively in sound recording for motion pictures, namely, the condenser microphone and the carbon microphone.

The condenser microphone was first proposed in 1881 but owing to its low sensitivity was limited in its field of usefulness until the development of suitable amplifiers. In 1917 E. C. Wente published an account of the work which he had done on a condenser microphone having a stretched diaphragm and a back plate so designed as to introduce an appreciable amount of air damping. The major portion of the condenser microphones used today in sound recording embody the essential features of the Wente microphone. Marked progress has, however, been made in the design and construction of these instruments with the result that they are not only more sensitive but also more stable. The factors which contribute to this improvement are described in detail in this paper. Recently a number of articles have appeared in the technical press calling attention to certain discrepancies between the conditions under which the thermophone calibration of the condenser microphone is made and those which exist in the studio. The nature of these discrepancies and their bearing on the use of the microphone are discussed.

Microphones in which the sound pressure on the diaphragm produces changes in the electrical resistance of a mass of carbon granules interposed between two electrode surfaces have been used commercially since the early days of the telephone. In recent years the faithfulness of the reproduction obtained with the carbon microphone has been materially improved by the introduction of an air damped, stretched diaphragm and a push-pull arrangement of two carbon elements. This instrument is finding extensive use in sound recording and reproduction fields where carbon noise is not an important factor. The outstanding design features of the push-pull carbon microphone are described in this paper and suggestions made as to the precautions to be taken in its use if the best quality, maximum life, etc., are to be obtained.

Of the numerous microphones which have been developed since Bell's original work on the telephone, only two are used extensively in sound recording for motion pictures, namely, the condenser microphone and the carbon microphone. It has, therefore, been suggested that it would be fitting to review at this time the construction of these instruments and consider some of their transmission char-

* Presented at the Fall 1930 Meeting, New York, N. Y.

** Bell Telephone Laboratories, Inc., New York, N. Y.

acteristics and the precautions which should be exercised in their use.

Condenser Microphone.—In 1881 A. E. Dolbear[1] proposed a telephone instrument which could be used either as an electrostatic microphone or receiver. This instrument consisted of two plates insulated from one another and clamped together at the periphery. The back plate was held in a fixed position whereas the front was free to vibrate and served as a diaphragm. It is obvious that if the diaphragm were set in vibration by sound pressure, the electrical capacitance between the two plates would be changed in response to the sound waves, and if a source of electrical potential were connected in series with the instrument a charging current would flow which would be a fairly faithful copy of the pressure due to the sound wave. Apparently Dolbear realized that the current developed in this way would be minute, for in the telephone system which he proposed as a substitute for the one using Bell's magnetic instruments he employed the electrostatic instrument only as a receiver and adopted the loose contact type of microphone. At approximately the same time an article appeared in the French press[2] calling attention to the use of a condenser as a microphone and commenting on the fact that this type of microphone had been found to be less sensitive than the loose contact type.

Owing to the low sensitivity of the condenser microphone, the field of usefulness of this instrument was extremely limited for a number of years and it did not assume a position of importance among the instruments used in acoustic measurements and sound reproduction until suitable amplifiers had been developed. The development of the vacuum tube amplifier, however, filled this need. In 1917 E. C. Wente[3] published an account of the work which he had done on an improved condenser microphone having a stretched diaphragm and a back plate so located relative to the diaphragm that, in addition to serving as one plate of the condenser, it added sufficient air damping to reduce the effect of diaphragm resonance to a minimum[4]. The response of this instrument was sufficiently uniform over a wide range of frequencies to make it not only useful in high quality sound reproduction but a valuable tool in acoustic measurements in general.

The major portion of the condenser microphones used today in sound recording embody the essential features of the Wente microphone. Marked progress has, however, been made in the design

and construction of these instruments since the initial disclosure and it will no doubt be of interest to many to consider briefly the nature of this advance.

In the early microphones employing air damping the diaphragm was composed of a thin sheet of steel which was stretched to give it a relatively high stiffness. When assembled in the microphone the stiffness was further increased by that of the air film between diaphragm and the damping plate with the result that the resonant frequency was well above the frequencies which it was desired to transmit and the diaphragm vibrated in its normal mode over a wide frequency range. In such a structure the mechanical impedance for

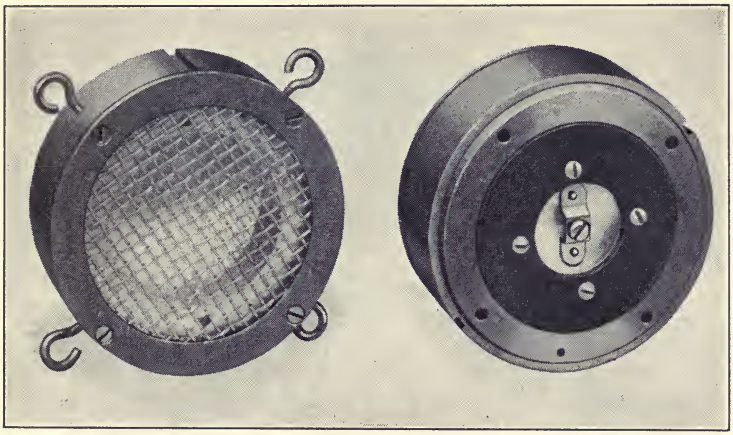

FIG. 1. Western Electric Company's 394 type condenser microphone.

frequencies below resonance is due almost entirely to stiffness reactance. Hence a constant sound pressure produces substantially the same displacement of the diaphragm at all frequencies within this range and uniform response results except at the very low frequencies where an appreciable reduction in the stiffness of the air film occurs. The effective mass of a steel diaphragm is, however, relatively large and necessitates a comparatively high stiffness to secure the desired resonant frequency. From the standpoint of securing maximum sensitivity of the microphone, *i. e.*, displacement of the diaphragm per unit force, it is of course important to make the stiffness as low as possible and employ as small a value of mechanical resistance as is consistent with the degree of damping required.

An improvement in both respects can be effected by decreasing the mass of the diaphragm, for with a reduced mass a given resonant frequency can be obtained with lower values of stiffness and the desired damping constant secured with less mechanical resistance.

The aluminum alloys have therefore replaced steel in the diaphragms of most of the condenser microphones in use today. A typical example of such a microphone is the Western Electric Company's instrument (394 type) shown in the photograph, Fig. 1, and the cross-sectional view, Fig. 2. The diaphragm of this instrument is made from aluminum alloy sheet 0.0011 inch in thickness. The

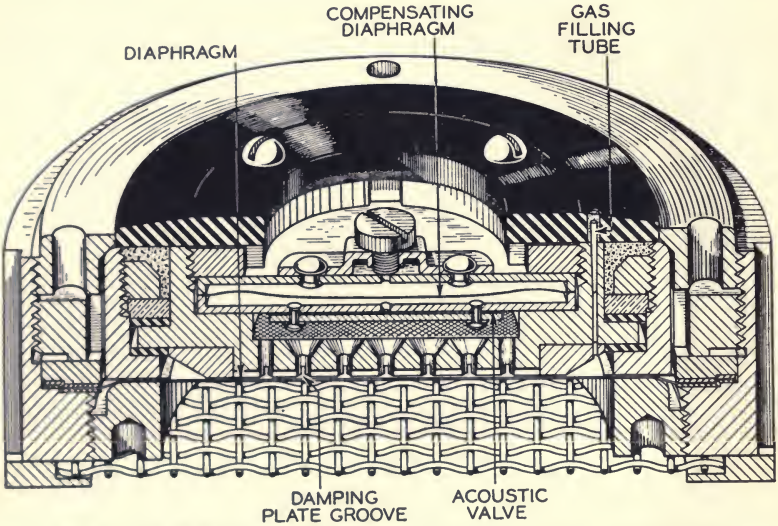

FIG. 2. Cross-sectional view of the 394 type condenser microphone.

edges are clamped securely between threaded rings, gaskets of softer aluminum being provided to prevent damage at the clamping surfaces. The requisite stiffness is obtained by advancing the stretching ring until a resonant frequency of 5000 cycles is obtained. The method of determining the resonant frequency of the diaphragm is as follows. The diaphragm assembly to be tested is coupled to a condenser microphone which is provided with a suitable circuit for measuring its output. A special telephone receiver is placed in contact with the diaphragm on the side opposite to the coupler. Current from a vacuum tube oscillator is then passed through the winding of the receiver, setting up eddy currents in the diaphragm under test.

The forces which are developed as a result of the reaction of the magnetic field produced by the eddy currents and that of the permanent magnet of the receiver set the test diaphragm in motion. The resonant frequency is determined by noting the frequency at which the output from the condenser microphone is a maximum.

In the early Wente microphone the damping plate was a continuous surface. Subsequent work by I. B. Crandall[5] showed that the required amount of damping at the resonant frequency could be obtained without adding unduly to the impedance at other frequencies by cutting grooves in the plate. This reduced the stiffness introduced by the air film and decreased the irregularity in response at low frequencies previously mentioned. The grooves in the damping plate of the Western Electric Company's 394 type microphone are cut at right angles. Holes, tapered at the outer end to reduce resonant effects, are bored through the plate at the intersection of the grooves to form connecting passages between the air film at the front and the cavity at the back. In order to prevent the resonance which would result if the grooves extended into the portion of the chamber surrounding the damping plate, the outer ends are closed by an annular ring which is pressed over a shoulder on the plate. The surface of the damping plate is plane within 8×10^{-5} inch. The departure from a plane in any individual case is determined commercially by the interference pattern developed when an optically flat plate is placed over the damping plate under test.

A duralumin spacing ring 0.001 inch in thickness separates the damping plate from the diaphragm. It is essential that all dust and dirt be excluded from this space. To prevent foreign material from entering through the holes in the plate a piece of silk is fastened over the outer surface. The assembly of the diaphragm and damping plate is made in a dust-proof glass cabinet.

If the back wall of the condenser microphone were rigid, changes in the separation between the damping plate and the diaphragm of sufficient magnitude to affect not only the sensitivity of the instrument but also its frequency response characteristic would result from variations in barometric pressure. Complete compensation for these changes in pressure can only be obtained by permitting free interchange of air between both sides of the microphone diaphragm. This is, however, objectionable owing to the fact that sufficient moisture is likely to be introduced to start corrosion and affect the insulation between the damping plate and the diaphragm.

A compensating diaphragm of organic material has therefore been introduced which prevents this undesirable effect of humidity but is sufficiently low in stiffness to equalize the changes in pressure encountered in the normal use of the microphone.

In order to prevent transmission losses at voice frequencies due to the presence of the compensating diaphragm, an acoustic valve is inserted between the damping plate and this diaphragm. This valve consists of a disk of silk clamped between two aluminum plates of unequal diameters. Gas in passing from the damping plate to the compensating diaphragm moves laterally from the edges of the smaller plate through the silk to a hole in the center of the larger plate. The impedance of this path is high at voice frequencies but low enough

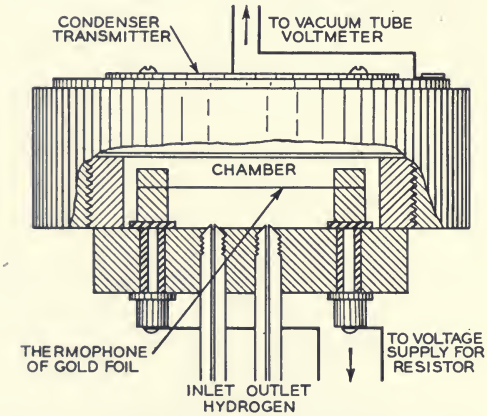

FIG. 3. Cross-sectional view of the thermophone and the condenser microphone.

for steadily applied pressure differences to permit compensation for changes in barometric pressure.

After the damping plate and diaphragm are assembled the space between the clamping rings is filled with beeswax to make the joints gas-tight and exclude moisture. A hole is, however, provided for filling the microphone with nitrogen. The purpose of the nitrogen is to prevent corrosion of the damping plate and diaphragm surfaces and eliminate any reduction in pressure due to oxidation of the sealing compound.

It has been customary for some time to determine the response characteristics of a condenser microphone by the thermophone method.[6] In making this measurement the diaphragm of the micro-

phone is coupled acoustically to the thermophone in the manner shown in Fig. 3. The thermophone consists of two strips of gold foil which are mounted on a plate and fit into the recess in the front of the microphone. Capillary tubes are provided for filling the space enclosed between the plate and the microphone diaphragm with hydrogen. This is done in order to make the wave-length of the sound developed in the recess as large as possible compared with dimensions of the chamber. If this were not the case the sound pressure at different positions in the chamber would not be in phase and the conditions on which the computations of the magnitude of the sound pressure are based would not be met. A direct current of known value is passed through the foil. Super-imposed upon the direct current is an alternating current of the desired frequency which causes fluctuations in the temperature of the foil and in the gas immediately surrounding it. These fluctuations in temperature in

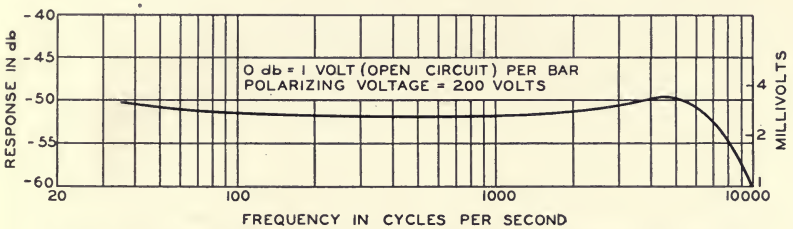

FIG. 4. Pressure calibration of the 394 type condenser microphone.

turn cause changes in the pressure on the microphone diaphragm. The magnitude of the pressure developed on the diaphragm can be computed from the constants of the thermophone and the coupling cavity, and the voltage developed by the microphone for a given pressure determined with suitable measuring circuits.[7] Obviously, such a calibration affords a measure of the response of the microphone in terms of the actual pressure developed on the diaphragm and is independent of the external dimensions of the instrument. Hence, it does not take into account any effect which the microphone may have on the sound field when used as a pickup instrument for recording or broadcasting purposes. The thermophone calibration is often referred to as a "pressure" calibration and the response obtained by placing the instrument in a sound field of constant pressure, a "field" calibration. A thermophone calibration of a representative Western Electric 394 type condenser microphone is shown in Fig. 4.

For many of the uses to which the condenser microphone is put, for example, the calibration of head type telephone receivers, the conditions under which it operates agree with those under which the thermophone calibration is made. There are, however, cases where this agreement does not exist, for when a microphone is inserted in a sound field of uniform intensity the pressure on the diaphragm may depart rather widely from a constant value in certain frequency ranges. Several articles[8] have recently appeared calling attention to this discrepancy between the pressure and field calibrations and pointing out that a pressure calibration of a microphone may not be entirely representative of its performance under the conditions which exist in a studio.

The difference between the pressure and field calibrations is due to several factors. In the first place the sound is diffracted around

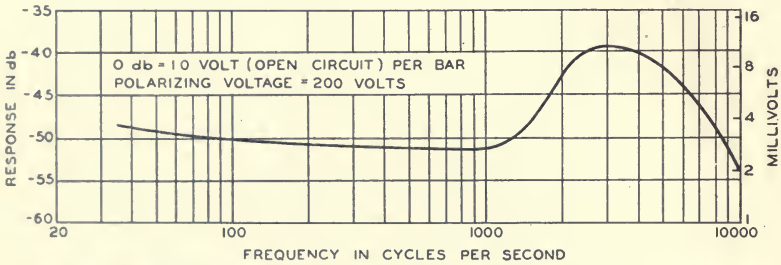

FIG. 5. Field calibration of the 394 type condenser microphone for a direction of approach of sound normal to the diaphragm.

the microphone differently at different frequencies. At frequencies where the wave-length is large as compared with its external dimensions the pressure is the same as that of the undisturbed wave. At the higher frequencies where the microphone is large in comparison with the wave-length of the sound, the pressure is twice that developed at the lower frequencies. In the 394 type microphone the effect of diffraction first becomes noticeable in the region of 1200 cycles and reaches a maximum of 6 db. at approximately 2200 cycles. The second factor which causes a difference between the pressure and field calibrations is acoustic resonance in the shallow cavity in front of the microphone. This causes the pressure actuating the diaphragm to be higher than that of the incident sound wave in the frequency region of 1500 to 5500 cycles. The maximum increase in pressure occurs at approximately 3500 cycles. If the sound source

is so located relative to the microphone that the waves approach from a direction normal to the diaphragm and reflection from surrounding walls and objects is negligible, the combined effect of diffraction and resonance is to produce a maximum departure from flatness of approximately 12 db. as is shown by the field calibration, Fig. 5.[9] If the sound wave travels along the diaphragm the effective pressure is reduced at the higher frequencies due to difference in phase. Hence, if the direction of approach of the sound wave is parallel to the plane of the diaphragm, the departure from flatness is materially reduced. This is brought out quite clearly by the field calibration for sound approaching from a direction parallel to the diaphragm, Fig. 6.[9]

The discrepancy between the pressure and field calibrations of the

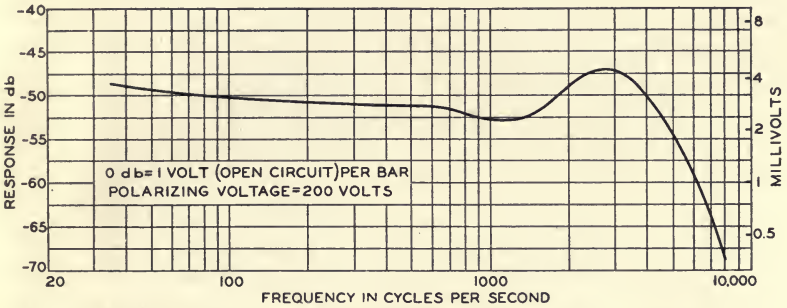

FIG. 6. Field calibration of the 394 type condenser microphone for a direction of approach of sound parallel to the diaphragm.

condenser microphone involves two important assumptions, namely, a plane sound wave and no reflection from walls or surrounding objects. When the microphone is used in a studio much of the sound reaches the diaphragm by way of reflection from the walls of the room. The requirement of no reflection is therefore not met and the influence of the acoustic properties of the reflecting surface is added to the characteristics of the microphone. The effect of the diffusion of the sound field and the tendency for most materials to be more absorbent for sounds of high frequency appears to cause the response under studio conditions to be more nearly like that obtained when the sound approaches in a direction parallel to the diaphragm and makes the departures from the pressure calibration less marked than the field calibration for a direction normal to the diaphragm would indicate. This perhaps accounts in part at least for the instances

in which a corrective network designed to compensate for the field calibration normal to the diaphragm failed to effect a material improvement in quality.

The acoustic conditions under which a microphone is used cover a wide range. It would therefore be difficult if not impossible to adopt a set of conditions for use in connection with a field calibration of the condenser microphone, which would be known to be representative of those encountered in practice. The pressure method of calibration on the other hand is definite, simple, and is capable of being accurately duplicated in different laboratories. In view of this situation it would seem advisable to retain, at least for the present, the thermophone or pressure method of calibration for general use. In cases where precise quantitative measurements are required a field calibration of the microphone should of course be secured under the conditions of actual use. Various methods of making such a calibration have been proposed. The Rayleigh disk has been used extensively in this work thus far but there are certain very definite limitations to the extent to which it can be applied. An interesting discussion of the use of the Rayleigh disk may be found in papers by E. J. Barnes and W. West,[10] and L. J. Sivian.[11]

It would seem reasonable to expect that future design work would be directed toward reducing transition, resonance, and phase difference effects to a minimum. The results of work along this line have been reported by S. Ballantine[12] and D. A. Oliver.[13] In both instances the mechanical design is such that the resonant cavity in front of the diaphragm is eliminated and the housing is spherical or stream line to reduce the diffraction effect. There has as yet been little opportunity to determine the extent of the practical improvement effected by these changes in design and the whole discussion continues to be somewhat academic in character.

Carbon Microphone.—Bell's original microphone was essentially a generator and hence was limited in its output to the maximum speech power available at its diaphragm. The demand for telephonic communication over longer distances led to the early introduction of a carbon microphone. In this instrument the resistance of the carbon element is caused to vary in response to the sound pressure on the diaphragm and produces changes in the current supplied from an external source of electrical potential, which are fairly faithful copies of the pressure changes which constitute the sound wave. The carbon microphone is therefore in general an amplifier in which

a local source of power is controlled by the acoustic power of the sound wave.

The carbon element or "button" of the first microphones (Edison—1877) was made from plumbago compressed into cylindrical form. This type of button was relatively insensitive and shortly after its introduction the suggestion (Hunnings—1878) was made that the space between the diaphragm and the fixed electrode be "partially filled with pulverized engine coke,"[14] in order to increase the number of contact points and render them more susceptible to the forces developed by the motion of the diaphragm. When at its best the Hunnings transmitter was fairly efficient but at times was erratic in its performance due in part to the nature of the microphonic

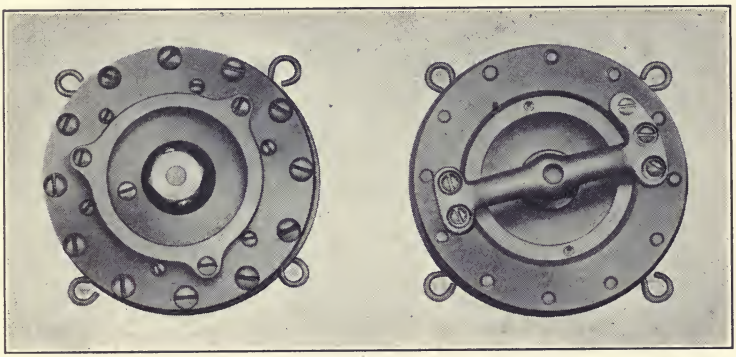

FIG. 7. Western Electric Company's 387 type carbon microphone.

material. In 1886 Edison[15] proposed the use of granules of hard coal which had been heat treated. This was an important advance for carbon made from anthracite coal is not only used in the microphones which are being considered in this paper but in commercial telephone transmitters as well.

As in the case of the condenser microphone, the displacement of the diaphragm of the carbon microphone must be substantially constant at all frequencies if uniform response is to be obtained. In the early microphones of the carbon type diaphragm resonance introduced rather prominent irregularities in response. Air damped stretched diaphragms offered one solution of this problem. During the World War instruments of this type were developed and applied to the problem of locating airplanes. In 1921 double button stretched

diaphragm microphones were made available for use with the public address equipment installed for the inaugural address of President Harding and the exercises at Arlington on Armistice Day.[16] The carbon microphones employed in sound picture recording are of the stretched diaphragm double button type. The electrical output from this type of microphone is not only of substantially uniform intensity over a wide frequency range but due to the "push-pull" arrangement of the buttons is comparatively free from harmonics. A typical example of the present day carbon microphone is shown

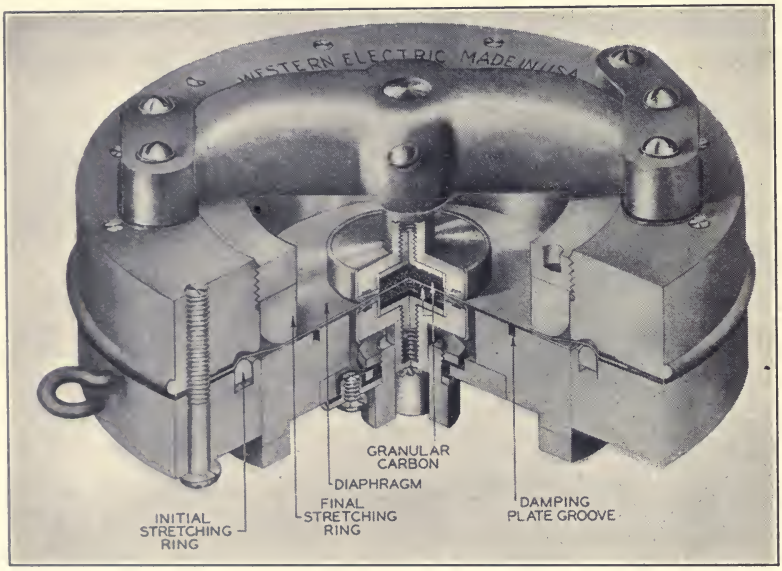

FIG. 8. Cross-sectional view of the 387 type carbon microphone.

in the photograph, Fig. 7. Fig. 8 is a cross-sectional view of the same type of microphone.

The diaphragm is made from duralumin 0.0017 inch in thickness and is clamped securely at its outer edge. The clamping surfaces are corrugated and emery cloth gaskets are provided to prevent slipping. The stretching of the diaphragm is done in two steps. The initial stretching ring is first advanced by means of six equally spaced screws until the diaphragm is smooth and free from irregularities. The inner or final stretching ring is then adjusted to a position which gives the diaphragm a resonant frequency of 5700 cycles per

second. The method employed in making the determination of the resonant frequency is substantially the same as that used in connection with the assembly of the condenser microphone, with the exception that the frequency at which the maximum output occurs is usually determined by ear rather than by the coupler method previously described. In order to insure a uniformly low contact resistance the portions of the diaphragm which are in contact with the granular carbon are covered with a film of gold deposited by cathode sputtering.

A spacing washer 0.001 inch in thickness separates the diaphragm from the damping plate. A single concentric groove is provided in the damping plate.

The buttons are of the conventional cylindrical type but are provided with a novel form of closure to prevent carbon leakage at the

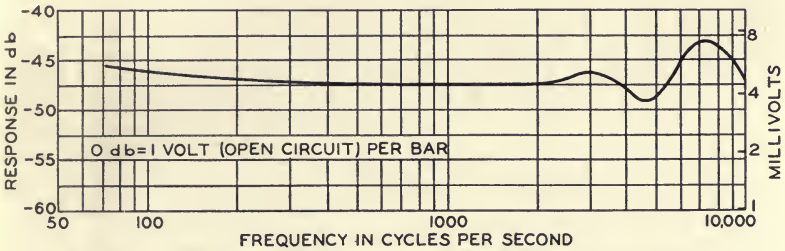

FIG. 9. Pressure calibration of the 387 type carbon microphone.

point where they make contact with the diaphragm. The closure consists of twenty-seven rings of 0.0004 inch paper clamped firmly together at the outer edge and spreading apart at the inner edge to form a structure which effectively seals the junction between the diaphragm and the buttons without adding materially to the mechanical impedance.

As has already been pointed out the granular carbon is made from selected anthracite coal. The size of the granules is such that they will pass through a screen having 60 meshes per inch but will be retained on a screen having 80 meshes per inch. Before heat treatment the raw material is treated with hydrofluoric and hydrochloric acids to reduce the ash content. Each button contains 0.060 cc. of carbon, *i. e.*, about 3000 granules.

The bridge which supports the button on the front of the diaphragm partially closes the acoustic cavity on that side. It is essential,

therefore, that it be so proportioned as to have a minimum reaction on the response of the microphone and yet provide the required degree of rigidity. It was this consideration that led to the smooth stream line contour now employed.

Referring to Fig. 9 it will be observed that the adoption of an air damped stretched duralumin diaphragm for the carbon microphone has resulted in an instrument having a substantially uniform response over a wide range of frequencies. The arrangement of the

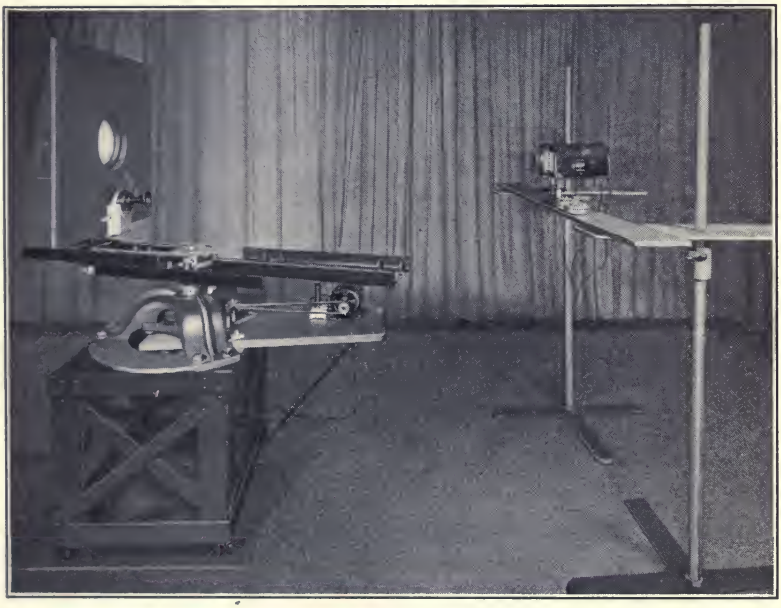

FIG. 10. Apparatus employed in calibrating the 387 type carbon microphone.

apparatus employed in securing the data from which this curve was plotted is shown in the photograph Fig. 10. The microphone under test was mounted in a highly damped room at a distance of six to eight feet from a source of sound which consisted of two loud speaking receivers. One of the receivers was the conventional form of moving coil direct radiator and was used to provide sound in the lower frequency range. The other was a special moving coil receiver with a short horn so designed as to serve as an efficient source of sound up to 10,000 cycles.[17] To reduce the effect of standing waves the mounting

for the receivers was so constructed that they could be rotated through a circle approximately five feet in diameter and always face the microphone under test. Before starting the test of the carbon microphone the receivers were calibrated by placing a calibrated condenser microphone at the point where the test instrument was to be located and determining the receiver current required to produce a pressure of one bar (one dyne per square centimeter) on the microphone diaphragm. The condenser microphone was then removed and the test microphone substituted. The open circuit voltage developed by the microphone when supplied with a direct current of 0.025

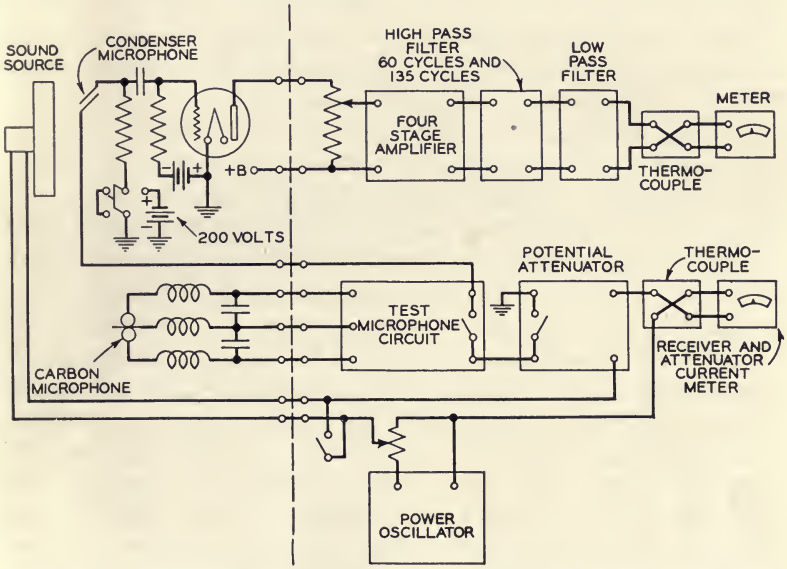

FIG. 11. Circuit employed in calibrating the 387 type carbon microphone.

ampere per button was then measured. The data obtained in this way are essentially a "pressure calibration" of the microphone and in interpreting them in terms of "field" performance the same factors must be taken into account which have been discussed in considerable detail in connection with the condenser microphone.

The circuit employed in measuring the response of the carbon microphone is shown on Fig. 11. Two steps are involved in the calibration of the sound source. With the output terminals of the microphone circuit and the sound source short circuited and the polarizing voltage for the condenser microphone removed, the attenuator is

adjusted until the voltage applied to the measuring circuit is that developed by the condenser microphone when a sound pressure of one bar is impressed on its diaphragm. A record is made of the reading of the output meter in the measuring circuit. The polarizing voltage is then applied to the condenser microphone. After the output terminals of the attenuator have been short circuited an alternating current of a known frequency is supplied to the sound source and the magnitude of this current adjusted until the meter reading is the same as that previously obtained with the attenuator. This completes the calibration of the sound source for that frequency. After the carbon microphone has been placed in the position previously occupied by the condenser microphone, the polarizing voltage is once more removed from the condenser microphone and the output from the carbon microphone circuit impressed on the measuring circuit. The reading of the output meter is recorded. The sound source and carbon microphone circuit are then short circuited and the output from the attenuator again applied to the measuring circuit. The attenuator is adjusted until the reading of the output meter is the same as was previously obtained with the carbon microphone in circuit. In this way the voltage applied to the measuring circuit when the carbon microphone is in operation is determined. The open circuit voltage developed by the carbon microphone may then be computed from the voltage and the constants of the microphone circuit. At the locations where these measurements were made a certain amount of interference from 60 cycle circuits and low frequency acoustic disturbances was encountered. The high pass filter in the measuring circuit was introduced to facilitate the measurements under these conditions. The adjustable low pass filter was used to confine the measurements to the fundamental frequency. Only that portion of the apparatus to the left of the dotted line was mounted in the damped room.

The two buttons of the carbon microphone are identical in their dimensions and if the granular carbon is in the same mechanical state have substantially the same electrical characteristics. They are also practically free from the cyclic variations in resistance known as "breathing" which result from the temperature changes caused by the power dissipated in the granular carbon. It is, however, a matter of every-day experience that a given mass of granular material will occupy different volumes depending upon the configuration of the particles. In the case of microphone carbon this change in con-

figuration of the granules results in changes in the contact forces of sufficient magnitude to affect the resistance and sensitivity. If these changes occur in unequal amounts in the buttons electrical unbalance results. When complete balance exists the electrical output is free from all harmonics introduced by the circuit. Hence, in using the microphone care should be taken to see that a fair degree of balance between the buttons is maintained.

The performance of a carbon microphone may be affected adversely by cohering of the granules. Severe cohering is accompanied by a serious reduction in resistance and sensitivity which persists for an extended period unless the instrument is tapped or agitated mechanically. One of the common causes of cohering is breaking the circuit when current is flowing through the microphone. Experiment has shown that the insertion of a simple filter consisting of two 0.02 mμ. condensers and three coupled retardation coils each having a self-inductance 0.0014 henry, will effectively protect the microphone button from cohering influences without introducing an appreciable transmission loss. This filter may be located in the base of the mounting or in a container fastened to the back of the microphone.

Aging of granular carbon may result from changes in the contact surface caused either by mechanical abrasion or overheating due to excessive contact potentials. Aging is usually accompanied by an increase in resistance and loss in sensitivity. Care should therefore be exercised in the use of the carbon microphone that it is not subjected to unnecessary vibration which would cause the granules to move relative to one another and abrade the surfaces. The use of abnormally high voltages should also be avoided.

The quality of transmission obtained with the double button carbon microphone compares favorably with that secured with a condenser microphone. The carbon microphone also requires less amplification. There is, however, one characteristic which limits its use, namely, carbon noise. The level of the noise is much higher than that due to thermal agitation within the carbon granules[18] and appears to be caused by heating at the contacts between the granules. A certain amount of gas is contained in the pores in the contact surfaces. When current passes through the button, a sufficient increase in contact temperature takes place to cause a portion of this gas to be driven off and produce the non-periodic changes in resistance which give rise to carbon noise.

In conclusion, it may be stated that the condenser and carbon

types of microphones have been developed to a point where there is little to choose between them from the standpoint of quality of transmission. The design from a mechanical standpoint has also been carried to a point where little difficulty should be experienced in their use if reasonable precautions are exercised. Although requiring less amplification than the condenser microphone the extent to which the carbon microphone is used at present is limited by the higher noise level obtained. The condenser type of microphone has therefore been adopted for most of the recording work in the sound picture field.

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DISCUSSION

MR. COOK: I believe it has been stated in some of the published literature that the main contribution to the mechanical impedance of the diaphragm from the air chamber back of this diaphragm is from an increase in stiffness alone. Is the advantage of that thin slice of air in stiffness or is it in resistive load as far as the diaphragm alone is concerned?

MR. JONES: It is true that in the early microphones, such as the Wente microphone shown in Fig. 2, the air film introduced considerable stiffness as well as resistance. In the later designs where an effort has been made to secure maximum sensitivity, the stiffness of the air film has been materially reduced by the use of a grooved damping plate. The resistance introduced by the air film is now the more important factor and in microphones of the type described in this paper is relied upon to give the desired degree of flatness of response at resonance.

MR. LEWIN: I should like to inquire, regarding the condenser microphone, how constant does the tuning point maintain itself and how often should it be checked? In our studio we have a number of microphones which have been in use for over two years, and I wonder if it is necessary to re-check the tuning point after such a long period.

MR. JONES: The tuning of a microphone diaphragm involves two factors, namely, its effective mass and stiffness. If either or both change a different resonant frequency may be obtained. There is no evidence that the diaphragm changes its mode of vibration. Inasmuch as it is the predominant mass no change in the resonant frequency is introduced from this source. Changes in stiffness might arise from slipping at the diaphragm clamping surfaces or a drop in tension if the stresses in the diaphragm material are too near the yield point. All the available data point to stable clamping and the characteristics of the diaphragm material are such that the stresses are well below the yield point.

MR. KELLOGG: One wonders on hearing the statement in the paper in regard to the large contribution which the air behind the diaphragm makes to the net stiffness of the diaphragm, whether the air film might be relied on rather than the tension on the diaphragm to give the necessary high natural frequency. I assume that the tension must be sufficient to keep the diaphragm flat, but I should be interested in what Mr. Jones has to say about this possibility. I wonder if it would be asking too much to have the author give further explanation of the reasons why and the conditions under which the free-space calibration seems to give a result which is no more representative of what you actually hear than the pressure calibration.

MR. JONES: In regard to the use of air stiffness to secure a high resonant frequency, my suggestion is this: It is common knowledge that the stiffness of an air film is a function of frequency. The stiffness is small at the low frequencies where the air is readily displaced when the diaphragm vibrates. At the higher frequencies there is a tendency to imprison the air and compress it and a higher stiffness results. If air stiffness were relied upon to control the resonant frequency, these changes in stiffness with frequency would make it difficult to secure uniform response. In addition it should be borne in mind that a small separation between the diaphragm and damping plate is necessary if the desired degree of sensitivity is to be obtained. A high diaphragm stiffness is required to maintain this separation.

Perhaps I did not make my views in regard to the relative merits of the pressure and field calibrations entirely clear. I didn't mean to convey the impression that the pressure calibration is a better measure of what goes on under free space conditions. In fact, if quantitative acoustic measurements of high precision are to be made with a condenser microphone, it is essential to secure a field calibration under the actual conditions of use. The "field" conditions which exist in different studios vary to such an extent that it is difficult, if not impossible, to arrive at a set of acoustic conditions which are representative of all conditions of use. The pressure calibration on the other hand is precise and can be duplicated in any laboratory. It would therefore appear advisable to retain for the present the pressure calibration for checking and comparing instruments and make such corrections as are necessary to fit each set of studio conditions.

MICROPHONE CONCENTRATORS IN PICTURE PRODUCTION*

CARL DREHER**

Summary.—*By means of microphone concentrators high quality sound pickup is rendered possible at distances of the order of 20–40 feet. One such device utilizes a metal horn with the microphone placed at the throat. In another form, applied commercially by RKO Studios, sound is picked up by an ellipsoidal or parabolic reflector and focused on a microphone, with the sensitive face of the transmitter turned away from the action. The advantages of this type of concentrator are relatively high gain, ability to record against wind or noise interference, and suitable acoustic characteristics for high quality pickup at a distance. The importance of these factors in lowering moving picture production costs is described.*

When speech is picked up electrically with a microphone it is usually possible to secure high quality only by placing the pickup device relatively close to the source of sound. It is well known that the higher speech frequencies, on which intelligibility largely depends, are projected from the mouth in a beam. With the pickup close to the speaker a considerable portion of the energy in this beam is utilized. Moreover, when the microphone is close to the speaker, the direct output of sound predominates, whereas with the pickup at a greater distance from the source, sound reflected from the walls of the enclosure becomes a factor, and the acoustic characteristics of the room or stage enter into the equation. The microphone does not discriminate, as does the human ear, between the direct emission of speech sounds and the heterogeneous reflections which are set up in an acoustic enclosure.

In talking picture production it is always necessary to compromise between the demands of the camera and those of the microphone. If the microphone were always placed in the most favorable position for sound pickup, it would frequently come within the field of the camera. If the microphone is kept outside the camera lines, as is required in photographing the action, it may be so far from the source of sound that the quality deteriorates. Moreover, the camera has an

* Presented at the Fall 1930 Meeting, New York, N. Y.

** RKO Radio Pictures, Hollywood, Cal.

important advantage in production in that by using proper lenses it is often feasible with a given stage set-up to photograph close-up and long shots at the same time. The unaided microphone, on the contrary, will pick up high quality sound corresponding to the close-up picture only when it is near the speaker, say, within three or four feet. Thus it is frequently necessary to make additional takes merely in order to get correct sound pickup corresponding to the two views. This conflict between sound and picture requirements is shown graphically in Fig. 1.

If it were possible to modify a microphone in such a way that high quality speech could be picked up at a distance corresponding to a medium camera shot, takes for sound only could in many instances be

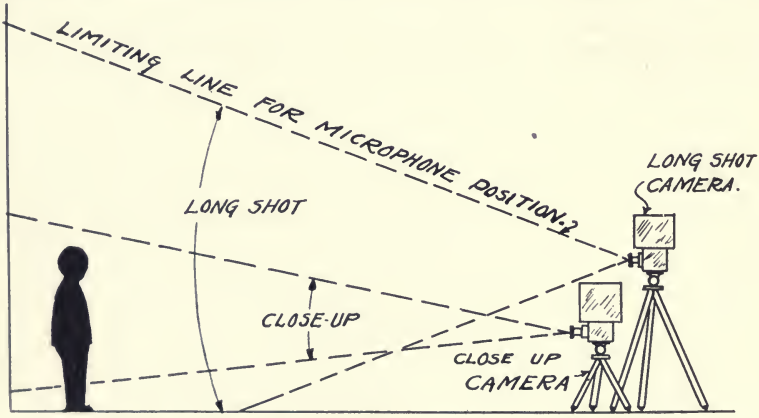

FIG. 1. Showing simultaneous photographing of long shot and close-up and consequent limitations on high quality sound pickup.

eliminated, with a resulting saving in time and cost. The procedure would then be to shoot close-up sound only, modifying the quality in re-recording when necessary to simulate more distant pickup for the long shot picture. In the attainment of this objective, promising results are being secured by the use of microphone concentrating devices. One such development has been described by Olson and Wolff.[1] Substantially this is a metal horn in the shape of a parabola of revolution, with the microphone placed at the small end, as shown in Fig. 2. At the higher speech frequencies the horn functions as a parabolic reflector, focusing sound on the microphone. At a lower frequency there is a transition from the reflector action to one in which the horn reënforces the lower notes. Peaks of response in this

range are smoothed out by the addition of Helmholtz resonators coupled to the horn at the throat. The increase in pressure at the focus over pressure in free space is of the order of five times. The device is directional for frequencies above 200 cycles. The Olson-Wolff device is in successful operation at various points in the sound picture and radio broadcasting fields.

Fig. 3 shows another type of microphone sound concentrator which is in use at RKO Studios in Hollywood in sound picture production. The microphone is turned away from the source of sound. Sound issues from the source, strikes the reflector, and is concentrated to a focus, at or near which the microphone is placed, with its diaphragm or sensitive element facing the reflector. Various types of reflector curves may be used, such as parabolas and ellipses. In most

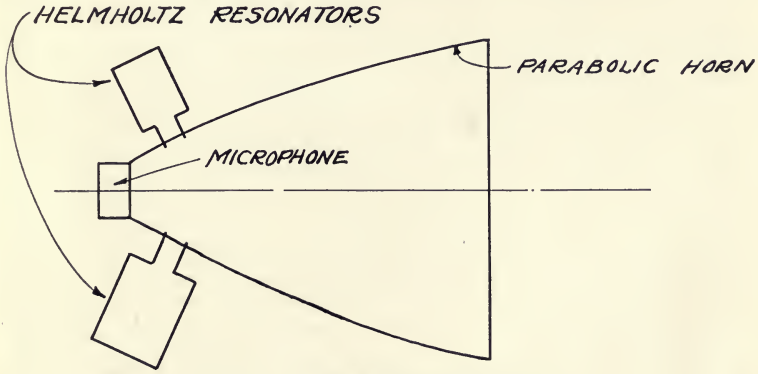

FIG. 2. Horn sound concentrator.

cases the curve is an open one, corresponding roughly to a parabola of the equation $y^2 = 12x$. The diameter of the surface varies, 40 to 60 inches, being commercial shapes. Means for sighting and orienting the bowl are provided, so that the action may be conveniently followed.

The technic of picking up sound with such a device is not as simple as the theory would indicate. The horn must be kept pointed at the source of sound for good quality pickup. With the above moderate dimensions the concentrator loses low frequencies (below about 500 cycles) to some extent, and contributes a marked increase in pressure, corresponding roughly to a stage of amplification, at high frequencies. In order to obviate excessive reënforcement of higher frequencies it is necessary to modify the shape of the curve or

to throw the microphone somewhat out of focus. In general the effort is to make the device a soft focus acoustic element, rather than to utilize maximum sharpness of focus. While there are certain voices which benefit decidedly by the dropping out of the lower tones, others become harsh and strident, and care must be used in fitting the characteristics of the concentrator to the type of pickup. However, with experience it is not difficult to arrive at a proper setting for use under average conditions of pickup.

The directional properties of reflectors of the type described are often valuable in discriminating against interfering noises. For example, in RKO's *Danger Lights* it was necessary to shoot some

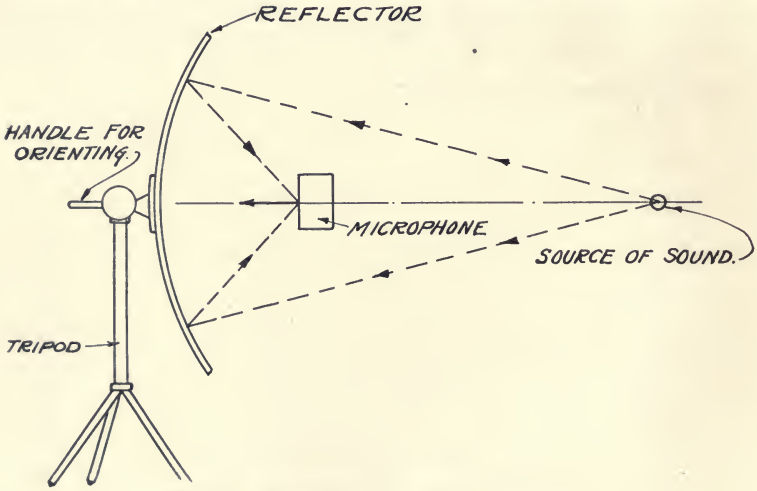

FIG. 3. Open-bowl sound concentrator.

scenes in a railroad roundhouse. With an open microphone it was impossible to pick up intelligible dialog at a distance of three feet from the speaker, but by utilizing the directional properties of the parabolic concentrators, good dialog pickup was possible at much greater distances, the noises being reduced to a realistic background. Another advantage of the device is in outdoor shooting, when wind interference is encountered. When the concentrator can be turned with its concave face down-wind, it acts as a shield, the microphone being in the lee of the reflector. Wind interference is a frequent cause of delay in outdoor shooting, so that this property is valuable from a production standpoint.

Promising experimental results have also been secured with the

device indoors. On a properly constructed set it is at times difficult to discriminate by ear between the pickup of an open microphone three feet from the speaker and concentrator pickup at a distance of twenty feet. In general it is advisable to place the concentrators no further from the action than the cameras. The concentrator may be mounted on a parallel under which a camera is set up. Sets in which reverberation is kept down to a minimum are required, since concentrators in sizes which will not interfere with photography have little directional effect at the lower frequencies. However, the loss of lows in the device may compensate roughly for the tendency toward low frequency reverberation commonly found in moving picture sets.

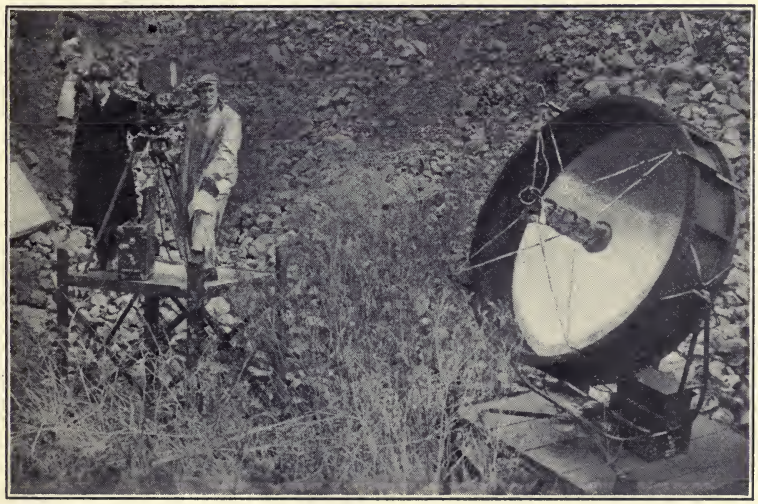

FIG. 4.

To date RKO Radio Pictures have used this form of microphone concentrator for almost all outdoor pickup in connection with such pictures as *Danger Lights*, *Silver Horde*, and *Cimarron*. The absence of reverberation outdoors makes it relatively easy to apply the device without sacrificing quality. A sizeable increase in speed of production and facility in photographing is realized. A ten or fifteen per cent reduction in over-all production cost may be realized by the skillful use of sound concentrators instead of open microphones. Not only is the microphone taken out of the zone of action, but by reason of the directional properties of the reflector

camera blimps can usually be dispensed with outdoors, thus further freeing the cameramen from the limitations imposed by sound. The photographs show the RKO concentrators on location (Fig. 4 and Fig. 5).

The horn type of concentrator was developed by Harry F. Olson and Irving Wolff of RCA Photophone, Inc., under the supervision of Julius Weinberger. Major credit for the open-bowl type of concentrator is due to C. W. Horn, now General Engineer of the National Broadcasting Company, who applied it in the broadcast studios of the

FIG. 5.

Westinghouse Electric & Manufacturing Company at Pittsburgh as early as 1923, and was granted a patent, No. 1,732,722, on October 22, 1929, the application being dated January 2, 1924. Parabolic reflectors were used for airplane location work during the World War, but their use for broadcast pickup appears to have originated with Mr. Horn. The application to motion picture sound recording was carried on by Ralph K. Spotts, Philip J. Faulkner, Jr., and other members of the Sound Department of RKO Studios under the direction of the writer.

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DISCUSSION

MR. TAYLOR: Wouldn't it add to the interest if we were told one or two spots where the reflector was used and why it was desirable at that spot?

MR. BATSEL: It is my understanding that the reflector was used in all exteriors in the entire feature.

MR. READ: What material was used in the concentrator? A metal?

MR. BATSEL: I don't know what was used. I know that in experimenting they used different materials—plasters having various absorption characteristics. I believe this one was hard plaster but I am not sure.

PRESIDENT CRABTREE: Has this method been used in the East?

MR. BATSEL: The first one shown, the horn type, has been used in the East on short subjects and in broadcasting. The larger reflector is a development of the West Coast. We have not seen one here as yet.

MR. KELLOGG: I was told a number of years ago that large parabolic reflectors had been tried in broadcasting work and had been discarded. Can anyone tell what the faults were?

MR. KNUDSON: There must be difficulty in getting fidelity for frequencies having wave-lengths comparable with the dimensions of the reflector. From the photographs it would appear that the reflector is five or six feet in diameter; difficulties, therefore, would be introduced at frequencies below about 300 cycles.

MR. BATSEL: Mr. Dreher has already covered that subject pretty well in his paper. He doesn't claim that the device gives equal quality to a 3 foot pickup, and the diameter of the reflector is a serious consideration in picking up low frequencies. If a small reflector is used, a considerable range of frequencies is lost.

MR. HILL: I have made forty or fifty measurements on it under a variety of conditions and what Dr. Knudson said holds true. The cut-off at the low frequency end is serious excepting with reflectors 15 or 16 feet across. There is an advantage in that a gain of 10 or 12 db. may be obtained on some frequencies, but not at the low frequencies.

MR. KNUDSON: I should not like these remarks to be construed that we are disapproving of the directive microphone. I think the demonstration we have listened to today is ample justification for its use. The quality of reproduction resulting from the combined use of reflector and microphone was strikingly exhibited in Mr. Dreher's demonstration. Listening to the low puffs of the locomotive, you are conscious of distortion in the low frequency sounds. The high frequency hissing of the steam, I think, was recorded perfectly. The results attained were certainly worth while in spite of the limitations of the combined use of reflector and microphone.

CARL DREHER (Communicated): Mr. Batsel has already answered most of the questions. Mr. Read asked what materials were used in the construction of the reflector. In some of the early types, we used plaster on burlap and similar materials, but in the forms which have been applied commercially, the usual material for the reflector has been aluminum sheeting about one thirty-second inch thick, backed by wooden cross-pieces to add rigidity. When the reflectors are manufactured in quantity, an all-metal form would naturally be adopted, but, up to now, the number built at RKO has not justified the manufacture of a mold.

As pointed out by Dr. Knudson and as I stated in the paper, there is a loss

of bass with reflectors of commercial diameters (40–60″). This is more pronounced with the original sharply focused parabolic concentrators used in *Danger Lights*. As was stated in the paper, we have obviated this to some degree by using the microphone out of focus and by developing other forms of reflectors, notably the ellipsoidal type shown in the photographs.

Frequency characteristics and measurements do not always give a true indication of the commercial value of an acoustic device. Such measurements are of the utmost value in indicating methods of improvement and lines of future development, but the actual conditions of motion picture recording are so complex that what appears to be a serious fault in theory may at times be a benefit in practice. There are situations in motion picture recording when it is decidedly beneficial to drop out some of the energy in the lower part of the frequency band.

Again, we must consider recording as only one part of the process of making a picture, and we must also consider cost. For example, if a given form of pickup yielded good acoustic quality and allowed extreme mobility in camera work, we might be justified in using that form of recording in preference to another which afforded slightly better sound at a great sacrifice of other picture elements. With the reflector concentrators we have been able to make some shots which added greatly to the interest of the pictures as a whole, and which would have been quite impossible with the more orthodox methods of pickup.

Moreover, if we can reduce production costs appreciably by a slight or moderate sacrifice of sound quality, there are times when we may be justified in taking that course. Many pictures are made with much greater restrictions in casting photography, set construction, *etc.*, because of commercial limitations on expenditures. I do not wish to be understood as advocating deliberate sacrifices in quality of sound recording. No engineer would be justified in recording poor sound, no matter how cheaply he did it, or how much he facilitated the work of the other crafts thereby. My position is merely that, as compromises must often be made, devices like the microphone concentrators described in the paper may find a very useful field of application and that in the present state of the art it is necessary to follow up such developments in the field as well as in the laboratory.

TESTS OF MOTION PICTURE SCREENS*

WILLIAM F. LITTLE**

Summary.—*Inasmuch as the common methods of measuring motion picture screen reflection factors fail to bring out the essential differences between metallic and beaded screens, and fail to correctly describe the diffusing screen, a modified test procedure is suggested. This involves brightness measurements in two planes mutually perpendicular and perpendicular to the screen on which the incident beam is inclined at some suitable angle above the screen axis. Such a modification of test procedure permits the accurate analysis of a screen in terms of its suitability for a particular theater.*

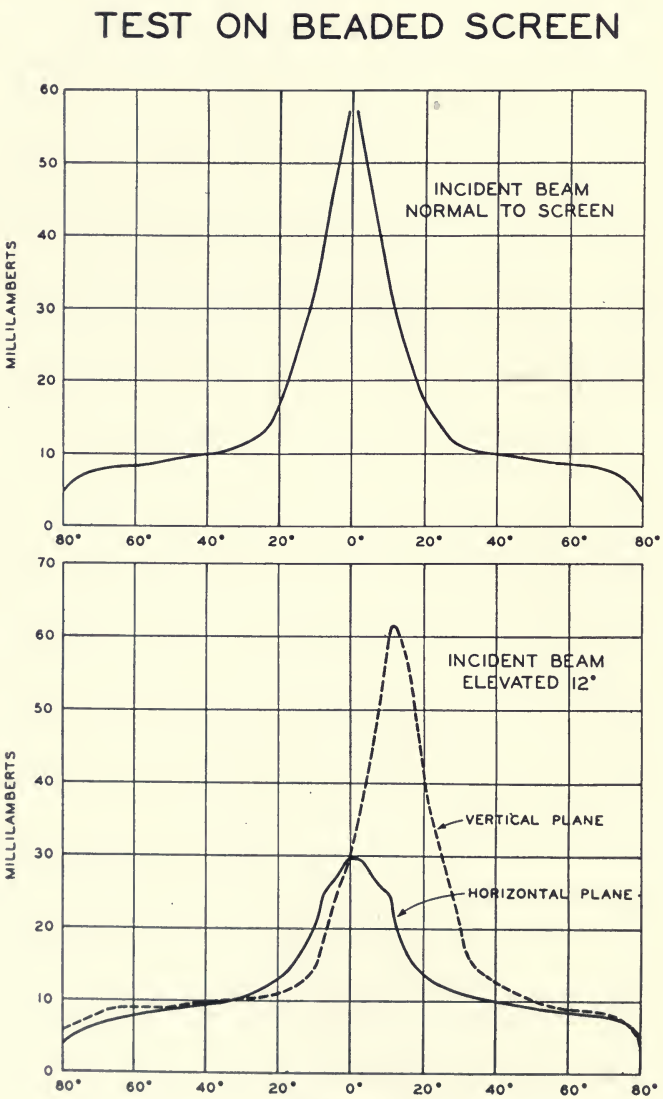
Tests of screen color are also recommended whereby the screen surface color and the color of the light source may be brought into closer coördination.

A superficial examination of the surfaces of a number of motion picture screens suggests their division into three classes. A plain matte surface such as white plaster gives a screen of an extremely diffusing type. A surface prepared with a metallic paint gives a surface which provides somewhat less diffusion and more specular reflection. Covering the screen surface with fine glass beads gives it specular characteristics strikingly different from those of the metallic surface screen. Two kinds of tests for the evaluation of quality in motion picture screens have been in use up to the present time. The first test evaluates the total reflection factor. The second test indicates the brightness of the screen surface, illuminated at normal incidence, when viewed from different angles.

The customary procedure used at present for testing motion picture screens closely follows that described by Mr. L. A. Jones and his associates in papers read before the society in 1920[1] and 1927[2] and published in the *Transactions*. In these tests the light was incident on the screen perpendicular to the surface and the brightness was observed at various angles in the plane perpendicular to the screen and passing through the incident beam. It was assumed that for a screen to be satisfactory, the ratio of the greatest to the least brightness should be no greater than 4:1. The greatest brightness would be

* Presented at the Fall 1930 Meeting, New York, N. Y.

** Electrical Testing Laboratories, New York, N. Y.


TEST ON BEADED SCREEN
MILLILAMBERTS
INCIDENT BEAM
NORMAL TO SCREEN
0
10
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40
50
60
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40°
20°
0°
20°
40°
60°
80°
MILLILAMBERTS
INCIDENT BEAM
ELEVATED 12°
VERTICAL PLANE
HORIZONTAL PLANE
0
10
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30
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60
70
80°
60°
40°
20°
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FIG. 1.

observed on the axis of the screen, that is, at 0 degree; and the least brightness would be observed at as great an angle as the width of the house permitted.

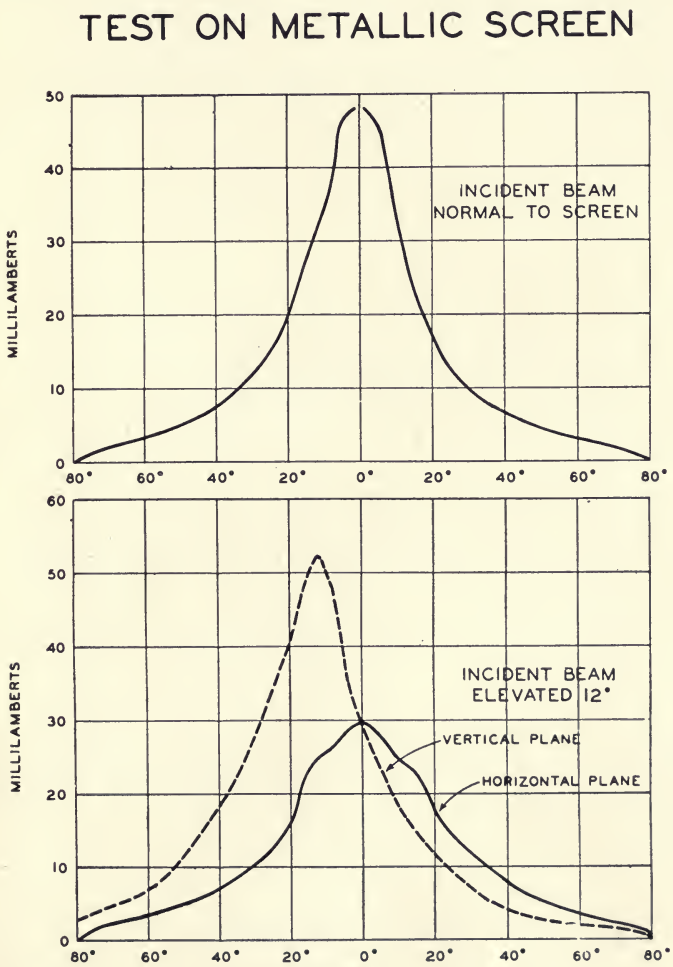

FIG. 2.

In actual practice the incident beam is inclined downward onto the screen, making an angle with the horizontal of from 5° to 25°, depending on the design of the house. The need for testing screens at such an angle is clearly shown in Figs. 1, 2, and 3. The upper curves

show screen brightness data with the light incident normally. The lower curves show the light incident 12° off the normal. In this case, separate determinations must be made in the horizontal and vertical planes. These are shown by full and dash lines, respectively. It will be noted from these curves that the diffusing screen shows substantially the same results irrespective of the angle of light incidence, whereas the beaded and metallic surface screens appear substantially the same when tested at normal incidence, but diametrically opposed when the incident light is 12° off the axis.

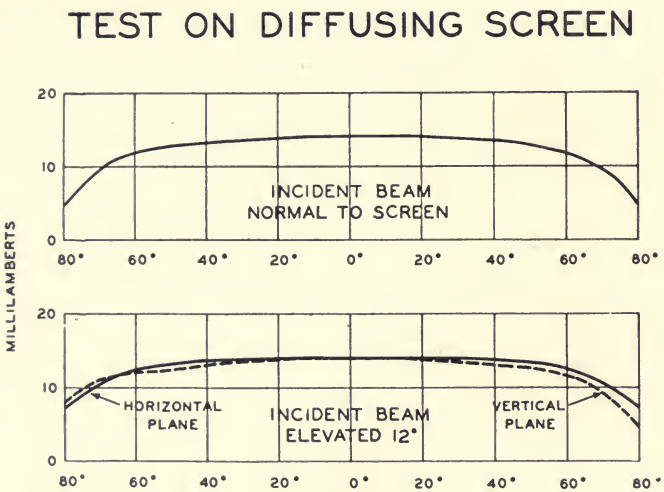

FIG. 3.

Another point in which the test at normal incidence fails to show the screen as it really is in practice can be seen by comparing the maximum brightness of the three screens under the two conditions of the test. This is shown in Table I.

TABLE I

Maximum Screen Brightness

Screen	*Normal Incidence*	*12° off Normal*
Beaded	58 ml.	62 ml.
Metallic	48 ml.	52 ml.
Diffusing	14 ml.	14 ml.

This suggested change in the test procedure makes possible the more accurate use of another criterion in the comparison of screens.

The fact that one observer in a house might see the screen four times as bright as another observer would seem to be of less consequence than for one observer to see one edge of the screen two or three times as bright as the other edge. For the comparison of screens without regard to a particular theater, suitable angles such as 12° or 15°

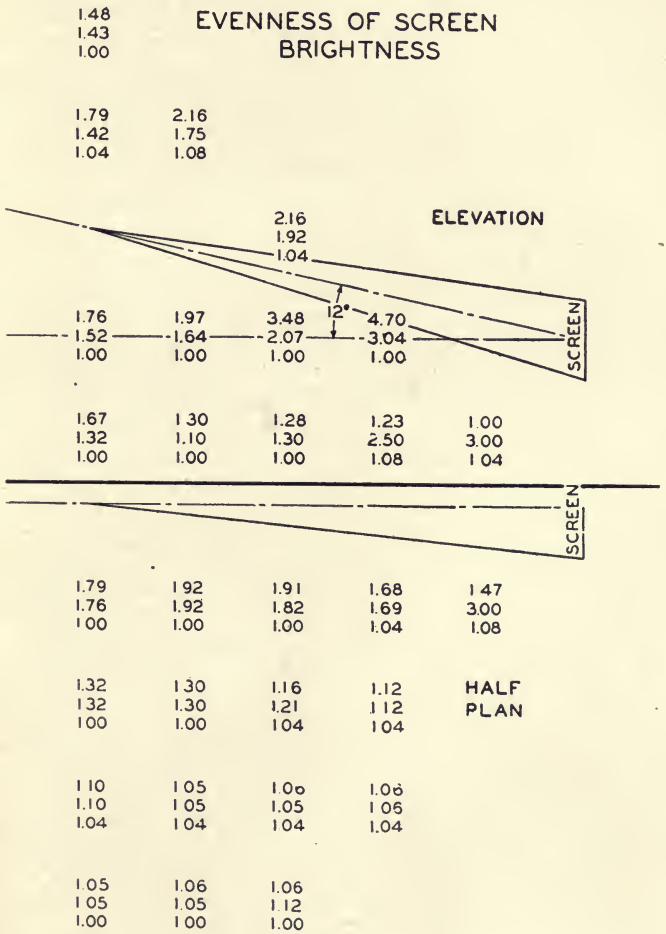

FIG 4

may be arbitrarily chosen or experience may indicate the advisability of making complete tests at two angles, say, 12° and 25°.

The chart, Fig. 4, shows a typical theater in elevation and one-half of it in plan, on which are recorded screen brightness ratios

taken from edge to edge of the screen. In each group, which are assumed to be 20 feet apart, the upper number refers to the beaded screen, the center number to the metallic screen, and the lower one to the diffuse screen. From the viewpoint of axial to marginal brightness a person viewing the diffusing screen from one of the back corners of the house would see it at its worst. In the case of the metallic and beaded screens the variation of brightness over the screen from a single observation point becomes of increased importance. The location which, according to this criterion, presents the poorest view for the metallic screen would be that nearest the screen in the angle of specular reflection from the lower edge. Assuming the front row of seats to be at about twice the screen width from the screen, an observer sitting in a central front seat would be viewing the lower edge at approximately 12° to the normal, the upper edge at approximately 35° to the normal and there would be a variation in brightness on the metallic screen of about 3 to 1, assuming the illuminated field was actually uniform as viewed from the projector. The poorest view for the beaded screen, judged by the same criterion, would be near the screen and just below the incident beam. In this position the observer would see the bottom edge of the screen at approximately 12° and the top at about 17° or a variation of screen brightness of about 5 to 1.

Since a change in test procedure is being advocated, it might be well to consider the advisability of including a test of the variation of reflection factor with wave-length. There are a few tinted screens on the market for which special claims are advanced and among the so-called "white" screens the degree of whiteness is by no means constant. Just as the angular brightness tests involve the shape of the house, so the spectral brightness tests involve the spectral composition of the projector light source for the complete interpretation of results. It is a fact which can be substantiated by test that since high intensity arcs, low intensity arcs, and Mazda lamps differ slightly in color, screens can be chosen to match any of these particular sources.

In view of the fact that our present test procedure shows, first, the metallic and beaded types of screen to have the same brightness characteristics, which is not the case in actual practice, second, that the data are not sufficiently complete to make screen brightness comparisons possible from any part of the house, third, that the projection angle is practically never at 0° incidence in a motion picture house, and fourth, that the importance of color or variations in whiteness

is at present ignored, it is suggested that the Society review the situation with the thought that some modification in test methods might be recommended.

It is a pleasure to acknowledge obligation to E. I. Du Pont de Nemours & Company who through the kindness of their Dr. McBurnie provided the screens used in getting data for this paper.

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DISCUSSION

MR. RAVEN: I heartily agree with Mr. Little in his comment that some thorough work should be done in this matter with regard to reading screen brightnesses from angles and positions that approximate the actual conditions in the theater rather than by projecting the light normally and having the angle readings taken from that. As Mr. Little has said, little worthwhile information can be obtained by a screen purchaser from a reading taken when the light is normal. I hope the Projection Committee will take up the matter thoroughly so that the exhibitor will soon have available some real information that will enable him to decide what screen is best suited for his particular theater.

MR. TUTTLE: In the paper referred to by Mr. Little, of which Mr. Jones and I are the authors, we discussed the effect of varying the angle of incidence. In none of the large number of screens which we tested did the magnitude of the angle of incidence affect the measured value of reflection factor by any considerable amount.

From our experience, I should say that the method of test which we used is just as applicable as that advocated by Mr. Little. I am inclined to think that the differences between the results of the two methods are not real, but are due to misinterpretation of the original data.

In our data, the value of the zero degree reflection factor should, of course, be taken as the factor for regular reflection—*i. e.*, angle of incidence equal to angle of reflection—and the other values given represent factors at various angles from the angle of regular reflection. When properly interpreted such data are applicable to conditions existing in any theater.

DUBBING AND ITS RELATION TO SOUND PICTURE PRODUCTION*

GEORGE LEWIN**

Summary.—*Dubbing is essentially a re-recording process and has three important applications. The first is the re-recording of a completed feature from one form to another, as from film to disk, for release purposes. The second is the re-recording of the dialog, for the purpose of mixing in with it, sound effects or incidental music which, for technical or economic reasons, could not have been put in during the original recording. The third application is the synchronizing of foreign voices to a picture which was originally recorded in English. This last is a "doubling" rather than a dubbing process.*

The original meaning of the term "dubbing" as applied to sound pictures was simply the process of re-recording a sound record. The object of re-recording is usually to transform the record from one form to another, as from film to disk, or *vice versa*, or else simply re-record in the same form, for the purpose of changing the recorded level or frequency characteristic. But with the rapid development of sound pictures the meaning of the term "dubbing" broadened more and more, until at the present time, it is used rather loosely to describe any process whereby the original recording is modified in any way. It is also used to describe the process whereby foreign versions of domestic pictures are made by synchronizing foreign voices to the lip movements of the original version. This latter process is essentially a "faking" process, since, when viewing such a picture, the voices we hear are not those of the original cast, but of an entirely different group of people. The same principle was used in some of the earlier domestic talking pictures in an effort to maintain the popularity of certain actors and actresses, whose speaking accents or singing voices would have been a disappointment to the film fans. So-called "voice doubles" were used to actually speak or sing while the player himself simply went through the lip motions. This form of faking, however, has been completely aban-

* Presented at the Fall 1930 Meeting, New York, N. Y.

** Paramount Publix Corp., Long Island City, N. Y.

doned now and the public may rest assured that they are actually hearing the voices of their favorites, in all domestic releases.

For the purpose of discussion, dubbing may be classified into three broad groups:

(1) Straight Dubbing
(2) Combined Dubbing and Synchronizing
(3) Dialog Dubbing

To make the discussion complete it might be well to also add a fourth group which may be called "indirect recording." This is not a form of dubbing at all, but since it is one purpose of this paper to dispel the illusion which many people seem to have, that most sound pictures are full of artificial and faked effects, it would be well to say some words later on this subject also.

STRAIGHT DUBBING

Straight dubbing is the process of re-recording a sound record by reconverting the recorded vibrations into electrical vibrations and using these reproduced vibrations to make a new record. straight dubbing may be subdivided into four groups:

(1) Film to Disk
(2) Film to Film
(3) Disk to Film
(4) Disk to Disk

In a studio, such as Paramount's, where all recording is originally done on film, film to disk dubbing is the most common form of straight dubbing. It is used only on completed features and short subjects, after they are ready for release, and is done for the purpose of making the product available to houses which are equipped for disk reproduction only.

Straight dubbing from film to film is used only for the purpose of level and quality correction. It sometimes is found, when editing a film, that various sequences which were recorded at widely separated times, or by different monitor men, or which were subjected to different laboratory processings, do not match each other in level or quality. In such cases the faulty sequences can be re-recorded and the level changed or the quality corrected by the use of suitable equalizers. This form of dubbing becomes less and less necessary as the personnel of the studio and laboratory become more expert in their respective duties, but occasionally instances do arise where expensive retakes can be avoided by suitable dubbing from

film to film. Level correction is made by simply raising or lowering the recording level of the dubbed record to what is considered the correct value. The level can be reduced to any desired point without difficulty, but in raising the level we are limited by the surface noise which is inherent in any form of recording. Quality correction is made by inserting suitable equalizers into the dubbing circuit. These will be discussed more fully later on. Film to film dubbing has its most important application in combined dubbing and synchronizing and will be discussed more fully under that heading.

Disk to film dubbing is comparatively rare; however, on one or two special occasions it has proved quite useful in this studio. Dubbing from ordinary pressings is not entirely satisfactory as the surface noise is somewhat high. Better results are obtained by dubbing from a metal mould, which has been chromium plated for the purpose. The surface noise from a chromium plated disk is about 6 db. lower than that of a regular pressing, for the same signal output, and there is also a noticeable improvement in the reproduction of high frequencies.

Straight dubbing from disk to film is done for release purposes by studios which record originally on disk. One or two special cases of disk to film dubbing are worthy of mention. One of these was where a certain musical selection which had been recorded on disk for the scoring of a feature picture was desired for a new feature on film. Rather than go to the expense of bringing in a full orchestra to make a new sound track, the selection was dubbed from the disk and served the same purpose. Another instance was where a silent picture, *The Silent Enemy*, had been scored entirely on disk. The first reel of this picture had a spoken prologue which had been originally recorded on film and later dubbed into the disk. On releasing this picture for foreign countries the problem was encountered of making a new first reel disk which would contain the prologue in the language of the respective countries to which it would be released. The different languages had already been recorded on film. The problem was solved by dubbing the entire first reel from the disk onto film. This film was in turn dubbed back to disk and as the spoken prologue started, the English version was turned off and the foreign version turned on. After the prologue finished we turned back to the music and completed the reel. It will be noted that the music on the completed first reel was therefore dubbed twice, from disk to film and then from film back to disk.

Disk to disk dubbing has practically no application in a studio which does all its original work on film. In a studio which records on disk, however, this form of dubbing is undoubtedly just as important as film to film dubbing in this studio.

COMBINED DUBBING AND SYNCHRONIZING

Combined dubbing and synchronizing is by far the most important application of the re-recording principle. After a picture has been completed and is cut into its final form as regards action and dialog, we find that much still remains to be done before it is ready for release. We find, for instance, many dialog scenes which are supposedly occurring in places where we would expect various forms of background noise to be heard. For instance, the dialog may be taking place in a street, and we would naturally expect to hear the characteristic street noises in the background. Actually, of course, such scenes are, as a rule, recorded in the studio, without the background noises and it becomes necessary to put these sounds in after the picture is complete. This is accomplished by combined dubbing and synchronizing.

The question might be raised as to why such scenes are not recorded in their actual location, with the real background noises taking place during the actual shooting of the dialog. There are several answers to this question. In the first place, there are many locations which are often called for in stories, where it would be practically impossible to do combined recording and photographing.

For example, if we were walking along a crowded and noisy street, and were at the same time trying to hear the conversation of two people walking in back of us, we could probably do so without much difficulty, because our ears would automatically concentrate on what we were trying to hear and would reject all extraneous noises. A microphone, unfortunately is not capable of differentiating between what we are trying to record and the background noises, for it will pick up the latter with discouraging fidelity. In addition to this there is the difficulty of controlling crowds of curious onlookers and of placing cables and other sound equipment in locations where traffic is heavy. For similar reasons it would not be practical to do any recording on an actual train. It would be found that while the noise of the wheels striking the rails would seem natural enough to a person actually sitting in a train, it would sound all out of proportion to the dialog when heard in the theater.

All such scenes must therefore be recorded in the studio, using an artificial set, and any background noises which may be necessary are easily put in later by dubbing. They can then be controlled and made to sound just as we want them to. Other examples of sound effects best put in by dubbing, which are worthy of mention, are thunder and wind noise for storm scenes, the roar of cannon or gun shots for battle and fight scenes, the noise of passing trains and automobiles for indoor scenes where it is desired to convey the effect that outdoor noises are being heard.

The argument might be raised by those who advocate natural sound effects as opposed to artificial ones, that, granted it is impossible to successfully record natural sound effects together with the dialog in the actual location, we might at least record them in the studio while the actual dialog takes place. It should be pointed out in this connection that dubbing of all such characteristic noises rather than recording them together with the action, has an advantage not only as regards tone fidelity, but also from an economic standpoint. It is of great importance that a feature be completed in the shortest possible time. If production is delayed while the monitor man experiments with the balance between voices and sound effects, the cost of production mounts up rapidly. The working crew during the shooting of a feature picture usually consists of about forty people, and is composed of directors, assistants, sound men, cameramen, electricians, and so forth, in addition to the players and extras, of whom there may be hundreds during some scenes. A dubbing crew for sound effects, on the other hand, consists at the most of ten or twelve men and they can in one or two working days synchronize a complete feature picture. By putting in the incidental effects after the picture is completed, considerably more time can be devoted and more pains taken to obtain the desired effects, at but a fraction of the cost.

Another important advantage of dubbing in sound effects is that stock sound tracks of these effects can be dubbed whenever necessary. This studio has a record of a thunder storm which has stood in good stead in the dubbing of several pictures.

Incidental music is almost always dubbed in after the picture is completed. In many pictures there are sequences which can be rendered more effective by the addition of a background of appropriate music, which can either be played by an orchestra while the dialog is being re-recorded, or can be dubbed from previously

recorded sound track. The present tendency is to avoid the use of music during the shooting of the picture wherever possible, as the presence of music in the sound track hampers the editing of a picture. Without music under the dialog it is possible to rearrange sequences, and make additions or omissions wherever desired when cutting the picture. This would be impossible, of course, if there were music in the track.

Straight musical sequences, however, such as songs or dance scenes, are usually recorded with an orchestra on the set. Attempts have been made in the past to economize on the use of orchestras during the shooting of such sequences, by having the artist sing or dance only to the accompaniment of a piano and drum, and then later dub a full orchestral accompaniment over this. This has not proved very successful, as it has been found difficult to keep the orchestra in exact time with the original track in dubbing, and even more important than this, it has been found that the artist usually does not perform with as much enthusiasm accompanied by piano and drum as he does with the aid of a full orchestra.

DIALOG DUBBING

Dialog dubbing is the expression used to describe the synchronizing of words to the lip movements of a picture which was shot silent, or with sound in some other language. This is not really a dubbing process at all, as it does not involve the re-recording principle, and is mentioned only for the sake of completeness. Dialog dubbing is used principally in adapting domestic pictures for foreign release. The foreign market has always been very important in motion pictures, from an economic standpoint. In the days of silent pictures, there was no particular problem involved, as it was only necessary to translate the English titles into the foreign language. The advent of sound pictures introduced a new problem, and three different solutions have been attempted. One is to record the picture in the foreign language while the English version is being made. This is done by having two casts, one for each version, and so record each scene in both languages. This plan was used in making the French version of *The Big Pond*. A disadvantage of this method is that the success of a picture usually depends upon the popularity of its star, and unless he can also appear in the foreign version, the picture is considerably handicapped from the box-office standpoint. It is also difficult to obtain a full cast in America to

speak a foreign language without traces of American accent. The second method seeks to overcome this problem by making the foreign version in the foreign country itself. This method is quite expensive, however, and the finished product still lacks the box-office attraction of the original star.

The third method is the so-called "dubbed" version. In this method the original picture is preserved, but a foreign cast is assembled and after much painstaking preparation, a foreign dialog script is prepared which matches the lip movements of the original version. This script is then recorded in synchronism with the original picture. The dubbed version has the advantage of preserving the original cast in the picture, but is very difficult to synchronize, and there are many places where it is undoubtedly apparent that the voices have been faked.

In making the dubbed version, only the dialog is recorded. After this has been completed, the picture must be scored and synchronized, just as an original version is. If several foreign versions of the same picture are to be made, as is often the case, it is a good plan to record all synchronized music and sound effects on a separate track. All the foreign versions can then be synchronized by dubbing this sound track.

TECHNICAL PROBLEMS IN DUBBING

We come now to a short discussion of the technical problems involved in dubbing. An ordinary recording channel is used, and the output of a projection machine is fed into one of the mixer positions on the monitor table. In the case of straight dubbing, this is all that is necessary, except for the addition of suitable equalizers, if they are required. In the case of combined dubbing and synchronizing, several projection machines or sound dubbing heads are fed into as many mixer positions, in order to combine several sound tracks. At the same time microphones and non-synchronous records can also be mixed in. In some elaborate cases of combined dubbing and synchronizing, as many as seven or eight mixer positions may be in use simultaneously. These might include the original dialog, a sound track of street noises, a synchronized track of background music, a non-synchronous record of characteristic crowd noise, one or two microphones for direct pickup of special sound effects, and so forth. All of these are under control of the monitor man and can be faded in or out in any desired combination. The combined output is

recorded in the usual fashion on film to produce a new negative which is finally cut into the finished picture.

Obviously, the quality of the combined product depends to a great degree upon the fidelity with which each separate sound track is reproduced during the dubbing process. There is a certain amount of distortion inherent in any form of reproducing apparatus. In a high-grade projector using a carefully prepared release print this distortion is quite small, and for this reason the sound reproduction in high-class theaters is as a rule quite satisfactory. When reproducing sound track for dubbing purposes, however, it should be remembered that whatever distortion is present, even though it be very slight, it is recorded into the new sound track, and when this track is again reproduced in the theater, the two distortions add up, and the final effect is much more noticeable.

It might be well at this point to go into some detail regarding the inherent distortion present in a sound projection machine so as to make clear why it is negligible in a theater using high-quality release prints, and why it constitutes a serious problem in dubbing work, where we must obtain exceptionally good reproduction and must get it from green film. (Green film is the name given to film which is fresh from the laboratory and has not been run through a projector more than once or twice.) The distortion present in a sound projector may be divided into two types. One is the loss of high frequencies, and the second is the introduction of a mechanical flutter due to lack of absolutely uniform motion of the film past the scanning beam in the sound gate, which results in distortion of the high frequencies. The simple loss of these high frequencies is not a very serious matter in a good projector. By actual measurement of frequency test films, recorded at constant level with our best commercial recording set-up, there is no appreciable loss up to 2000 cycles, and from this point upward, the loss increases gradually to about 9 db. at 6000 cycles. This loss includes both the recording and reproducing loss, and is not serious because it can be compensated for by the use of a suitable equalizer.

The introduction of mechanical flutter, however, is a much more serious problem. This flutter is apparently caused chiefly by the friction which is present between the film itself and the pressure pad which holds it in the focal plane of the optical system of the sound head. If the film has become thoroughly dry and the emulsion hardened by several days' aging, and if it has acquired a slight

coating of oil as a result of having been played through a projector five or six times, the friction between film and pressure pad is very slight and uniform, and the flutter is quite negligible. If, on the other hand, the film is green, the friction is much greater and less uniform, with the result that considerable flutter is produced which results in reproduction which is popularly described as being fuzzy or raspy. In addition to this, the softness of the emulsion allows some of it to scrape off and pile up on the pressure pad to such an extent that the film sometimes goes considerably out of focus, with resulting loss of volume especially at the high frequencies.

Much work has been done on the development of special equipment which would be capable of high quality reproduction regardless of the mechanical condition of the film. An ordinary film recording machine has recently been modified to enable it to be used as a reproducer, and appears to solve the problem quite well. This machine is capable of reproducing up to 9000 cycles without appreciable flutter, and the frequency characteristic is better than that of an ordinary projector to the extent of about 6 db. at 6000 cycles, without equalization of any sort. Another development which has been worked out for the purpose of accelerating the dubbing and synchronizing of pictures, is a "toe recording" process which enables one to dub directly from the negative of a sound track, without waiting for a print to be made. Toe recording is the process whereby the exposure in recording is held down to a point where we operate on the toe of the negative H & D curve of the film, rather than on the straight line portion. This process has been evolved with the view of making the negative and print interchangeable, so that prints can be made if desired, but the negative itself can be used to save time. As a matter of fact it has been found that the negative gives even better quality than a regular process print. Use of this process is made in cases where the synchronizing music is first recorded on separate tracks and these tracks later dubbed with the original dialog.

DUBBING EQUALIZERS

In recording sound tracks which are to be used for dubbing purposes, the level is kept as high as possible, so that the ground noise will be relatively low. This is important especially when equalizers are used, as the action of an equalizer usually results in bringing up the ground noise. Two forms of simple equalizers are used. In

dubbing from film to wax it is, of course, necessary to reduce the energy of the low frequencies; this is done by shunting an inductance coil of proper value across the projector output. In this way there is obtained a gradual cut-off of low frequencies from 500 cycles down. In dubbing from film to film use is made of a tuned circuit filter giving a gradual rise at high frequencies beginning at about 2000 cycles and coming to a peak at 6000 cycles. This rise in high frequencies approximately compensates for the combined loss which takes place in recording and reproduction.

INDIRECT RECORDING

As is quite well known, it is important to have the microphone reasonably close to the source of sound in order to obtain a good recording. Instances often arise where extremely long shots are necessary and make it impossible to get the microphone closer to the principals than thirty or forty feet. A good example of a case of this sort is in the shooting of large chorus scenes with one or two principals singing out in front. In viewing such a picture the audience would naturally expect the voices of the soloists to be clear and distinct, and to stand out from the voices of the chorus, and yet it would obviously be impossible to get a microphone close to the soloists and at the same time keep it out of the camera angle, especially if the principals move back and forth during the rendition of the number. In instances such as these we resort to what is known as "indirect recording" or more popularly, the "synchronous playback." In this method the sound is recorded first, without the picture, so that the singers may be placed in any way desired. After a good take is obtained, it is printed and then played back on the stage through large horns. The cast then take up their regular formation on the stage and go through their actions in synchronism with the sound coming from the horns, while the cameras grind. The picture is then printed together with the original sound track, and the final effect gives the illusion that both sound and action took place at the same time. In this way it is seen that full scope is give to both the sound men and cameramen to do the most justice to their respective tasks without handicapping each other. It should be understood, however, that this is not a faking process in the ordinary sense of the word, because the voices we hear are actually those of the people we see, except that they were not recorded at the same time that the action was photographed. It cannot be called a

dubbing process either, since the original sound track is used. It is mentioned in this paper simply for the sake of completeness in order to cover all forms of recording other than simple, direct recording.

In closing this paper I would like to emphasize the fact that ordinary dubbing is not a form of faking, since, regardless of how many times a voice may be re-recorded for the purpose of adding sound effects, it still remains the actual voice of the person who is seen speaking in the picture. The only time voices are really faked is in the preparation of foreign versions in which case it is done only to bring to foreign countries at least the face and personality, if not the actual voice, of a popular star. The old practice of using "voice doubles" to fake the speech of actors whose own voices were not suited for recording has been completely abandoned, and only those players who can record as well as act have survived the complete transformation which the microphone has wrought in the motion picture industry.

THREE COLOR SUBTRACTIVE CINEMATOGRAPHY*

P. D. BREWSTER AND PALMER MILLER**

Summary.—*It is suggested that the most promising line of development of the three-color camera will involve use of three films sensitized primarily for light of different colors, and that a lens of 50 mm. focus and f/2 speed will be used in connection with twin revolving bladed mirrors for splitting the light from the lens. The requirement of the positive print will be met by means of a transparent dye mordant that will at least retain the size and outlines of the negative grain to produce the necessary definition.*

It seemed to the writers that a general outline of the problems confronting those engaged in trying to improve three color subtractive pictures might be of interest to the members of the Society.

Up to the present only two color subtractive pictures have been shown, and while great improvements have been made in two color subtractive cinematography, these pictures only seem to stress more greatly the need for a three-color process. It is apparent that color cinematography will never be generally demanded by the public until it can portray colors with a reasonable degree of accuracy.

The problem is divided into two parts: first, the design of the camera, and second, the chemistry and the development of the mechanisms necessary to produce a three-color film adapted for use in any theater without changes in the projection apparatus.

It is generally conceded that any practical color camera must make its color separations simultaneously to avoid intolerable flashes or fringes of color around moving objects and that all three separations must be made from the same viewpoint; otherwise, it would be impossible to register or superimpose the several component color images in the positive.

Accepting the limitations of a camera for making simultaneous separations from the same viewpoint, the next step is to inquire into the requirements of lenses with regard to focal length and speed. Under sound studio conditions where tungsten light is very largely in

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* Presented at the Fall Meeting, October, 1930, New York, N. Y.

** Brewster Color Film Corp., Newark, N. J.

use, and where an excessive amount of light cannot be used on account of the incident heat and strain on the actor's eyes, it is necessary to use the fastest possible lens having good color correction. The limiting aperture at the present time is $f/2$.

The great size of some of the sets used in the studios, and the limited floor space of sound stages, make it essential that the color camera be adapted to use a wide angle lens of not over 50 mm. focus, though 40 mm. would be still better. At the same time the beam splitting system must permit the use of lenses of from 100 mm. to 150 mm. focal length for making simultaneous close-ups and semi-close-ups in connection with a 50 mm. camera shooting long shots.

This is a very difficult requirement for both the 50 mm. and 150 mm. lenses for several reasons. In a 50 mm. camera it is very difficult to get a double beam splitter (adapted to reflect two images and transmit one) in the small lengths of 33 or 35 mm. between the rear vertex of the lens and the focal plane; while in the case of the 150 mm. $f/2$ lens the cone of light leaving the rear vertex is nearly 75 mm. in diameter, which very greatly increases the size of the beam splitter if no light is to be lost.

Where two or three matched lenses are used, it is necessary to have a beam splitter in front of these lenses to reflect the light rays received from one point into the separate lenses, and where one lens is employed the splitter must be behind to divide the light rays projected from the single lens into three groups. We believe this can be done only in two ways; either by a series of glass prisms, or by means of a highly polished mirror revolving at an angle to the lens and in the path of light rays. This mirror consists of a disk having a number of slots in it so that one portion of the light rays is transmitted through these slots or openings, and after passing through a suitable filter, is recorded as one of the separations; the portion of the light rays which strikes the polished surface of the blades is reflected through another filter to form the second separation; a second mirror revolving at right angles to the first is used for making the third separation. The mirror usually has three blades and makes at least two revolutions for each exposure so that each frame is exposed three or four times. These repeated exposures have proven to give exactly the same effect on the screen as simultaneous exposure of the different color separations.[1]

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[1] U. S. Patent No. 1,752,477.

The glass prism system has the advantage of extending, in effect, the extremely important distance between the rear vertex of the lens and the focal plane in proportion to the index of refraction of the glass used. It also has the advantage of cheapness when compared with the revolving mirrors, while the size of the driving mechanism of the camera is reduced thereby preventing noise and reducing the size of the camera.

The revolving mirror system has the advantage of not having to transmit the light through glass, which results in a loss of light, but what is more important, a possible loss of definition near the edges of the picture if the glass path is too long. Most important of all, it is possible with a revolving mirror system to make three color separations on three separate films from a 50 mm. $f/2$ lens, without adding any lenses to the standard objective to increase the light path between the rear vertex and the focal plane.

The decision as to whether to use one, two, or three films for recording the color separations depends not only on the camera design, but also on the study of the relative efficiency of panchromatic film exposed through three filters in comparison with that of two or three separate films sensitized for the region in the spectrum which they are to record.

Color separations are usually made on panchromatic emulsions by photographing through the Wratten filter No. 25 for the red, No. 57A or 58 for the green, and 49A, 49, and 49B for the blue. Transmission curves for these filters taken from the Eastman filter chart and illustrated in Fig. 1 show that No. 25 is nearly an ideal filter for the red. It transmits light of its own color, red, with high efficiency and then cuts off the other colors abruptly. None of the green filters are nearly as perfect—they transmit blue-green and green fairly well, but cut well into the orange by a long slope, with a possible average efficiency in the very important yellow green region of 30% or 40%. This critical region which largely controls the true color rendering of flesh and foliage is also harmed by the low sensitivity of panchromatic film at this point.

The blue filters 49A, 49, and 49B are even less efficient; their total over-all efficiency being only 0.7%, 0.5%, and 0.3%, respectively, and of their most favorable colors they transmit only 42%, 26%, and 15%. They cut off practically all exposure in the violet and record solely in the true blue region, while the sloping cut transmits some of the blue-green which should not be recorded by the blue separation.

The lack of efficiency of these filters is due to inherent qualities common to all dyes of these colors and cannot be improved. In fact, we have found Wratten filters to be of very high efficiency, and were it possible to have filters in the blue and green as good as the red No. 25, which hypothetical filters are represented by the dotted lines, they would be satisfactory.

By using three separate films for the color separation, it is possible to use an old type of non-color sensitive negative for the blue separation. The sensitiveness of this type of emulsion stops almost exactly at

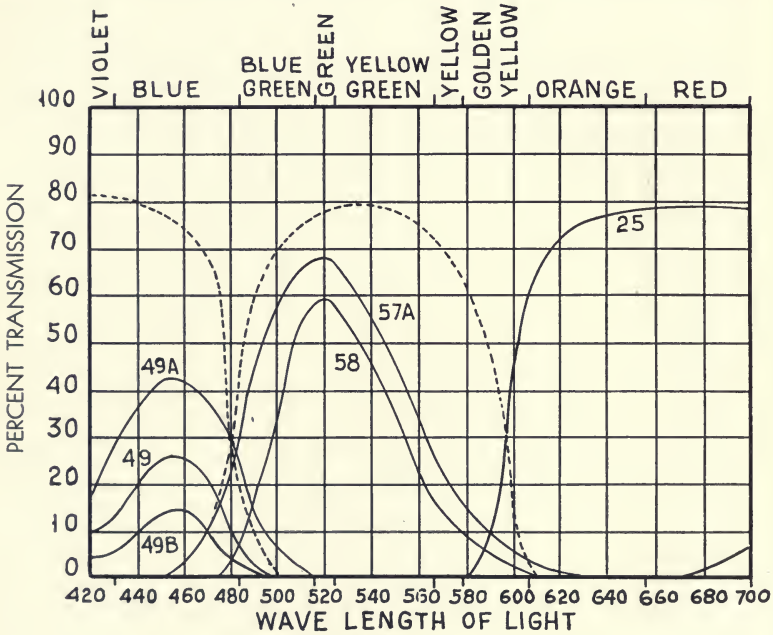

FIG. 1.

the ideal point, naturally recording the violet as well as all of the blue. Not having to use a filter, its speed is many times greater than if it were necessary to use an inefficient type of blue filter with panchromatic film. Advantage can be taken of this fact by reflecting only a small portion (possibly 10% to 15%) of the light rays received from the lens to form the blue separation.

In case of the green separation, the use of separately sensitized films is even more important, for we then are able to obtain an emulsion which records the green and yellow-green very evenly,

almost to the *D* line, and then abruptly cuts off. Of course this emulsion is sensitive to blue, but this blue is cut off by the use of a filter of high efficiency such as an Eastman K2. By this means we get a much higher over-all efficiency and are able to record the yellow-green region with much greater fidelity.

The red separation can be made on a red sensitive emulsion, but the present panchromatic emulsion is excellent for this purpose. In either case it is necessary to use the No. 25 filter which cuts in exactly the correct place and which has a very high efficiency.

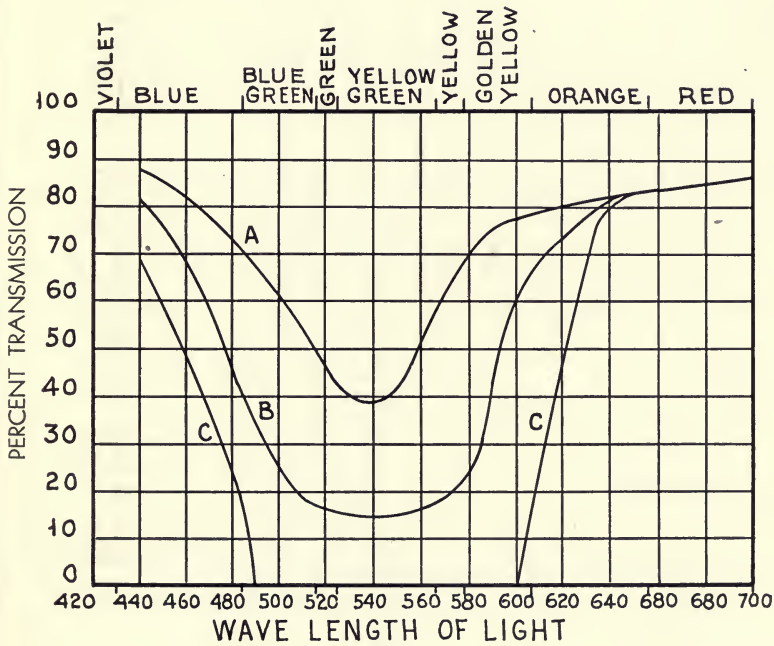

FIG. 2.

There is a second point in favor of separate films. It is well known that if different portions of a negative emulsion are exposed to light of different colors, they will develop to different contrasts for the same time in the developer; or these different portions of the films acted upon by lights of different colors will have different gammas. This would result in an incorrect contrast scale of the color positive, and make it difficult, if not impossible, to get a true rendering of highlights and shades; though it would be perfectly possible to reproduce

middle tones in the picture substantially correctly. The film exposed to the red light will develop the highest contrast or gamma, and the blue the lowest, for a given time in the developer. For example, if the middle tones were correct one might have red highlights and blue deep shadows.

By determining in advance the gamma curves of the separate films for light of the three primary colors, it is possible to time the development of these films so that they will produce three negatives of equal

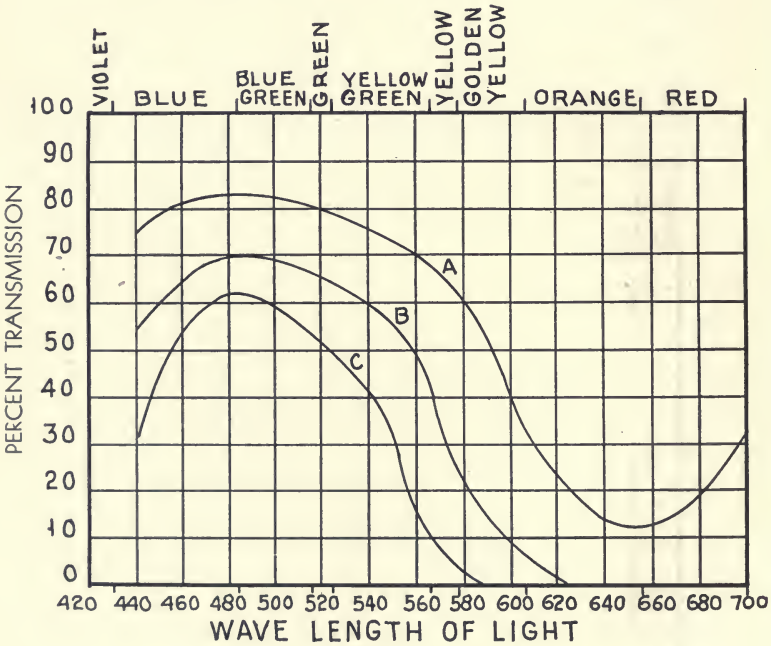

FIG. 3.

gamma, or contrast range, from which correct positive prints can be made.

In our opinion, the requirements in the positive for each of the component images of a three color film are: definition, transparency, gradation, and hue.

Definition, especially for the blue-green and magenta images, is a matter of extreme importance. In our experience, it is necessary to retain the outlines and size of the negative image grain on the screen in order to maintain proper sharpness. Anything less than this pro-

duces a soft effect which, although very desirable for certain effects, is objectionable for long shots.

Transparency throughout the entire color range is absolutely essential. Three color cinematography requires the exact blending of all colors, and frequently needs a small percentage of one primary mixed with the other two to obtain the exact shade. It is essential that each of these primaries, whether in heavy or light shades, shall be absolutely transparent and not have the heavy tones blocked up

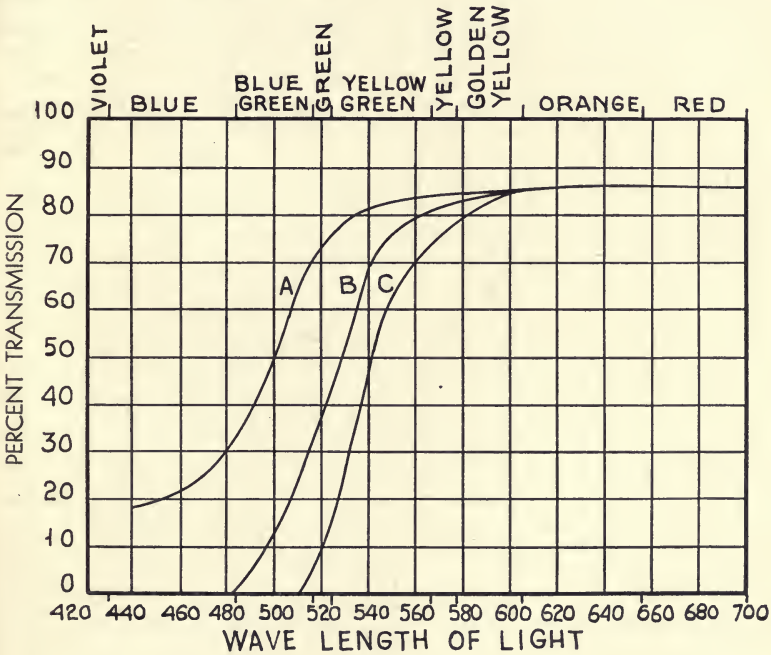

FIG. 4.

by a residual silver or mordanted image. The ideal component image would be like a color filter, pure color imbedded in the gelatin.

Finally we come to the hue and gradation of the color images. We again have the same difficulty in securing dyes that approximate the ideal as noted in the case of the filters.

The ideal requirements of the three color dyes are that each should transmit as nearly as possible 100% of the light of two of the three primary colors and in its heavier densities absorb entirely light of the other primary color.

In Fig. 2 Curve *C* shows the transmission of a heavy step in a magenta "H & D" strip and curves *A* and *B* the lighter steps. This dye passes nearly all the blue and red but no green. Figs. 3 and 4 show the blue-green and yellow curves for the same densities.

In order to obtain a good black it is necessary that each of the three colors absorb practically all light of one of the other primaries, and it is equally important that each in their lighter gradations pass practically equal quantities of the corresponding primary in order to obtain good greys, as is seen by the opening of the filter in the lighter steps. With the three dyes shown equal densities of the three superimposed yield a grey.

DOUBLE TONING OF MOTION PICTURE FILMS*

J. I. CRABTREE AND W. MARSH**

Summary.—*A motion picture image with green shadows and blue halftones can be prepared by toning the image blue in the usual toning solution, fixing in hypo, washing, and then re-toning followed by immersion in a solution of a basic dye. In this way the first toning bath converts the silver image to a mixture of Prussian blue and silver ferrocyanide, the reaction going to completion in the halftones but incompletely in the shadows so that some of the silver is unaffected. The silver ferrocyanide is removed in the hypo solution leaving an image consisting of pure Prussian blue in the halftones and a mixture of this substance and silver in the shadows. On re-immersion in the blue toning bath, the silver in the shadows is again converted to a mixture of Prussian blue and silver ferrocyanide which latter substance is a mordant for basic dyes, so that on immersion in a dye solution the dye is absorbed only to the shadows.*

Commencing with a black and white image on positive motion picture film, it is possible to color this differentially by purely chemical means so that the hue of the shadows is different from that of the halftones while the highlights remain perfectly clear.

One method of accomplishing this worked out by one of the authors and described previously[1] consists in toning the positive image in the usual single solution iron toning bath from which the potassium alum has been omitted, washing, and then immersing in a solution of a basic dye. The omission of the potassium alum from the formula causes the bath to convert the halftones to white silver ferrocyanide while only the shadows are toned blue. On immersing the film in a basic dye, the halftones assume the color of the dye while the color of the shadows is a combination of blue and that of the dye employed. For example, safranine gives pink halftones and purple shadows while auramine gives yellow halftones and green shadows.

A new method of double toning recently devised produces blue halftones and differently colored shadows. The procedure consists of four operations as follows:

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* Presented at the Fall 1930 Meeting, New York, N. Y.

** Communication No. 455 from the Kodak Research Laboratories.

(1) Tone the positive print of normal quality in the following:

	Avoirdupois	*Metric*
Ammonium persulfate	$3^1/_4$ ounces	100 grams
Ferric alum (ferric ammonium sulfate)	$8^1/_4$ ounces	250 grams
Oxalic acid	$1^1/_4$ pounds	600 grams
Potassium ferricyanide	$8^1/_4$ ounces	250 grams
Ammonium alum	1 pound 10 ounces	800 grams
Hydrochloric acid (10%)	$6^1/_2$ ounces	200 cc.
Water to make	50 gallons	200 liters

The method of compounding this bath is very important. Each of the solid chemicals should be dissolved separately in a small quantity of warm water, the solutions allowed to cool, filtered into the tank strictly in the order given, and the whole diluted to the required volume. If these instructions are followed, the bath will be a pale yellow color and perfectly clear.

Time of Toning.—Tone fully at 70°F. (21°C.). The color of the toned image varies from a light bluish gray for short time toning (about 3 minutes) to a deep blue for long time toning (10 minutes).

Time of Washing.—Wash for 10 to 15 minutes until the highlights are clear. A very slight permanent yellow coloration of the clear gelatin will usually occur, but should be only just perceptible. If the highlights are stained blue, then either the film was fogged during development or the bath was not compounded correctly. Washing should not be carried out for too long a period, especially with water inclined to be alkaline, because the toned image is soluble in alkali.

Life of Bath.—If the acid is renewed to the extent of the original amount after toning each 5000 feet, the bath is capable of toning 15,000 feet per 50 gallons of solution.

If even after revival the tone remains flat, the bath is exhausted and should be thrown away.

After continued use, a slight bluish sludge will collect in the bath, but this is not harmful. Should this form, to any appreciable extent, it is a result of incorrect mixing, the action of light, contact with metallic surfaces, or the presence of hypo in the bath.

(2) Immerse in a 10 per cent solution of hypo for 2 to 3 minutes and wash for 5 to 10 minutes.

(3) Re-immerse in the above iron toning bath for 5 minutes and wash for 10 to 15 minutes.

(4) Immerse in the solution of the basic dye for 5 to 15 minutes

until the desired depth of color in the halftones is obtained. The formula for the dye solution is as follows:

Dye	3.2 grams
Acetic acid (glacial)	2 cc.
Water to make	4 liters

Dissolve the dye thoroughly in hot water, filter, add the acid, and dilute with cold water. After toning, wash the film in water until the highlights are clear or the halftones are blue.

Suitable dyes are Safranine A (pink), Chrysoidine 3R (yellowish brown), and Auramine (yellow) supplied by the National Aniline & Chemical Company, New York, N. Y. They produce purple, dark green, and green shadows, respectively.

Theory of Process.—(*a*) The iron toning bath consists essentially of a solution of ferric ferricyanide in oxalic acid. This reacts with the silver image forming silver ferrocyanide and ferric ferrocyanide according to the following equation:

$$4Fe_3(FeCN_6)_3 + 12Ag = 3Ag_4FeCN_6 + 3Fe_4(FeCN_6)_3$$

Ferric Ferricyanide — Silver — Silver Ferrocyanide — Ferric Ferrocyanide (Prussian blue)

The reaction goes to completion in the highlights but not in the shadows so that after toning the composition of the shadows and halftones may be represented as follows:

Halftones—Silver Ferrocyanide + Prussian blue
Shadows —Silver + silver ferrocyanide + Prussian blue

(*b*) Treatment with hypo removes the silver ferrocyanide from the halftones and shadows leaving Prussian blue in the halftones and a mixture of silver and Prussian blue in the shadows.

(*c*) Further treatment in the blue toning bath does not affect the halftones but the silver in the shadows is converted to a mixture of silver ferrocyanide and Prussian blue as explained above. The composition of the shadows and halftones is now as follows:

Halftones—Prussian blue
Shadows —Silver Ferrocyanide + Prussian blue

(*d*) Silver ferrocyanide is a mordant for basic dyes and on immersion in the dye bath the blue color of the shadows is therefore modified by virtue of the addition of the dye.

Effect of Toning on Sound Track.—Tests with both the variable area and variable density types of sound records indicated that toning by the above method had little or no effect on sound quality. It is therefore possible to apply this method to sound prints.

Equipment.—Suitable materials for the construction of processing apparatus have been described.[2] Allegheny metal is fairly resistant to toning baths but hard rubber is the most satisfactory material for constructing sprockets or moving parts which come into contact with the toning solution.

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DISCUSSION

MR. TEITEL: I would like to point out, in regard to multi-toning, that these colors have been successfully produced in the laboratories of the Multicolor Improving Co., Inc., as far back as 1914. When projected, the colors will show up properly only when the subjects portrayed are still objects. If the subject were in motion, as a moving person, vehicle or fast moving clouds, the effect would be that of a mass of uneven color spots, quite unpleasant to view.

MR. CRABTREE: I agree, of course. The applications of the process are limited.

SOME CAUSES FOR VARIATIONS IN THE LIGHT AND STEADINESS OF HIGH INTENSITY CARBONS*

D. B. JOY AND A. C. DOWNES**

Summary.—*The arc length-arc voltage relations of the high intensity arc depend very largely upon the relative positions of the positive and negative carbons. There is a very definite point at which the light is a maximum and the point of maximum light is not the point of maximum steadiness.*

It has been shown[1,2,3,4] that the relative positions of the positive and negative carbons in the high intensity arc affect its behavior. This paper deals with the variations in the relative positions possible in commercial lamps where the angle formed by the axes of the two carbons is fixed. It will be shown that rather minor variations have an unexpectedly large effect on the amount of light and the steadiness of the arc.

The results of these variations are common to all types of high intensity lamps and carbons but the greater part of the work described here was done on 13.6 mm. positives with $^3/_8$ in. copper coated cored negative carbons at 120 amperes unless otherwise specified. The angle of the axes of the carbons was 45 degrees.

It has been the practice for carbon manufacturers to specify the current at which high intensity carbons of various sizes should be burned, but they have been reluctant to specify the voltage. A glance at Fig. 1 will explain the reason for this reticence. This figure gives graphic representations of three 70 volt arcs, but the arc lengths, measured as shown in the figure, vary from $1^1/_8$ in. to $^5/_8$ in. In X the negative flame does not touch the lower part of the positive carbon, in Y it just touches it, and in Z it overlaps it considerably. These arcs give entirely different results in quantity and quality of crater light and the projectionist would only be confused by any voltage specification without qualification as to the relative position of positive and negative carbon and this latter relationship is probably more important than the arc voltage.

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*Presented at the Fall 1930 Meeting, New York, N. Y.

**Research Laboratories, National Carbon Company, Inc., Cleveland, Ohio.

The most practical means of studying the results of the movement of the positive carbon with respect to the negative is to hold the negative carbon tip in one position and move the positive carbon along its axis. Graphic representations of the arcs obtained at 120 amperes by moving the positive carbon successive steps of $^1/_8$ in. along its axis are given in Fig. 2. The arc voltage for this particular set varies from 86 in position *A* to 55 volts in position *F*. The negative flame in position *A* in Fig. 2 is considerably ahead of the positive so that the positive flame actually rolls out of the bottom of the positive crater before the negative flame strikes it and diverts it upward. As the positive carbon is moved ahead this condition is altered so that at *D* the edge of the negative flame just touches the lower edge of the positive carbon and practically the whole negative

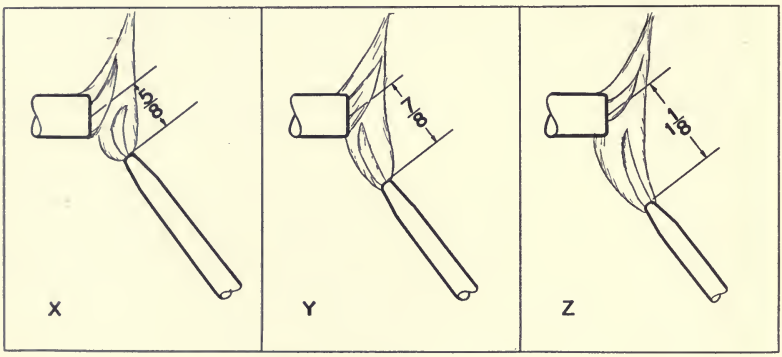

FIG. 1.

flame is sweeping across the crater opening as though compressing the positive flame. Finally at *F* a good portion of the negative flame plays against the bottom of the positive carbon and again only a part sweeps across the positive crater. The values of relative light and arc voltage for these different arcs at 120 amperes are shown in Fig. 3. The maximum useful light is obtained at position *D* (as would be expected from the above description of the action of the negative flame against the positive crater opening). The light diminishes as the positive is moved in either direction from position *D*.

Unfortunately the position of maximum light is not the position of maximum steadiness. With the arc in position *A*, the direction of the positive flame from the crater is not stable, resulting in many

large flickers in the crater or useful light. This condition is improved as the positive carbon is moved forward so that the large flickers decrease and are practically eliminated at positions *C* and *D*. In these positions small flickers of rather short duration are evident. The negative flame is either just hitting or just clearing the lower side of the positive carbon in these positions and tends to oscillate on and off the edge of the positive shell in a rapid movement causing medium size flickers of short duration.

When the positive has been advanced to position *E* in Fig. 2 the edge of the negative flame is permanently on the bottom side of the

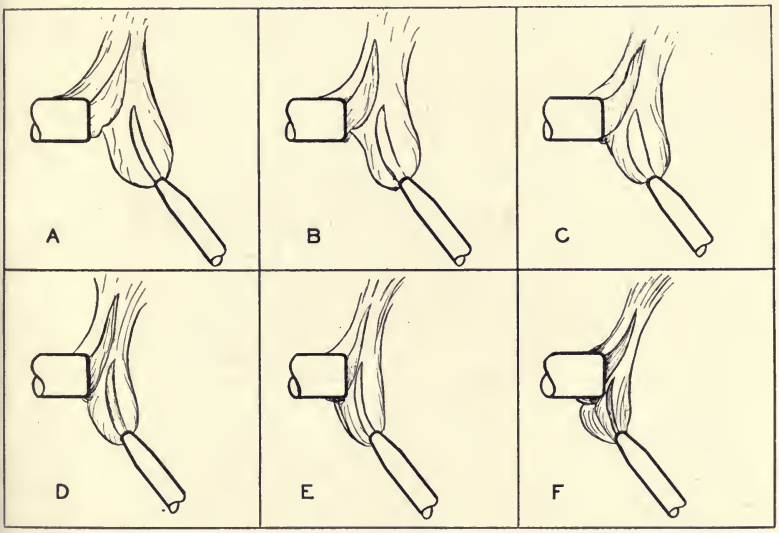

FIG. 2.

positive shell and the negative flame drives against the positive arc stream with a steady force of uniform direction and magnitude so that there is practically no flicker in the useful light from the arc. With the arc in this position, a high intensity spot lamp has been observed for half an hour at a time without detecting any noticeable flicker in the spot.

The light is lower as shown in Fig. 3 for this position than in position *D* where some flickering is obtained. The light is still lower in position *F* without any change in steadiness so that the optimum condition position is that in which the edge of the negative flame

impinges on the positive carbon as close to the end as possible without noticeable flickering on the screen or in the spotlight.

If the positive carbon is changed from *C* or *D* to that of *E* without changing the position of the negative or the ballast resistance, as is often done in the projection booth, there might actually be an increase in light with the elimination of practically all of the noticeable

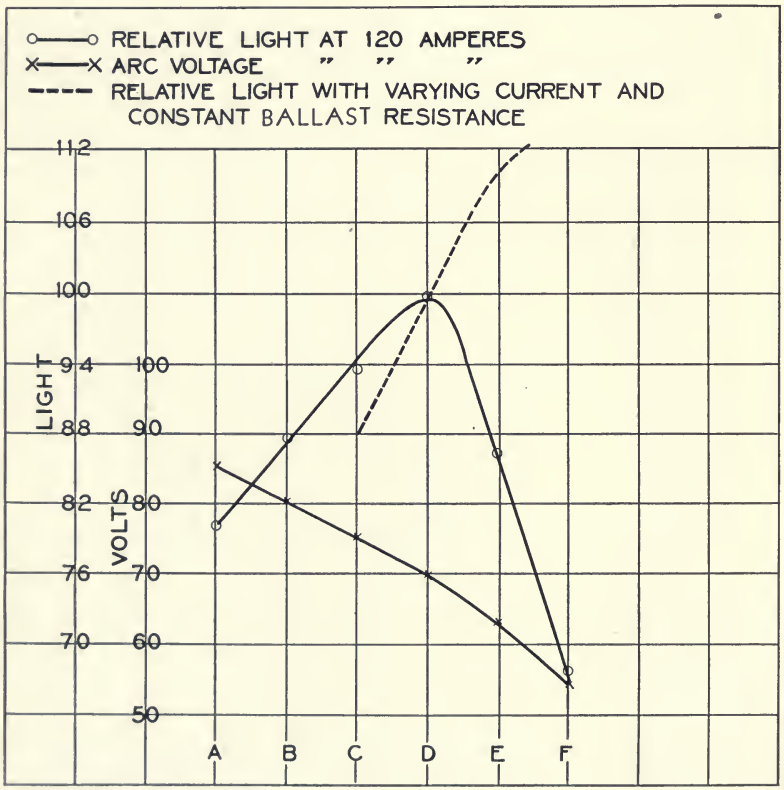

FIG. 3.

flicker. If the positive is moved in the opposite direction toward position *A* the decrease of light will be much greater than that shown in the solid line of Fig. 3. This change is shown by the dotted line in Fig. 3 for a 115 volt power line. The reason for this is obvious when the decrease of voltage in going from *A* to *F* is noted. If the ballast resistance and line voltage were kept constant, a movement

of the positive from position A to any of the other positions would necessarily give an increase in current.

The distance from the projected axis of the positive carbon to the tip of the negative carbon for the arc illustrated in Fig. 2 is $^5/_8$ in. Similar experiments were made with distances of $^1/_2$ in. and $^3/_4$ in., with exactly the same results. Within these limits and with the same relative position of the positive and negative flames the arc length had no noticeable effect on the useful light.

In the high intensity arc burning 16 mm. positives and 11 mm. plain cored negatives with an angle of 28 degrees between the carbon axes, it was found similarly that the position of maximum light was not that of maximum steadiness and that the edge of the negative flame definitely bathed the lower edge of the positive carbon when the light was most free from flickers.

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DISCUSSION

MR. BASSETT: I should like to congratulate Mr. Downes on this short paper with a lot of meat in it because it is the first time that one of the mysteries of the high intensity arc has been brought down to a concise explanation. Some operators can always get the best out of a high intensity arc, and this was considered a special knack. Any operator who will study this paper can acquire the knack and improve his projection.

MR. BENFORD: I think there is one point about that paper that might be stressed a little more and that is that it is not always wise to increase the current in order to get more light. When the electrode is over-loaded it is likely to smoke and the gas becomes extremely unstable. I have known of several cases where there is an actual decrease in light after the current had been increased some 10 per cent over its rated value.

PRESIDENT CRABTREE: What are the probabilities of our getting a light source of greater brightness; also what is the temperature of the brightest source that you have been able to obtain as compared with the sun?

MR. BENFORD: The temperature of the high intensity current as measured by its color is some 5600°K., a brightness temperature which is comparable with that of the sun.

PRESIDENT CRABTREE: This is of importance in connection with large screen

pictures. With the present 35 mm. film with a very small aperture, we cannot get enough light through it to give a large screen having sufficient brightness. That is one of the unfortunate limitations of the use of 35 mm. film for the very large theaters.

Mr. Downes: In the paper we presented last year, I think at Toronto, there were values given for the average intrinsic brilliancy of several high intensity arcs. The most efficient one is the 13.6 mm. arc at about 125 amperes when looked at from the point of view of high average intrinsic brilliancy. That particular one, as I remember it, is of the order of 820 candle-power per square millimeter of crater opening area. That is the highest of all the ordinary high intensity arcs. The super high intensity arc at about 250 amperes has a higher intrinsic brilliancy, say from 850 to 1200 candle-power per square millimeter with the sun at about 900. Attempts have been made to use this arc for motion picture projection but so far this seems impracticable as this arc tends to be unstable and is very difficult to handle. There is work going on in our laboratories in efforts to improve the figures, and we hope that we may be able to get something satisfactory for the large size pictures.

President Crabtree: Yes, but what percentage increase of brightness over the present source are you hopeful of getting?

Mr. Downes: To increase the intrinsic brilliancy and at the same time retain the necessary steadiness of operation is very difficult and efforts to do both have not been very successful so far. Probably slightly larger light sources of about the same intrinsic brilliancy as the present arcs can be used.

AN ESTIMATE OF THE PRESENT STATUS AND FUTURE DEVELOPMENT OF THE HOME TALKIES*

J. B. CARRIGAN** AND RUSSELL C. HOLSLAG†

Summary.—*In this paper the 16 mm. home talkie situation is considered from the viewpoint of the amateur. The nature and interests of present users of 16 mm. apparatus are discussed. It is concluded that only a modest distribution of sound equipment among the amateurs will be realized, and that widespread use of this equipment will be found in a new group looking more for a source of entertainment than for a hobby. Available 16 mm. sound apparatus and subject matter are described. An estimate of possible developments in apparatus and appropriate subjects is given. There is also a discussion of the amateur's requirements in regard to sound apparatus from the technical viewpoint.*

In approaching the problem of the 16 mm. home talkie, it will be the purpose of this paper to examine the subject primarily from the viewpoint of the users and prospective users of home talkie equipment, considering its many angles chiefly as the consumer sees them and touching upon the questions of its nature, design, production, and distribution as they affect or will affect this great potential market. The conclusions reached are based on the data which it was possible to secure from the industry and upon personal contact or correspondence with the thousands of present home movie users who are members of the Amateur Cinema League, their international organization, or readers of its publication, *Movie Makers*.

Prior to the comparatively recent widespread adoption of sound motion pictures in the commercial theaters, the home, or amateur movie field, was concerned solely with the making or projection of silent pictures. It is a major fact in the situation that this is still practically the case. One reason for this lies in the difference between the interest of those who have so far embraced amateur movies, approximately 200,000 people, and the millions who are the patrons of commercial movie theaters. Both are seeking entertainment, of

* Presented at the Fall 1930 Meeting, New York, N. Y.

** Editor of *Movie Makers*, magazine of the Amateur Cinema League, Inc.

† Technical Editor of *Movie Makers* and Technical Consultant of the Amateur Cinema League, Inc.

course, but the latter find satisfaction in entertainment in which they take no part, and of which they are merely spectators. The amateur movie enthusiasts, on the other hand, find in their avocation, entertainment of an active nature, a recreation in which they are producers, exhibitors, and spectators combined. All of these functions are a present actuality with the silent film, whereas the making of home talkies is at present attended with such difficulties that the results are nearly always of an indifferent sort. Consequently only a part of the enjoyment of home movies to which they are accustomed is provided by the present home talkie. One may rent or buy professional 16 mm. talkie productions synchronized with disk records for showing on any one of several machines now available for this purpose. One may be an exhibitor and spectator but not be a producer. This, with the vast majority of the present group of amateurs, would not seem to be wholly satisfying. Hence, we find a very practical psychological reason for the modest distribution to date of sound apparatus among the present home movie consumers.

But, it might be asked, are there not thousands of amateurs who are interested only in projection, who have bought projectors in order to be able to have their own home movie shows and who are not interested in making their own films? Undoubtedly there are some who answer to this description, but the limited number would be astonishing to anyone examining the situation unless one were more or less acquainted with the nature of the home movie enthusiast. While it may be obvious that there are practically no camera owners who do not have projectors, the converse is also true, that there are very few projector owners who do not also own cameras. That more projectors are sold than cameras might point to a different conclusion but examination of the facts shows that this disparity comes chiefly from the wide purchase of projectors by industry for use in selling, by schools for the development of visual education programs, and so forth.

Therefore, it would seem reasonable that we may not look to the present type of amateur for a wide adoption of home talkies until such time as the amateur can make his own. There will be a steady conversion of large numbers of the present group, of course, since the distinctions which have been drawn are purely relative and vary in intensity with the individual. The availability of synchronized films, on both a sale and rental basis, is a vital factor. At present, the home talkie offerings are distinctly limited, for the combined sale

price of film and disk is considerable. Rental libraries for inexpensive distribution are just coming into being but undoubtedly these facilities will rapidly be improved and an increasing amount of talkie equipment be gradually absorbed by a certain percentage of the present silent film users.

But, if this would not seem to promise a wide growth for home talkie exhibition, wherein lies the future of this development? Having described the present home movie user as somewhat similar to the radio fan, who in the early days of radio was chiefly concerned with the making of things, we must not forget that these radio set constructors were decidedly limited in number when compared with the millions who today enjoy commercially built radio receivers. Nor should we overlook the similarity between this latter group, enjoying the sedentary amusement of radio reception, and the millions, possibly the very same, who patronize the commercial talkies.

FIG. 1. Victor Animatophone with unique vertical turntable for 16 mm. talkies.

That the users of home talkies should ever approach in number those enjoying radio reception seems doubtful. While the first cost does not seem to be prohibitive, as home talkie equipment can even today be bought as moderately as a good radio and will undoubtedly be cheaper in the future, upkeep, however, is a different matter. The program for a radio set costs its owner nothing, at least directly, while home talkie programs mean a regular and not inconsiderable outlay. Furthermore, the radio requires only the turn of a knob in order to operate it, while the showing of a film and synchronized record requires more effort and intelligence. However, this problem, which will be discussed more fully later on, is not insurmountable.

Let us now consider the 16 mm. talkie equipment commercially available. As mentioned before, only projection equipment has to date been marketed and all of these machines have provided only for sound-on-disk. No sound-on-film apparatus has yet been offered commercially, although many companies are said to be working on such equipment. Several of the sound-on-disk machines first advertised for the home have been withdrawn by their makers because of technical obstacles encountered in their satisfactory operation under home conditions. At the moment, there are three 16 mm. units being offered specifically for home use, the Cine-Voice, produced by the Hollywood Film Enterprises, Inc., of Hollywood, California, the Tone-O-Graph, manufactured by the North American Sound Pic-

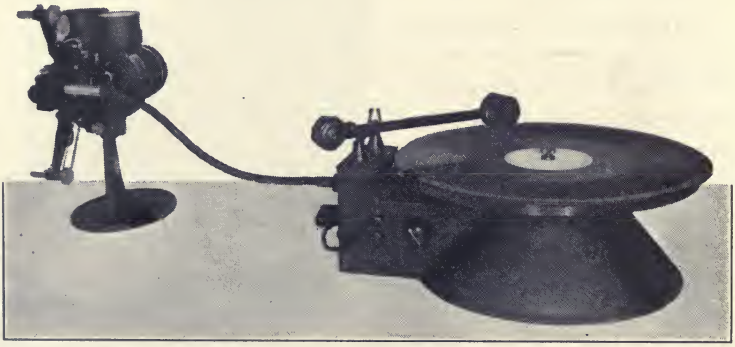

FIG. 2. Cine-Voice, attachable with flexible shaft to any make of 16 mm. projector.

tures Corporation of New York City, and the Filmophone-radio, of the Bell & Howell Company of Chicago. Pathé Films, Inc., is also offering a 9.5 mm. machine. Two other units are being distributed specifically for use in industry and education, although they may be used in the home as well. They are the Project-O-Phone, manufactured by the Bell & Howell Company of Chicago, and the Cinetone of the QRS-DeVry Corporation, also of Chicago. Two other units which will be appropriate for home use will shortly be announced for distribution. They are the Animatophone of the Victor Animatograph Corporation of Davenport, Iowa, and the Visionola of the Visionola Manufacturing Company, New York City.

The Cine-Voice may be attached to any of the 16 mm. projectors now in use. It is a separate twelve or sixteen inch turntable unit

which is operated by the projector motor through a flexible shaft attachment. It will play either $33^1/_3$ rpm. theater records or 78 rpm. home phonograph records. When using the former, a film speed of 24 frames per second must of course be used, the regular sixteen frames per second for the latter. It can be played either through the home radio set or through a standard amplifier and dynamic loud speaker which are available as a separate unit. It sells from $105 to $129 plus $80 for the amplifying unit.

The Tone-O-Graph, consisting of motor, projector, and turntable for 16 inch records, is a compact unit incorporated in a single carrying

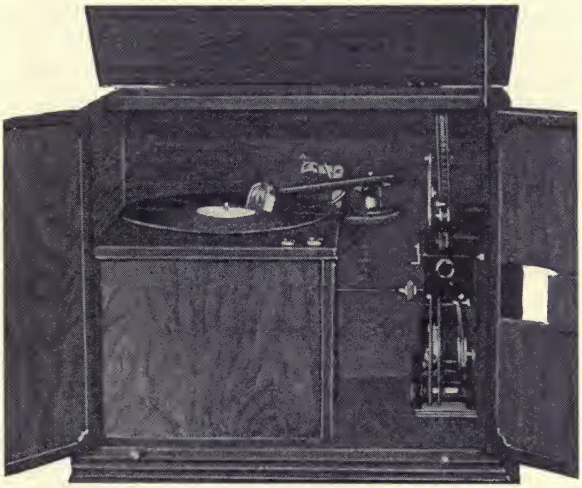

FIG. 3. Pathé cabinet model for 9.5 mm. sound pictures.

case. The separate motor unit drives both projector and turntable in synchronism. It can be operated through the home radio or a separate amplifier unit. It can be adapted for either $33^1/_3$ or 78 rpm., and film speed of either 24 or 16 frames per second. Its price is $175.00, amplification system extra.

The Pathé 9.5 mm. machine is cabinet housed and one motor operates both turntable and projector. The cabinet may be closed during projection, a port being provided in one of the doors for the light ray. It sells at $195, plus amplification system.

The Bell & Howell Project-O-Phone is provided in three carrying cases, one for projector, one for dynamic speaker, and one for a turn-

table and amplifier. The turntable is operated by an induction motor independently of the projector motor, excepting in so far as they are connected by a flexible shaft, insuring synchronous motor action but relieving the projector motor of the turntable load. Its 16 inch turntable revolves at $33^1/_3$ rpm., with film speed at 24 frames per second. It weighs sixty-nine pounds and sells complete at $761.

The Filmophone-radio, also manufactured by this company, is a combination home talkie and radio placed in a handsome cabinet with synchronized turntable for either 78 or $33^1/_3$ rpm.

The QRS-DeVry Cinetone uses an independent synchronous motor which controls both projector and turntable. A specially designed governor insures fixed operating speed. Projector, motor, sixteen inch turntable, and pickup are contained in one case, the amplifier and speaker are packed in another, being separated when in use. It operates at $33^1/_3$ rpm., film speed of 24 frames per second, weighs ninety pounds, and is priced at $500 plus tubes.

The Animatophone is unique in construction, varying from the other units described in that the turntable operates in a vertical position, perpendicular to the projector base, instead of in the customary horizontal plane. In this instrument, the shaft of the turntable is intimately connected with the projector mechanism, being operated through an extension of one of the projector gear shafts, thus eliminating the necessity for auxiliary flexible shafts or gear trains. The customary electrical pickup and arm are used, counterbalanced so that the needle comes in contact with the vertical record with the correct pressure for reproduction. It runs either at $33^1/_3$ rpm., film speed of 24 frames per second or, by shifting the turntable to a secondary geared shaft, at 78 rpm., film speed of 16 frames per second. Thus either 16 inch records or ordinary home phonograph records may be reproduced. A special "air vane" governor has been incorporated in a revised model of the Victor Projector which must be used in connection with this unit. The blast from a cooling fan on this governor, impinging against a vane which causes a break in the circuit when the speed is too high momentarily slows down the motor to the proper speed, whereupon the contact is reëstablished. Amplification may be provided either by the home radio or by means of a unit and speaker provided separately. The device will sell at approximately $100, not including projector, amplifier, and speaker.

The Visionola will be the most elaborate unit yet offered, combining an electric phonograph, projector, radio, and screen, all in a

cabinet of the more elaborate console type. The screen is constructed on the underside of the cabinet cover. When raised it assumes the proper angle to receive the screen image. A small mirror, carried on a collapsible arm drawn from the front of the cabinet, reflects the film image from the projector back to the screen. A unique arrangement of the film feed and takeup reels on a panel in the front of the cabinet allows easy threading. The radio unit is placed below the projector unit. The turntable, operated by the same motor which operates the projector, is in the upper part of the

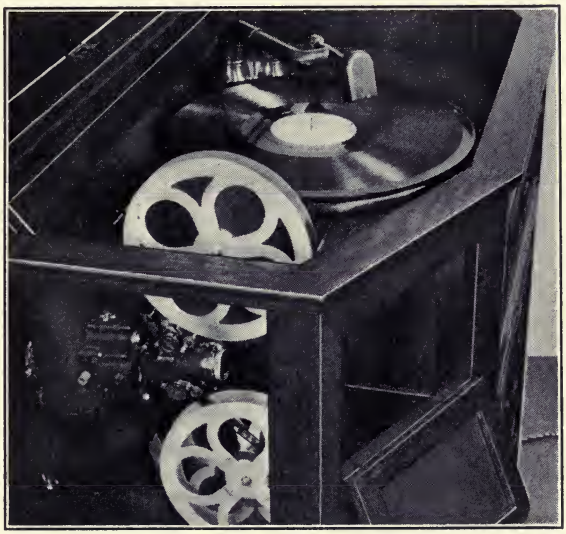

FIG. 4. Bell & Howell Filmophone radio, a 16 mm. talkie cabinet model.

cabinet above the projector. It can be operated at $33^1/_3$ or 78 rpm. with appropriate film speeds. This unit will retail at $500.00.

These, then, are the chief instruments at present available. Films synchronized with disks are now being offered in limited numbers by various companies, including Bell & Howell, Hollywood Film Enterprises, Q.R.S.-DeVry, Fowler Studios, and, most recently, Pathé. Among the present professional producing companies which are releasing theater sound subjects on 16 mm. through the companies mentioned are Ufa, Amkino, Educational Pictures, Inc., and Pathé.

But what other developments may be looked for in the near future

on equipment for sound-on-disk picture projection? What does the future hold for sound-on-film projection apparatus? Is there any prospect of taking-apparatus either for sound-on-disk or sound-on-film? What steps are being taken to provide a larger and finer supply of sound film subjects?

There will certainly be several more sound-on-disk projection machines offered in the near future. In the field of amateur recording, 16 mm. sound-on-disk recording cameras will probably be available in 1931. Sound-on-film projection machines will come still later, possibly in 1931. Almost certainly the last development will be 16 mm. sound-on-film recording cameras.

In regard to increased offerings of sound films, within six months or a year, there should be greatly increased facilities for home talkie programs of the highest quality, provided from the professional production field.

Let us now consider some of the practical problems arising in the use of home sound pictures by the amateur and some of the advantages and disadvantages of both sound-on-disk and the sound-on-film methods. We have seen from the general development of non-professional, or home projection, apparatus that the sound-on-disk synchronizer has so far led the field. The reasons for this are logical. First of all, the turntable and pickup furnished with the home talking picture unit are similar in operation to that of the familiar phonograph and usually little difficulty is experienced in making it work properly. For the rest, since the turntable is connected to the projector by mechanical means, it is only necessary to thread and operate the projector in the usual way. The only added points of difficulty, therefore, are the careful starting of the pickup needle at an indicated spot on the record groove and the placing of a marked film frame in the projector gate, a simplified facsimile of the professional procedure in a theater projection booth when synchronized records are employed. But, whereas the machine in the theater booth is provided with specially built pickup and amplifier systems, the electrical and acoustical characteristics of pickup, amplifier, loudspeakers, and horns being carefully coördinated, the home projectionist usually turns to an unclassified selection of electrical apparatus in order to reproduce the sound vibrations recorded on the disk. The pickup is always furnished with the sound attachment but there is no guarantee that good results in amplification will be obtained when the pickup output is amplified and reproduced through a radio receiver. Such amplify-

ing systems are notorious for their widely varying characteristics and it is only by chance that the best results are obtained, since the impedance of the pickup should be taken into consideration when designing amplifier transformers for use in conjunction with it. Loud speakers also are of widely varying types although in most modern sets some form of the dynamic cone is employed.

The home sound projectionist usually makes no effort to place his loud speaker in such a position relative to the screen that the illusion of sound actually emanating from the picture is produced. He is usually content to leave his loud speaker in a fixed position with relation to the radio set—many times the loud speaker is incorporated in the set—and to erect his screen on a wall or table. The sound volume simply fills the room, with no directional effect whatever.

The deplorable tendency to judge a radio set by the amount of noise it will emit seems unfortunately to be carried over by the amateur to his motion picture sound projection. No matter what the size of the screen picture, and it is sometimes as small as 30 by 40 inches, the tendency is to produce a great volume of sound, simply because the amplifier will permit it. Not realizing that this does more to destroy the illusion than to create it, this type of amateur soon tires of home talkies and wonders why they seem unnatural.

In general, therefore, it would seem that with the present home sound synchronizing equipment now in use, there is little chance of even approaching the almost perfect illusion afforded by the specially coördinated apparatus used in the better theaters. Until home talkie outfits are commercially introduced that are entirely self-contained—turntable, projector, pickup, amplifier, and loud speaker self-contained and technically coördinated—the satisfactory reproduction of home talkies is uncertain.

It appears also, that it will be practically impossible to duplicate the perfection of theater installations even on a miniature scale, since remodeling of rooms to improve acoustical properties, the installation of large exponential horns, control boards, and other aids are out of the question for the amateur. In most homes, the motion picture projector is regarded as a piece of portable equipment to be packed up and stowed away in the closet when not in use, and, although several manufacturers have introduced the permanent cabinet idea—the use of a projector as a piece of furniture—it has not met with as much success as predictions would indicate. One reason probably is the already crowded condition of the living room of the average American

home which boasts its console or cabinet radio set and overstuffed furniture. The introduction of another cabinet to take up floor-space is frowned upon, and the fact that a talking motion picture cabinet with self-contained screen must of necessity be large is a definite factor for its sales resistance except in those cases where the home is large.

Refinements in the mechanics of home talking picture apparatus have in a general way followed the early development of professional synchronized disk work. Independent designers found that a direct connection of turntable to projector without the intervention of adequate mechanical filters was unsatisfactory for the reasons that the tendency to "flutter" was produced by the projector gears and that the projector usually had no electrical or mechanical governor for maintaining a uniform speed—a requirement absolutely necessary to prevent a periodic variation of the pitch of the reproduced sound.

Many of the familiar professional objections to the sound-on-disk system have also been advanced by the advocates of other systems. Sound film libraries must store, classify, and combine two commodities, the film and the disk. Amateur users must do the same. If the film should become torn, synchronism between film and record would be destroyed. Black leader or blank film would then have to be spliced in, carefully, frame for frame. The proper disk may become separated from the film and misplaced. These and a number of other objections give rise to the question, "Why not sound-on-film for the amateur?"

The problem, of course, is not easy. Lacking definite experience with such apparatus for the amateur, it might be appropriate to discuss the difficulties that will have to be overcome to make the apparatus desirable.

In the first place, expense would have to be considered. That such an apparatus would be costly, there is little doubt. In order to secure results better than mediocre, the 16 mm. or amateur sound head would have to be as well designed as that of the professional projector. Film speed would have to be just as carefully governed and regulated in the small projector as in the large one. Yet the price of the apparatus would have to be on an amateur basis, not a professional one, if such apparatus is to be other than an extreme luxury. Other difficulties are mechanical ones. The width of the customary 35 mm. sound track, 0.1 inch or 2.5 mm., would have to be reduced considerably—half this width or less—to be accommodated in the present picture area of the 16 mm. film and still preserve an

image of satisfactory dimensions for home projection. Various plans have been proposed to overcome this difficulty. One of these is to omit the perforations from one edge of the film, leaving this band for the sound track. A film moving mechanism can be designed to function satisfactorily in this way. However, this location of the sound track is such that it would be subject to the extra wear imposed on the outer edges of the film. Plans have also been proposed for film wider than 16 mm. DeForest has recently announced sound-on-film plans involving 20 mm. film. Split 35 mm. film, giving a 17.5 mm. width, is also being tried out. These variations from the accepted home standard might be practical if controlled by a firm of exceptional resources, otherwise they would require the complete redesigning and reëquipment of the market for this size. Such a step would involve so many difficulties, considering the present foothold of 16 mm. in the home, that a very drastic series of changes would have to be instituted to accommodate it.

Another potential difficulty lies in the fact that speed of 16 mm. film in passing through the projector is but 38 feet per minute (even at the rate of 24 frames per second), whereas practically all previous sound recording has been done at a film speed of 90 feet per minute. The problem of recording the higher frequencies at a speed almost one-third that of standard practice is a very definite one.

Even if the recording is done on the standard sound track and reduced to small film proportions by optical printing, the compressing of the high frequency record into a smaller space may be prevented by difficulties in resolution caused by the greater magnification of emulsion "grain."

It is said, however, that these problems may be and are being overcome. If this is the case, there remains but one problem peculiar to amateur use. That is the care and operation of the sound-on-film device. Such systems involve light-sensitive cells and exciter lamps which, with their attendant electrical adjustments, are extremely sensitive. Such apparatus attached to the open type of amateur projector would in all probability be constantly subjected to abuse by a variety of amateur operators who are not particularly trained in such use. A home sound-on-film system would therefore have to be simplified to the utmost in the matter of control and would have to be carefully housed and protected.

So far, no steps have been taken to provide the amateur with means for recording sound. From the number of inquiries received

through the technical service department of the Amateur Cinema League, it is evident that the amateur requires such equipment, so that it will be possible to make an audible record with the same ease and refinement as a visual one can be made. However, sound recording is an unfamiliar subject, even in its simplest form, full of technical difficulties. At this juncture, therefore, it may be better that the amateur is not provided with apparatus that will record sound.

Most proposals for sound-on-disk synchronized recording for the amateur have involved the engraving of a soft aluminum disk, from which a play-back may be obtained immediately by means of a pickup actuated by a fiber or cactus needle. A record so engraved and reproduced will last for repeated playings and is quite satisfactory as far as reproduction qualities are concerned if properly amplified. Unsynchronized sound pickup has generally been accomplished through the agency of a carbon microphone and amplifier. Recordings have been made at 78 rpm. with much success, although the problem of recording at a slower $33^1/_3$ still demands mechanical refinements in most cases. However, these are already beginning to appear, so that an entire 400 foot reel may be synchronized on a 16 inch aluminum disk.

A number of central sources for the recording of sound have been instituted for meeting the slowly increasing amateur demand. To a small, properly equipped, sound studio, the amateur may bring his films, which have already been developed, have them run off on a synchronized projector, and have his sound recorded to match on the spot. Such a procedure is entirely feasible and will undoubtedly become more prominent in the amateur field as sound reproduction becomes more familiar.

DISCUSSION

MR. ENGSTROM: From the amateur's standpoint in making his own sound picture, what priced apparatus would he be most interested in, what degree of apparatus complication would be acceptable, and what standards of sound quality would he set up?

MR. CARRIGAN: The answer to the first question is that the amateur, being familiar with the present equipment prices, would be willing to pay not exceeding $250.00; generally, he would pay that but would hesitate to pay more except in the case of wealthy individuals. It would have to be as simple as possible. There are three types of amateurs: the one who knows nothing, the one who knows something, and the one who knows a lot. The first and second groups form the great majority and would want something very simple.

With regard to the quality of reproduction, the amateur would not be overly critical; he is not so of his film at present. Since he made the picture, he will swallow a good deal, and the same would be true of sound.

PRESIDENT CRABTREE: On the one hand, the amateur has his radio playing every day, and occasionally the sound movie; doesn't he have a measure there? Except for recordings of himself and his friends, he would probably be just as critical as he is of the radio.

MR. CARRIGAN: I think you are correct; I was thinking of personally made films.

MR. TOWNSEND: As I remember, it was mentioned that acoustics in the home would need to be corrected. I don't think that is a strong factor. The paper also stated that air column horns were necessary. It seems to me that the acoustics in the average home are so far ahead of those in the average theater that this would not be a difficulty. The average speaker used in the home should be acceptable for reproduction of sound pictures.

MR. CARRIGAN: I was going more deeply into possible refinements. In order to get perfection, precautions would probably have to be taken.

MR. COOK: What size picture would the amateur expect? How long will he tolerate this "breadboard" collection of apparatus, or how long will his family tolerate it? This is a question that interests the manufacturer. The question of price which was brought up by Mr. Engstrom applies to the cabinet machine. In order for a manufacturer to go into it, he must make a profit. Expensive apparatus can be sold, I suppose, but most people won't buy it. The radio and automobile industry offer good proof of this. If a manufacturer can market this apparatus at a price comparable to present-day prices in radio, he can expect a profitable market from those whose earnings are from $1500 to $2500 a year.

MR. CARRIGAN: I think there the measuring stick will be the radio. I think the cabinet outfits could be put forward as cars are. The price will determine the size of the market. At first it will probably be a luxury at a high price. However, I think a firm could put out a line varying in price and touch various groups.

The normal size of picture is about 30 by 40 unless it is Kodacolor. I think the majority would accept a smaller picture if the screen were incorporated, as in the "Visionola," which gives a good effect, and has a smaller screen.

METHODS OF SECURING A LARGE SCREEN PICTURE

OPEN DISCUSSION AT THE OCTOBER, 1930, MEETING AT NEW YORK, N. Y.

PRESIDENT CRABTREE: In order to give everyone an opportunity to air his views on the possible methods of securing a large screen picture, we reserved a place on this program for an open discussion on the subject. As Professor Hardy pointed out, if the photographic emulsion were absolutely grainless, if it were sufficiently fast, if it were so hard that it could not be scratched, and that it would not accumulate dirt, then wide film would not be necessary. Enough light could then pass through the film to ensure a reasonably large screen picture.

It has been suggested that the 35 mm. film should be run sideways. I think Mr Fear was originally responsible for that suggestion. Please correct me if I am wrong.

MR. FEAR: I believe I was the first.

PRESIDENT CRABTREE: The wide image has been squeezed optically on the 35 mm. film and then stretched out optically in projection. You can see an example of that at the Capitol Theater this week. This picture was produced by reducing an image on 70 mm. film down to 35 mm. film. It has been suggested that the sound be put on a separate film so as to permit of more picture space on the 35 mm. film, and there is the suggestion of the Standards Committee to introduce a film intermediate in size between 70 mm. and 35 mm. There are probably other alternatives. I should like to have your opinions.

MR. STERN: I gave a demonstration at the Paramount Theater on the 30th of September in which standard 35 mm. film was projected with the theater's own Magnoscope projector on the large screen measuring $43 \times 31^1/_2$ ft. with excellent definition, and without excess granulation. This result was made possible by a special laboratory process of my own which will make feasible the use of large screens with 35 mm. film. I have also an invention for putting the sound track on separate film, saving the whole field for the picture. This

invention consists of printing two sound tracks on 35 mm. film running in opposite directions. The film so printed is processed in the usual way and then slit in half, each half accompanying a reel of picture. It is wound on a special combination reel, of which one side carries the picture and the other side the sound track.

MR. ROSS: We strongly believe in maintaining standards whenever possible. We further believe it would be a mistake to adopt a standard of 50 or 65 mm. film or any size other than 35 and 70 mm. The small house does not have a large enough stage to accommodate wide screen pictures, whereas the de luxe houses have such stages. The de luxe house with its comparatively larger box-office receipts can easily afford to install 70 mm. apparatus, whereas the cost of such a change would be prohibitive to the small house. We recommend the use of 70 mm. film and apparatus for the de luxe houses and 35 mm. film and apparatus for the smaller houses. Furthermore, we believe that sound will eventually be recorded on a separate film. The sound for *Hell's Angels* is produced on separate film having two sound tracks. We will have more to say of this during the discussion of the question of sound on separate film. It is our belief that all pictures should be recorded on 70 mm. film; however, we see no reason why pictures dealing exclusively with intermediate and close-up shots should not be recorded on 35 mm. film and optically condensed laterally for printing wide film 1 to 1.8 release prints. Mr. Fear has modestly refrained from mentioning his system wherein the pictures are recorded longitudinally on 35 mm. film, whereby 70 mm. pictures may be printed directly therefrom. This requires the building of new cameras but so does the use of 70 mm. film. Another method of recording wide film consists of recording on 35 mm. film in the regular cameras, optically condensing the picture laterally during recording, and then optically printing normal pictures on 70 mm. film for the de luxe houses as well as optically printing normal pictures on 35 mm. film for the small houses. This can be accomplished by using bi-convex lenses, now standard products, which do not seem any different from ordinary printing lenses. In the final analysis we believe that all pictures will be recorded on 70 mm. film in the 1 to 1.8 ratio suggested, directly printed for the de luxe releases while for the smaller houses the 70 mm. pictures will be optically printed on 35 mm. film in the 3 to 4 regular ratio. This will make the objects appear slightly more slender than normal, an attribute for which all actors longingly crave. Obviously the

suggestion for using 35 and 70 mm. standards has to do with permitting the manufacturers of film to continue the production of 70 mm. raw stock which may be employed for 35 or 70 mm. recording or printing.

MR. FEAR: Gentlemen, it occured to me that you might be quite as interested in what we are doing in Hollywood as in the theoretical discussion of wide film. You have already seen two experiments, one of which was *Happy Days*, and soon you will see *The Big Trail*—one of the finest picture epics ever made, due to the photography and wide film. Wide film furnishes a clear background; you will see close-ups and yet miles away there will be clearly defined results. This can only be accomplished on wide film. Big pictures and equipment cannot be installed in all theaters without properly considering the economic side of the question. The producers in Hollywood are trying to find the solution. The wide pictures produced cost too much to show. In one case special cameras had to be bought, but no projectors were available. It was suggested that an optically reduced print be made and shown in 35 mm. projectors. The man who projected it knew something about this and was so interested that this method was adopted for release prints. It consists of reducing 70 mm. to 35 mm., using the full width of the film and a separate sound film. Two extra sound heads are required for the projection machine.

Other methods have been suggested, such as rebuilding the present equipment; this is feasible, but may involve considerable cost. In designing projectors there is a definite practical width which limits that of the film; it is the widest width of film that can possibly pass through the projector without rebuilding the latter. That width is 50 mm. If a film of that width is used the height must be considered. It is impracticable to use a higher picture in the theaters than is used at present, so it resolves itself into widening the pictures. The solution, then, is a 35 mm. film widened out. This is the answer to the controversy on wide film in Hollywood. It applies only to release prints.

PRESIDENT CRABTREE: Is Mr. Powrie here? With regard to reducing down from wide film on to 35 mm., if you look in the *Transactions* of the Society for 1924, you will find a paper by Mr. Powrie on the subject. He demonstrated the process and practically showed the improved graininess obtained by that method.

MR. ROSS: If we understand Mr. Fear correctly, he stated that

wide pictures can be photographed only onto wide film. We again call your attention to the fact that Mr. Fear's system produces wide film pictures recorded on 35 mm. film.

MR. FEAR: The 35 mm. method I suggested last year solved the problem as to projection suitable for general use. The great difficulty lies in the matter of employing untrained men.

In Hollywood, we are producing the 65 mm. and 70 mm. cameras. MGM and Fox are using 70 mm. There is some difficulty which probably will be overcome, due to using four perforations instead of five. It has been suggested that five perforations be used. Warner Brothers, First National, and Universal are using 65 mm. cameras for their photography. Some prefer to make release prints on 65 mm. film. It is desirable to eliminate the human factor as far as possible in all laboratory work. There should be one negative of constant density without light changes due to the inexperience of operators who are likely to miss a light change. This can be done only by making a larger negative—65 mm. or 70 mm.; from this a master positive is made and corrected for light change. An expert technician should do this. Then an optically reduced duplicate negative is produced. This optically reduced negative will be superior in quality to an original of the same size because of the reduction of grain in such an optical print.

I think that answers your question; it is an economic problem.

MR. ROSS: I merely wish to add that in suitably reconstructed printers no prisms are required. Further, the question of making dupe negatives or fixed density positives seems to be apart from the question of wide film.

MR. GRIFFIN: The suggestion has been made that it is a good plan to reduce optically from a wide negative to 35 mm. film. I have seen pictures projected which were made in this manner and as far as pictorial quality is concerned the result is very good. It must not be forgotten, however, that the problem of projecting this type of picture to a screen 40 ft. wide is highly impracticable because it is impossible to pass the necessary amount of light through the small aperture. The size of the aperture in this case is approximately 0.940 wide by half that in height. Using 135 amperes at high intensity and condensers of the most improved design, it is impossible to procure more than half the illumination on the screen that is acceptable for the projection of standard film, and it is necessary that the projectionist be on the alert at all times to constantly secure

even this result. It must also be remembered that this reduction print, running as it does across the film from sprocket hole to sprocket hole, allows for no sound track and it is necessary to record on either disk or separate film, which adds considerably to the cost of apparatus necessary for sound reproduction, to say nothing of the errors in synchronizing which may and do arise frequently under this system. I don't think the solution lies in using 35 mm. reduced prints. I feel that the industry should certainly consider going to a film of, perhaps, 50 mm., in which all the excellent quality obtainable in wide negatives can be incorporated and which we know can be satisfactorily projected. By adopting such a dimension all the projectors now in use could be converted to handle this size as well as 35 mm. film at comparatively little cost to the exhibitor compared with the cost of equipment for the wide film as we now know it. Such a standard would be economically sound and enable the production of wide film to go ahead without a great deal of delay. Our corporation has spent a tremendous amount of money on film equipment and wide films but I am sure we should be willing to discard this for a standard which is economically sound and which allows the salvaging of the greater part of equipment at present in use.

MR. STERN: I should like to know if *Billy the Kid* was produced by making a 35 mm. print from the 70 mm., or was it an optical print from a 70 mm. negative?

MR. FEAR: It was produced by original reduction of the negative to the positive. On such a huge reduction, it is almost impossible to utilize the method I outlined before. I have a company in production on a wide film picture with four more to start in the next 90 days, which will be released to the independent exhibitor. We are making plans for a patent license to rebuild projection machines for a certain size film and are anxious to have a standard to adopt. In our system of conversion of projectors, the 35 mm. sprocket is cut in two so that the film is run throughout in the extensible position. We have added space between the sprockets. By moving levers we can change from one film to the other. The method is extremely inexpensive.

MR. ROSS: I wish to call attention to the fact that the frames in *Billy the Kid* are about one-third smaller in height than in standard 35 mm. film and that, therefore, in the systems in which we have suggested using standard size frames there will be available one-third more light, or an average of approximately 7 foot candles. Furthermore, whereas the foot candles have been reduced from, say,

11 to 7, the picture viewed has approximately twice the area and there will be as much illumination at an intensity of 7 foot candles on wide pictures as at 11 foot candles on regular size pictures. We believe that if the wide screen pictures were to be projected with an average screen intensity of 11 foot candles, the amount of light reflected by the screen would be objectionable to the audience, especially to those in the rear portion of the auditorium. Furthermore, with quick changes of scene the light and shadows reflected onto the walls of the auditorium would also be objectionable.

PRESIDENT CRABTREE: What technical difficulties have been encountered in the handling of wide film in Hollywood?

MR. FEAR: In Hollywood, everybody is enthusiastic about wide film. The producers are a little anxious about the situation because they want to know what is going to be done about it. No cameras are being sold for 35 mm. film. I will not sell them because I know we are going to a new standard and they will become obsolete in a short time. United Artists, Warner Brothers, First National, Fox, MGM, and Universal are working on wide film at the present time. One of my cameramen, Mr. J. O. Taylor, started on another picture last week. Every producer out there is awaiting your decision. It is highly improbable that every producer will have a different standard. In the majority of cases where we have handled wide film we have not had any technical difficulty. It is handled the same as the other, and the cameras have caused no more trouble than the others. The cameraman shoots a little differently from the 35 mm., but the main difficulty lies in projection.

MR. GRIFFIN: Mr. Fear said that difficulty has been experienced on the Coast in the projection of wide pictures. I know that to be so but I believe it is because the improper condenser combinations were used and improper distances were maintained between the arc and condensers and the condensers and aperture. We in the East are closer to the optical manufacturing organizations and lamp manufacturers and close coöperation has enabled us to obtain satisfactory results more quickly. All of the data obtained have been forwarded to the Pacific Coast and I have word that they are getting far better results than formerly. I don't think there is any difficulty now with the projection of wide film but certainly a film of approximately 50 mm. width would eliminate any slight difficulty which might be experienced.

REPORT OF THE SECRETARY*
Sept. 30, 1929, to Oct. 1, 1930.

This report covers the term of the fiscal year beginning October 1, 1929, and ending September 30, 1930. During the first four months of the period covered by this report, the affairs of the Secretary were conducted by Mr. R. S. Burnap. Changes in the business administration of the company with which he was connected required his resignation from the office of secretary on February 9, 1930. Thereupon, at the invitation of the Board of Governors, the writer assumed the duties of the secretary's office for the remainder of the term.

MEMBERSHIP

The total membership of the Society, as of the last day of the past fiscal year, is 756 members, divided as follows:

Eight Honorary members. These are:

Mr. George Eastman, Rochester, New York.

Mr. Thomas A. Edison, West Orange, New Jersey.

Dr. F. E. Ives, Philadelphia, Pa.

Mr. C. Francis Jenkins, the founder of the Society, Washington, D.C.

Mr. Louis Lumière, Paris, France.

The Presidency, Société Française de Photographie, Paris, France.

The Presidency, Die Deutsche Kinotechnische Gesellschaft, Berlin, Germany.

The Presidency, Royal Photographic Society, London, England.

There are 371 Active members, and 377 Associate members. And, in addition, there are 14 sustaining members consisting of various commercial and industrial organizations.

DISTRIBUTION OF MEMBERSHIP

Of the Society's membership 664 are under the jurisdiction of four local sections, with headquarters in New York, N. Y.; Chicago, Ill.; Hollywood, Calif.; and London, England. The distribution of members among these four sections is as follows:

* Presented at the Fall 1930 Meeting, New York, N. Y.

New York Section	182 Active,	175 Associate
Chicago Section	29 Active,	48 Associate
Pacific Coast Section	61 Active,	47 Associate
London Section	71 Active,	51 Associate

The combined territory of the three American Sections covers the entire United States, exclusive of territorial possessions. The territorial limits of the several sections were defined by the Board of Governors as follows:

The United States is divided from East to West into three geographical sections by drawing two north and south parallels. One of these lies fifty miles west of Cleveland, Ohio, and the other fifty miles west of Denver, Colorado. That part of the United States lying east of the first-named parallel comprises the territory of the New York Section; that part of the United States lying west of the second-named parallel comprises the territory of the Pacific Coast Section; the area intermediate between the two parallels constitutes the territory of the Chicago Section.

The territory of the London Section remains unchanged as consisting of the British Isles.

There are 84 members of the Society, residing in 18 foreign countries, not including Great Britain, who do not come under the jurisdiction of any local Section. The membership distribution among these countries follows:

	Active	*Associate*
Argentina	–	1
Australia	–	2
Brazil	–	1
Burma	–	1
Canada	5	10
France	7	11
Germany	8	9
Holland	–	1
India	5	5
Italy	1	2
Japan	1	3
New Zealand	–	2
Norway	–	1
Poland	1	1
Russia	–	2
South Africa	–	1
Sweden	–	1
Switzerland	–	1

Territorial possessions of the United States provide one associate member who resides in the Philippine Islands.

In addition to the above, there are pending, 20 applications for Active membership, and 25 applications for Associate membership.

During this term 7 Active members and 4 Associates resigned; 10 Active members and 19 Associates were dropped for non-payment of dues; 3 Active members were transferred to Associate membership, and 2 Associate members were transferred to Active membership.

NEW MEMBERS

The large increase in membership during the past year was primarily due to increased interest in the Society's JOURNAL, now published monthly; a more widespread knowledge of the Society's aims and accomplishments; and the noteworthy activity of the Membership Committee. A total of 199 new members were admitted during this past year to the Society. The sectional distribution of these new members is as follows:

New York Section	77
Chicago Section	21
Pacific Coast Section	23
London Section	38

Foreign countries, not including Great Britain, 40.

JOURNAL SUBSCRIPTIONS

While the number of annual subscriptions to the JOURNAL is not increasing as rapidly as was at first expected, satisfactory progress is being made in this direction. Subscriptions total 202, of which 173 are paid, 4 are free to Local Sections, 11 are exchanges with other publications, and 14 are free to sustaining members.

SALE OF JOURNALS AND TRANSACTIONS

Total sales of single copies of the nine issues of the JOURNAL to date, exclusive of the October issue, numbered 52, as contrasted with 1030 copies of back numbers of the *Transactions*, sold during the past fiscal year.

SECOND CLASS POSTAL PRIVILEGES FOR JOURNAL

After many months of negotiation with the Post Office Department, your Secretary is especially pleased to report that second class postal privileges have at last been granted to our Society in the matter of mailing the monthly JOURNAL. By reason of obtaining this privilege, which was granted only after certain requirements of the Post Office

Department were met, a considerable saving in the cost of mailing the JOURNAL will be effected in the future, in addition to our obtaining a substantial refund on the mailing of past issues.

One of the more important changes required by the Post Office Department was in the matter of the subscription price to members of the Society. The ten dollar allowance for annual subscription to members was changed to nine dollars to make it less than the amount of the annual dues for Associate members. Notice to this effect is to be incorporated in new application blanks which will shortly be printed.

Respectfully submitted,
J. H. KURLANDER, *Secretary*

IMPORTANT NOTICE!

It is very necessary that all members of the Society and subscribers to the JOURNAL immediately advise the General Office of the Society, when a change in mailing address is made. Otherwise, when literature is returned by the Post Office for this reason, the member's or subscriber's name is removed from the mailing list for the JOURNAL until the proper address is obtained. Future issues of the JOURNAL will contain, from time to time, lists of members or subscribers for whom no address is known. Anyone knowing the whereabouts of those members or subscribers is requested to advise the General Office promptly.

COMMITTEE REPORTS

REPORT OF THE JOURNAL COMMITTEE

October, 1930

In this report an attempt will be made to set forth the manner in which the JOURNAL OF THE SOCIETY OF MOTION PICTURE ENGINEERS has been conducted since its establishment in January, 1930.

Following the autumn convention of 1929, at which time the publication of a journal was authorized by the Board of Governors, immediate steps were taken to set up the necessary machinery for publishing this journal at regular monthly intervals. The requirements and problems of publishing a technical journal were discussed with several publishing houses and bids on cost of publication were requested from two or three of those which to the committee appeared most capable of handling this work. After careful consideration a contract was signed with the Mack Printing Company of Easton, Pa. The decision of the committee to give the contract to this concern was based not only upon its bid on cost, but also upon its proximity to the cities in which are located the editorial office and the offices of the secretary and treasurer.

The question of general style, typography, *etc.*, was discussed at considerable length with the publisher and a style sheet was compiled to serve as a guide in obtaining uniformity of style throughout the JOURNAL.

An attempt was made to get the machinery of publishing established sufficiently early so that the first issue could appear on January 1. As a matter of fact the January issue was a few days late but was mailed during the first week of the month. Since that time, with perhaps one exception, the JOURNAL has been mailed from the office of publication prior to the first of each month and in most cases has reached the members and subscribers within the first few days of each month.

The committee has endeavored to keep the contents of the JOURNAL in harmony with the wishes of the Board of Governors as expressed specifically in the resolutions passed at the time the decision was

made to publish the JOURNAL. A statement of the material to be incorporated in the JOURNAL will be found in the JOURNAL **XIV** (January, 1930) p. 8, under item 5.

In Table I following will be found an analysis of the contents of the JOURNAL up to and including September, 1930. The first section of the table analyzes the contents in terms of numbers of pages. The totals at the extreme right of the table indicate the way in which the space of the JOURNAL has been utilized. In the first nine issues a total of 1130 pages have been published, of which 895 were devoted to purely technical papers; 36 pages to abstracts of scientific articles which, in the opinion of the editorial office, should be of interest to the membership; 9 pages to book reviews; and 168 pages to society notes, tables of officers, committees, photographs of officers and committees, and material of general interest to the Society but of a non-technical nature. The committee feels that this disposition of the space is fairly well in accord with the wishes of the Society as set forth by its Board of Governors.

TABLE I

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Total
Analysis of Contents in Terms of Pages										
Technical Papers	127	108	91	73	84	90	122	92	108	895
Abstracts	4	3	4	3	4	6	4	4	4	36
Book Reviews	2	2	1	..	1	..	1	1	1	9
Society Notes, Committees, etc.	13	9	4	27	37	9	14	33	22	168
Miscellaneous	2	2	2	3	2	3	3	2	3	22
Total pages	148	124	102	106	128	108	144	132	138	1130
Analysis of Contents in Terms of Material										
Convention Papers	8	7	11	8	3	5	7	7	11	67
Contributed Papers	..	..	1	..	2	1	..	2	..	6
Committee Reports	1	1	..	2	..	..	1	1	..	6
Translations	..	..	..	..	1	..	..	2	..	3
Total No. Papers	9	8	12	10	6	6	8	10	11	80
Abstracts	16	13	23	20	18	21	23	22	13	169
Book Reviews	4	3	3	..	2	..	2	2	1	17
Reprints ordered	2500	940	3850	3250	2500	2100	1150	1500	6050	23,840

The second part of the table shows an analysis of contents in terms of material. Again in the total column it will be seen that of the total scientific papers published, 67, were obtained from our two semi-annual conventions, while 6 were contributed directly to the editorial office. Six committee reports were published and 3

translated foreign articles, making a total of 80 scientific papers. The number of abstracts was 169 and book reviews 17.

In the last section of the table are shown the number of reprints which have been ordered from each month's publication. For the nine months covered by this table a total of 23,840 reprints have been ordered.

We now come to the very important question of how much the JOURNAL is costing the Society. In Table II will be found an analysis of the costs involved in publishing the first nine issues (January to September, inclusive) of the JOURNAL. In the first column will be found the number of copies printed for each month and in the second column the total number of pages in each month's issue. In the third column are shown the amounts directly chargeable to "editorial"

TABLE II

				Publisher				Reprints	
Month	Edition	Pages	Editorial	Printing	Cuts	Total	Postage	Cost	Postage
Jan.	2500	148	$120.00	$801.75	$75.85	$877.60	$99.15	$108.32	$14.12
Feb.	2000	124	84.00	591.25	74.89	666.14	46.23	90.91	3.54
March	2000	102	75.50	509.43	80.00	589.43	48.85	123.10	7.54
April	2000	106	83.50	513.35	139.74	653.09	45.55	101.06	6.15
May	2000	128	120.00	619.98	115.62	735.60	42.16	116.16	6.88
June	2000	108	132.00	576.49	98.74	675.23	55.42	175.97	9.32
July	2000	144	135.00	653.94	144.02	797.96	65.03	116.33	10.21
Aug.	2000	132	151.00	632.87	108.93	741.80	62.42	95.53	4.27
Sept.	2000	138	112.00	633.92	133.98	767.90	87.01	130.27	7.14
Total		1130	1013.00	5532.98	971.77	6504.75	551.82	1057.65	69.17
Av.			112.55			722.75			

work. This includes the preliminary preparation of the manuscript for the printer. It should be pointed out that many of the manuscripts as received by the editorial office require considerable work before they are in shape to be sent to the publisher. In some cases the drawings and illustrations submitted by the author are not satisfactory for reproduction. In some cases the editorial office has assumed the responsibility of having these redrawn, while in other cases they have been returned to the authors for correction. This item also includes all proof-reading, both of the galley and page. It includes all stenographic work and amounts paid out for the translation of foreign articles. The item does not include any charges for postage, telegrams, and long distance telephone messages. These items were absorbed by the office of the editor pro tem and paid by

the company by which he is employed. It is estimated that the total amount chargeable to these items up to the present time is not over $75.00. In the last column will be found the monthly cost of printing the JOURNAL. This includes all charges made by the publisher with the exception of cuts and postage. In the next column are shown the monthly costs chargeable to the making of cuts for the illustrations of the JOURNAL, and in the next column a total of these two items which represents the actual cost of printing the JOURNAL. The monthly postage bills chargeable directly to the mailing of the JOURNAL are shown in the column so designated. In the last two columns of the table are shown the cost to the Society of the reprints ordered by the various contributors and the postage involved in sending these out.

In arriving at the total cost of the JOURNAL for the first nine months, we must include the following items:

Editorial	$1013.00
Publisher	6504.75
Postage	551.82
Reprints	1057.66
Postage on reprint	69.17
	$9196.40

Since reprints are billed to the author at cost plus 50 per cent, the profit on reprints should be subtracted from the above figure. This profit is $528.83. Subtracting this from the total cost we find that the JOURNAL for the first nine months has actually cost the Society $8667.57.

Let us turn again for a moment to the consideration of Table I in which the analysis of content is shown. It will be noted that of the total number of technical papers published only six may be classed as *contributed*, all the remaining material of this type being derived from the 1929 autumn and the 1930 spring conventions. The JOURNAL Committee had hoped that as soon as a monthly journal had been established there would be a goodly number of contributions other than papers read at conventions. We feel that in the future there will be more material of this character. There can be no doubt that in many cases the results of experimental and research work going on in various localities mature and are ready for publication at times between our semi-annual meetings. The JOURNAL Committee would like to encourage authors to submit manuscripts

at any time. It is probable that greater activity on the part of the editor of the JOURNAL will be required to unearth this potential material. It would seem desirable to keep the number of pages published each month at a fairly constant level. We therefore hope that in the future more contributed papers will be available.

TABLE III

Month	Members and Subscribers	Samples and Back Orders	Stock	Special	Total
Jan.	661	497	770	300	2228
Feb.	705	246	1081	45	2087
March	759	223	913	100	1985
April	809	195	1020	25	2049
May	769	238	1100	60	2157
June	834	111	1089	45	2079
July	871	147	1068	35	2121
Aug.	908	76	1075	45	2104
Sept.	951	68	1068	20	2107
Total	7267	1801			

Moreover there is undoubtedly a large number of foreign articles which are well worth translating and printing in the JOURNAL. Here again, a regular editor with more time to devote to the search for such material would be an advantage. We should also like to see an expansion of the abstract section and an increase in the number of book reviews, provided books of sufficient value continue to appear from time to time as they undoubtedly will. It seems reasonable at the present time to plan upon a journal of approximately 150 pages per month. It will be noted that within the past nine months several of the issues have fallen considerably below this number of pages. If we assume a 150 page issue each month there is therefore space to accommodate more contributed and translated articles and some expansion of the abstract and book review sections.

The committee feels that the most important step now in the evolution of the JOURNAL is the appointment of an editor with suitable assistants to carry on the work and to develop the JOURNAL along the general lines as indicated.

LOYD A. JONES, *Chairman*
J. W. COFFMAN
H. T. COWLING
J. H. KURLANDER
W. C. HUBBARD

REPORT OF PUBLICITY COMMITTEE*

The present Publicity Committee was appointed directly following the Fall Meeting of 1929 at Toronto and has been actively functioning since that time.

The work of the committee naturally divides itself into two parts, namely: providing news to the trade press and newspapers of the semi-annual meeting and the activities of the Society throughout the year.

The present Publicity Committee has served during one meeting, the May, 1930, meeting at Washington, D. C. At this meeting two news releases were issued each day of the Convention. As a result of this work at the May Meeting, 1400 inches of news or approximately 20 newspaper columns were carried by trade papers and newspapers of which the Publicity Committee has accurate record. However, it is certain that a great deal more space was obtained since several of the stories were put on Associated Press and United Press wires and published in many newspapers throughout the country.

In furnishing news of the activities of the Society between conventions, the Publicity Committee has released more than 25 stories to the trade press.

When a story is released it is sent to all trade papers in the United States, all technical journals dealing with the motion picture industry, and foreign motion picture trade papers and technical journals. The list includes more than 30 publications altogether. Special stories have also been written for a number of publications, and reports of the May meeting were supplied to a number of technical journals. Abstracts of all papers read at the May meeting were mimeographed and supplied to papers in this country and abroad.

Another duty of the Publicity Committee was to establish exchanges of the Society's monthly JOURNAL with more than 30 motion picture and technical publications in this country and abroad. This exchange of publications has resulted in a great deal of publicity not only in this country but in some of the finest technical journals in European and other foreign countries.

Whatever success the present Publicity Committee may have ob-

* Presented at the Fall 1930 Meeting, New York, N. Y.

tained has been due not so much to its own work as to the splendid coöperation given by the motion picture trade-press. The Publicity Committee has found that the motion picture trade-press is extremely willing to offer every possible coöperation in publishing news regarding the activities of the Society and that its pages are always open for any legitimate news concerning the Society.

The Publicity Committee therefore wishes to express its appreciation to the motion picture trade-press for its splendid coöperation in reporting the activities of the Society.

The Publicity Committee also wishes to thank all those in the Society who have coöperated with it and who have helped to supply the Publicity Committee with details of the Society's activities, for transmission to the press for publication.

WILL WHITMORE, *Chairman*
F. C. BADGLEY
B. W. DEPUE
G. E. MATTHEWS
G. F. RACKETT
O. A. ROSS

REPORT OF STUDIO LIGHTING COMMITTEE*

There has been little change in the methods of studio lighting since the report given at the Washington convention last May with but one exception, that there seems to be a tendency on the part of many of the studios, where incandescent lighting has been used to a very large extent, to increase the number of high intensity spots and sun arcs for floodlighting purposes. This has been rendered possible by the efficient silencing devices which have been installed on d. c. generating equipment and arc lamps in the various studios.

Manufacturers of arc lamp equipment are advertising new equipment for high intensity arcs which is claimed to be free from many of the causes of noise present in the older lamps.

None of the information which your committee has been able to obtain in the past six months is of a character which advances the real knowledge of studio lighting to any considerable extent. Basic information which is available with regard to the various sources

* Presented at the Fall 1930 Meeting, New York, N. Y.

of light is given in many articles which have appeared in the *Transactions* of the Society, of which a bibliography was presented in the last committee report. Much additional knowledge can be obtained from the studios themselves, but in spite of very earnest efforts of the committee it has been impossible to obtain this information up to the present time.

We understand that in past years attempts have been made to utilize photometric measuring devices in the studios, but that none have been found satisfactory or useful for one reason or another. Some recent work has again been done on this problem, but up to the present time little progress has been made in the practical application of these instruments.

Continued efforts on the part of the committee should be made to obtain information from the studios which will permit the establishment of standards for desirable levels and types of illumination for the various kinds of sets encountered in the production of motion pictures. The methods which can be applied in this work probably lie in the determination of levels of illumination coupled with the photographic values of the light actually used and micro-density determinations on films taken with the various types and mixtures of illuminants.

A. C. DOWNES, *Chairman*
L. J. BUTTOLPH
R. E. FARNHAM
K. C. D. HICKMAN
M. W. PALMER

REPORT OF THE COLOR COMMITTEE*

The May report of the committee gave a list of producers of color pictures and the systems used. At that time the Photocolor Corporation[1] report had not been received. Mr. A. G. Waddingham, technical director of the corporation, supplied the following description of this system:

"The color camera is of special design, photographing a pair of images in conjunction with special taking-filters and an optical system employing the split beam method of photographing.

* Presented at the Fall 1930 Meeting, New York, N. Y.

[1] Letter dated July 11, 1930.

"The negative is printed upon a specially designed optical printer which prints the two respective images upon duplitized positive stock.

"The print is then transferred to the green processing room where the film receives an application of the blue-green complementary dye on the side containing the image from the red sensation negative.

"It then passes through a red processing machine, wherein the orange-red dye is applied to the image from the green sensation negative. At the termination of this operation the film is removed and sent to the assembly room where it is assembled and finally projected and inspected upon the screen."

According to Mr. Waddingham, the process is adaptable for the production of sound prints in color, either by the disk method or the sound-track on film method. The company is equipped with a thoroughly up-to-date laboratory, and a new sound studio is in the course of construction.

The Reporter, Hollywood, October 8, 1930, says the Photocolor Corporation of New York is planning to build a plant in Hollywood with a capacity of a million feet of film a week and expects to be in operation soon after the first of the year.

FILM PACK

A specially made negative is being marketed, for use with the Film Pack system, known as Red Ortho Front Negative.[2] This has a blue sensitive emulsion on the surface of which is a layer containing a red coloring matter.

In making color sensation negatives by this system, Red Ortho and a panchromatic negative are placed emulsion to emulsion in the camera and exposed simultaneously. The light from the lens passes through the Red Ortho, recording the blue end of the spectrum. The red colored layer then filters out the blue; the red end of the spectrum passing through is recorded by the panchromatic negative.

The red coloring matter on the Red Ortho is removed from the developed, fixed, and washed negative by bathing in a 3 per cent solution of hydrosulfite of soda.

NEW COLOR PROCESS

A new color process is being introduced from Germany, known as the "New Color Process." It is claimed that this is usable for either motion picture or stills, although in the description the method of using it for motion pictures was omitted.

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[2] English Provisional Patent No. 333,933, August 25, 1930.

Successive exposures are made in a special camera fitted with tri-color filters. The color value negatives are printed on positive films which have their respective dyes incorporated in the emulsions. The films are then developed, fixed, washed, and subjected to a warm water treatment. No formulas were given. The silver images are then reduced, leaving pure dyed images which, it is claimed, can be either transferred to an individual support, or the three films can be placed in register and bound. The printing is accomplished by printing through the celluloid side of the film.

THREE-COLOR ADDITIVE PROCESSES

In the Herault Color Process a three-color sector wheel is rotated in front of the camera and the contact print negative is dye tinted so that each successive group of frames is tinted one of the primary colors. The three-color positive is then projected with a continuous projector (Continsouza-Combes). The method is said to suppress the chromatic flicker when projected at 24 frames per second; only spherical lenses are used in this projector. This plan is somewhat similar to that now being suggested by Wolf-Heide.

HORST SYSTEM OF COLOR PHOTOGRAPHY

In this system three pictures are taken simultaneously with three-color filters, using a prism system in the camera. In the positive, each frame carries three images, each corresponding to one of the color separation images of the negative. This method is being sponsored in Great Britain by Universal Productions, Ltd.

REPORT FROM DR. WALTER CLARK

In a report from Dr. Walter Clark, London, August, 1930, he states that "a number of color cinematography processes are being investigated in England and a few productions are in progress utilizing some of them. Processes being studied or used in England include Pathecolor, Talkie-Color, Zoechrome, Dufay, and Raycol."

THE CHROMOLINOSCOPE

In a paper entitled "The Chromolinoscope Revived," Dr. H. E. Ives has described several applications of the instrument devised by his father, F. E. Ives, in 1901. This instrument was devised for the production of line images by the use of a special ribbed glass inserted in the optical system. Methods of making "ridged" images and

ridged film records from three-color separation negatives are described as well as a method of copying film (such as Kodacolor) containing line images. *J. Opt. Soc. Amer.*, June, 1930, Vol. 20, p. 343.

A REVIEW

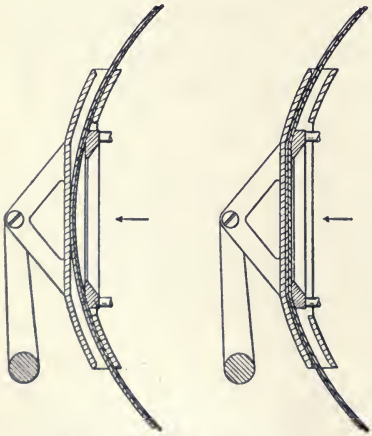
A review of recent advances in color photography is published by G. Grote in the *Photographische Korrespondenz*, April, 1930, Vol. 66, p. 91.

KELLER-DORIAN METHOD[3]

Dr. N. M. LaPorte of the Paramount Publix Corporation says, "relative to our experience with the Keller-Dorian method, would say that while our preliminary investigations show that there is considerable merit to the process, we have not made any commercial takes to date."

CAMERA GATE FOR FILM PACK[4]

A camera gate that holds two films in contact while at the aperture gate in a camera and suited for composite photograph and film pack color negatives has been issued in England. The gate seems specially suited for Bell & Howell cameras and is known to produce very excellent results.



Camera gate for film pack.

FIRST COLOR FILM

The Glorious Adventure, first of the full length, full color pictures to see the light of day, was shown some ten years after its original debut at the Filmarte Theater, 1228 Vine Street, Hollywood, California, for a week beginning August 15, 1930. It received favorable comments from the press.

MULTICOLOR

A demonstration reel, colored by the Multicolor System, was shown here last night. The negatives were

[3] September 23, 1930.

[4] August 25, 1930, No. 333,932.

made by the Film Pack System and most of the scenes exhibited were made under artificial light.

SENNETT BREVITIES

An exhibition of work done by the Sennett Laboratories, Studio City, California, was shown last night. All the negatives are made by the Film Pack system. The aim here, according to the Sennett organization, is to produce films with good photography and subdued color.

MAGNACHROME FILM

This system gives wide film sound and color. It is an additive method with many of the old features utilized, but designed to rid itself of color bombardment and color fringing.

This is accomplished by having the film pass through the normal projector at the standard speed of 90 feet a minute with an intermittent movement, using an 8 sided cam instead of the usual 4 sided cam. This gives 48 pictures a second of half the usual height, instead of 24 full frame pictures a second as is customary. At this speed of 48 changes a second, there is little or no color bombardment

The negatives are preferably made by the film pack system. The only change in the camera is that it is fitted with a half size aperture gate, and the normal speed of 24 pictures a second insures good exposures. Other methods of making the negatives may be used.

For the positives, the negatives, which have been exposed as above described, are printed in sequence, giving on projection a series of 48 pictures a second, with the sound at 90 feet a minute giving perfect reproduction. No fringing is discernible as the negatives have been made in pairs. In addition to this the film is tinted with alternate spaces of red and blue-green, so that after leaving the laboratory the films cannot be joined or run out of color.

No public demonstrations have been given although private exhibitions have brought forth encomiums. As the process has no toning, using black and white pictures, and makes use of a process in which the problems are familiar and well worked out, the film can be introduced at low cost.

The above description covers much that has been done but, as many changes are being made, no demonstration will be given until the Spring Meeting of the Society.

Mr. Roy Hunter of Universal Films, Inc., who has been active in the development of the Magnachrome System has supervised the making of a two reel picture without color using this method of projection.

WM. V. D. KELLEY, *Chairman*
JOHN G. CAPSTAFF
WM. T. CRESPINEL
F. E. IVES

REPORT OF THE HISTORICAL COMMITTEE*

On account of the recent appointment of the speaker to the Chairmanship of the Historical Committee of the Society of Motion Picture Engineers, it was found impossible to hold a meeting of the committee at which more than three members could attend at any one time. In spite of the fact that it was not possible to bring together the members of the committee for a formal meeting a considerable amount of work has been accomplished by conferences of the Chairman with the various individual members of the committee.

A schedule of the matters at present under consideration by the committee was sent by the Chairman to each individual member and replies have been obtained from all members of the committee residing in the United States.

The principal questions being considered by the Historical Committee at the present time are:

1. The selection of a museum as a repository for whatever specimens of a historical nature can be collected by the Society.

2. Consideration of a means for recognition by the Society of surviving pioneers who were active in the establishment of the motion picture industry.

3. The locating and obtaining, if possible, of any and all relics, films, and documents of importance concerned with the early history of the industry.

4. Planning for the future work of the committee.

That is a brief synopsis of the problems which have so far been considered by the committee.

Ever since the formation of the Society there has been more or less talk about the necessity of preserving in some manner the various

* Presented at the Fall 1930 Meeting, New York, N. Y.

relics, documents, and early films which represent the various stages of development of cinematography.

Although we are just beginning to be ashamed of referring to cinematography as an infant industry, nevertheless more than forty years have passed since the first chrono-photographic records were made and a great many steps in the development of motion pictures have passed into the limbo of forgotten things. The objects and aims of the Society place it automatically in the position of being best suited for the task of preserving the history of the industry. The Historical Committee has, therefore, considered very carefully the problem of a suitable repository for whatever specimens of a historical nature can be collected.

Most museums exhibit a definite class of objects and are thus automatically eliminated from consideration. The museums under consideration are those who have signified that they would like to obtain whatever motion picture exhibits which can be given by the Society. They are the Museum of Peaceful Arts, New York, Smithsonian Institute, Washington, D. C., Julius Rosenwald Museum of Science and Industry, and the Museum of the University of Southern California, Los Angeles, Calif. The committee believes that the museum best fitted for the purpose is the one which is most easily accessible to the greatest number of people interested in the motion picture industry. New York City is unquestionably the world center of the motion picture business, even though the majority of pictures are not produced in the vicinity of New York. The Museum of Peaceful Arts is at present housed in the New York Daily News Building at 220 East 42nd Street, accessible in a few minutes from the center of New York City. While it is a new museum and not yet well known to the public, its plans for future development look forward to a skyscraper museum in the center of the city, easily accessible to visitors with a limited amount of time. It is being developed along the latest and most approved methods of museum exhibition, wherein the exhibits are displayed in the best possible manner. Wherever possible the exhibits are mechanically operated either by motor, actuated by a push button pressed by the spectator, or by means of a crank operated by the observer. At the same time the exhibit is protected in a suitable glass case.

The space available in the Smithsonian Institute is limited. The ability of the museum to do certain things is also limited by the Federal law which governs it. Moreover, the number of visitors to

the Smithsonian Institute is limited. Most of these objections also apply to the other museums mentioned above.

As there does not appear to be any central museum available at the present time for the housing of what we hope will in time prove to be a considerable collection, it has been suggested that whatever material may be available at the present time be divided among those museums best suited for the present purpose as loan exhibits so that, should a more suitable place be found in the future for a central exhibit, the loans could be recalled and all of the collections be assembled in one place.

The Museum of Peaceful Arts has signified its willingness to accept exhibits on loan so that the Society at any time can withdraw exhibits allotted them and replace them in any more suitable place which may be selected in the future.

While the Historical Committee has no knowledge at the present time of any historical relics being presented to the Society for museum exhibition, a great amount of material has been located and it is believed that as soon as a suitable repository has been selected that it will not be difficult to obtain a very considerable array of objects of great interest concerning the development of the industry.

The matter of recognizing in some manner the pioneers of the industry has been taken up with the Board of Governors. The committee has investigated the careers of Jean Acme Leroy and of Eugene Augustin Lauste. Jean Acme Leroy seems to have been the first man to project pictures on a screen with a machine operating on the same principles as those in use today and Eugene Augustin Lauste took out the first patent for sound record on film.

Several of the members of the Historical Committee have investigated the lives of these two old men, whose advanced age makes it seem probable that they will not be with us much longer, and whose claims have been under consideration by the Society for over a year without definite action being taken.

Their friends in the Society think that their careers should be recognized in the form of an honorary membership for each of them. Others have maintained that although these men may have been pioneers, this might establish a poor precedent and perhaps may later cause embarrassment to the Society by the request of a large number of others for the same sort of recognition.

This seems an unfair argument. The Society has already in the past honored various persons of prominence in the early history of

the industry with honorary membership and the surviving pioneers of the industry are fast being decimated by the hand of time. Why should the Society not honor itself by extending to any pioneer of the industry who has materially helped in its advancement the epilogue of an honorary membership for their pioneer efforts? Only a few of these old men have reaped financial reward for the work which they have done and it does seem a shame that these few remaining pioneers who built the foundation of this great industry should be pointedly ignored and turned down.

Contrary to the unanimous recommendation of the preceding Historical Committee and a reëinforced recommendation by the present Committee, the Board of Governors at a meeting held October 19, 1930, refused to act on the report of the committee.

The future work of the committee seems to be very clearly defined in the selection of a suitable repository for the historical material to be collected; in the location and collection of this material, and in planning for the foundation of a fund by some means or other to meet the expense connected with this work.

Respectfully submitted,

C. L. GREGORY, *Chairman*

E. ADAMS
M. CRAWFORD
C. F. JENKINS
O. NELSON
A. S. NEWMAN
T. RAMSAYE

SOME ACCOMPLISHMENTS OF EUGENE AUGUSTIN LAUSTE—PIONEER SOUND-FILM INVENTOR*

In any historical outline of the important inventions which have contributed to the technical development of motion pictures those of Eugene Augustin Lauste, pioneer experimenter in sound-film processes, ought properly to have a prominent place.

They are unique, in that they relate directly not only to one, but to two periods of the utmost importance in the evolution of the modern screen. Mr. Lauste contributed to the early mechanical inventions which made the silent motion picture possible and later developed the fundamental theories which made practical the addition of synchronized sound to the animated scene upon the same film. In both these fields this modest Frenchman played by no means a minor part. He was—and is—in the truest sense, a pioneer—a discoverer.

* A contribution of the Historical Committee, prepared by Merritt Crawford.

It is not possible, in this brief record, prepared on behalf of the Historical Committee, to do more than indicate the principal contributions which he made to the development of the silent and the sound-film art. Nor is it possible here to quote all the authorities consulted by the writer in support of the now generally accepted contention that Mr. Lauste is entitled to recognition as an experimenter and inventor of premier rank in film history.

This will be done, however, in a fully documented biography, which is now being prepared and in which Mr. Lauste's early researches and discoveries will be amply set forth.

It is sufficient to say here that published accounts of his experiments extended over a period of years. The testimony of many members of our Society's London Section, who personally observed his work at various stages of its progress between the years 1908 and 1916—the records of the United States Courts—the existence of much of his early apparatus—the issuance of his British patent of 1906, covering basic means and methods for synchronously recording and reproducing sound and scene upon the same film—all serve to furnish a most complete picture of this remarkable man's researches and definite achievements in motion and sound picture history.

Mr. Lauste, who will be seventy-four his next birthday, is now living quietly in semi-retirement in Bloomfield, New Jersey. He has sold all his experimental apparatus to the Bell Telephone Laboratory, where it is expected it will eventually be placed on exhibition in the Bell Telephone Museum, at West and Bethune Streets, New York City, to take its place alongside of the epoch making inventions of Dr. Alexander Graham Bell and the long list of distinguished scientists and engineers who followed him in the development of sound and telephonic communication processes.

Mr. Lauste was born in the Montmartre district of Paris, January 17, 1857. It is said that he early displayed inventive and mechanical talents of a high order, and it is certain that before he was twenty-three he had filed with the French patent office no less than 53 models and designs on a variety of devices.

His connection with motion picture experimental and research work began in 1887, when he joined the technical staff of Thomas A. Edison at Orange, N. J. He was chief mechanical assistant to William Kennedy Laurie Dickson, for many years chief of Mr. Edison's technical and research staff, and shared with him in many of the early experiments in producing animated photography, which eventually resulted in the disclosure of the famous kinetoscope.

Mr. G. F. Atwood, now in charge of the Model Department at the Bell Telephone Laboratories, who occupied a similar post with Mr. Edison in that early day, tells me that Mr. Lauste was rated as one of the ablest mechanics in the Edison organization of that period and was highly regarded by all his superiors, including Mr. Edison himself. His assignments were seldom blue-printed, but were such as might be described as requiring much more than mere mechanical ability, as Mr. Lauste's ingenuity and inventive talents were fully recognized.

Mr. Lauste left the Edison organization in 1892 to develop a gasoline engine, which he had designed in association with another French engineer. His model worked, but he became discouraged and discarded it, when experts assured him that an engine of this type, with its noise and inflammable potentialities, could never be made commercial because it would not be permitted on the streets.

But for this mischance he might well have figured as an inventor in the beginnings of the automobile as well as the motion picture.

In 1894 he became associated with Major Woodville Latham, a teacher, who had become interested in the possibilities of a step-photography as disclosed by Mr. Edison in his kinetoscope. Major Latham, himself, had little mechanical knowledge or experience, but had conceived the idea of devising a projector for the infant film and engaged Mr. Lauste to perform the actual experimental and mechanical work.

While associated with Major Latham, Mr. Lauste designed and constructed the first wide film projector—the Eidoloscope—which embodied the famous so-called "Latham Loop," which is a fundamental feature in all modern projection machines and which was an important matter in the patent litigations of a quarter of a century ago. Mr. Lauste also designed and built for Major Latham several wide film cameras and a complete printing equipment. With the Eidoloscope public exhibitions were given in May, 1895, at No. 153 Broadway, New York, and during the following summer at Coney Island in a tent on Surf Avenue. The pictures shown were views of the Griffo-Barnet prize-fight, which Mr. Lauste had photographed on the roof of the old Madison Square Garden.

In 1896 Mr. Lauste joined the American Biograph Company, with which he was associated for several years, much of the time being in charge of their laboratory and experimental plant near Paris, France.

Mr. Lauste's invention of the "Loop," in connection with the projection machine, as well as other features of the Eidoloscope, which have borne Major Latham's name, has been fully set forth in the testimony in the case of Edison *vs.* The American Mutoscope Company, brought in 1898 in the United States Circuit Court, Southern District of New York. Major Latham, Mr. Lauste, and Mr. Dickson, who had then left Mr. Edison's employ to become one of the founders of the Biograph Company, all testified in this action and their testimony leavesd no question as to the authorship of the invention of the first wide film projector, the Eidoloscope.

Mr. Dickson, in a letter written as recently as March 28, 1927, in referring to the early inventors in the art, says: " . . . full credit must be given Mr. Lauste, who invented the indispensable 'Loop' and the second sprocket."

The foregoing will suffice to indicate the importance of Mr. Lauste's contributions to the early mechanical development of the art, but his chief fame will doubtless eventually rest upon his work in the field of the sound-film and its processes.

According to Mr. Lauste, himself, it was while he was employed at the Edison plant in 1888, that he first conceived the idea of photographing and reproducing sound and scene. In an old issue of the *Scientific American* dated May 21, 1881, which he found in the cellar of the Edison laboratory, he read a description by Dr. Alexander Graham Bell of his invention of the Photophone and the successful transmission of sound by means of radiant energy, using a microphone and selenium cell in conjunction.

The idea fascinated Mr. Lauste and it occurred to him that the sound waves might be recorded photographically and then reproduced by means of a light sensitive cell as Dr. Bell had done.

At first it was his idea to record the sound waves photographically upon a ribbon

or strip of bromide paper and to reproduce them, using a mirror and reflected light. He had then not yet seen a sample of Mr. Eastman's film. Early in 1890, however, in the Edison laboratory he saw for the first time a specimen of this film in the *Blacksmith*, one of the earliest kinetoscope subjects, and at once realized that the commercial material was available which would solve this phase of his problem.

Until the year 1900, however, the pressure of other work and his limited resources prevented Mr. Lauste from making much progress with his idea. In that year he made his first "light gate" of the grate type and drafted some sketches. But it was not until 1904 that he was enabled to build his first complete apparatus for experimental purposes.

It was very crude, but it demonstrated to him that he was following the right lines and on August 11, 1906, he applied at the British Patent Office for an invention described in its preliminary specifications as: *"A new and improved method of and means for simultaneously recording and reproducing movements and sounds."*

His complete specification was accepted and a patent, No. 18,057, issued August 10, 1907, which has often since been described as the "master patent" in the field of synchronized sound and movement photography. There certainly has never been another patent in this field which has quite compared with this in general interest and attention, for it has long been the "best seller" of the British Patent Office.

It has already gone through seven editions and an eighth is presently in prospect, so unprecedented has been the demand for this paper with the tremendous increase in experimental and research work on the sound-film in recent years.

To sketch, even in the most cursory fashion, Mr. Lauste's later experiments is difficult within the limits of this article. Until 1910 he devoted most of his efforts to obtaining adequate results in sound recording and reproduction. He had, of course, no amplification.

He experimented with and devised various types of mechanical and optical slits and lighting means. The grate light valves he first made for recording were unsatisfactory because of the inertia of the mechanical slit used. His limited mechanical equipment made it impossible for him to make a slit of this type sufficiently narrow.

He used an oscillating mirror with good results, but eventually found this also impracticable because the vibrations of the camera interfered with the light waves and distorted them. His ultimate sound gate, which embodied a vibrating diamagnetic wire (silicon) acting between the poles of two strong magnets, was entirely successful. He devised this early in the year 1910.

In this year also, he paid his first visit to Ernst Ruhmer, the eminent German experimenter, in Berlin. It is generally recognized now that these two pioneers, a Frenchman and a German, laid down the fundamental theories for photographic sound recording and reproduction. They collaborated and exchanged notes on their experiments until 1913, the year in which Ruhmer died, and for a time considered combining their research activities.

In 1910 Mr. Lauste first photographed sound and scene on the same film at his Brixton, London, studio. Between that date and 1914 he photographed many thousand feet of sound pictures. He came to America for a short visit in 1911,

with the idea of interesting capital, but was recalled to England too soon for him to make any definite arrangements.

In his short stay in America in the Spring of 1911 he demonstrated his sound camera-projector to a number of people and photographed at least one short length picture, recording sound and scene. This, doubtless, may properly be described as the first true sound picture to be taken in America.

In 1912 Mr. Lauste, having sufficiently perfected his recording and reproducing systems, began experiments to devise an amplifier for his sound films. But for the fact that his capital was limited and the later interruption of the war, it is quite possible that the sound picture might have made its public appearance at least a decade before its commercial possibilities were demonstrated by means of the sound amplifying system developed by the Bell Telephone engineers.

The fact that Mr. Lauste never succeeded in making his sound processes commercial or profiting from them, will have no bearing on the measure of fame which future film historians will accord him.

There can be no doubt but that he was the first to record sound and scene upon the same film and to reproduce it, and the importance of his researches and early experiments will become increasingly apparent with the passing of the years.

JEAN ACME LEROY—PROJECTION PIONEER*

In a brief historical report, such as follows, it is difficult to do justice to the colorful career of Jean Acme LeRoy, projection pioneer, whose experimental work and invention is the subject of this article. It is a constant temptation to turn aside from the cold consideration of his work to tell something of the man himself, his struggles, and disappointments, but these matters have no place here.

LeRoy's claim has been that he was the first to commercially show motion pictures on the screen, using a projection machine which he had devised. Previously, motion pictures had only been viewed through an aperture by a single individual at a time. LeRoy first made it possible for many to see the same picture simultaneously.

Nearly a year ago the Society took these claims under consideration and last Spring a report was made by the Historical Committee after a careful investigation of the available records, of which this article is the substance. Much testimony in affidavit form was examined, living eye witnesses interviewed, and other corroboratory evidence considered before the report of the Historical Committee was prepared. All of it bore out the contention, which at first had occasioned some doubt and surprise because of the generally accepted idea that commercial motion picture projection did not exist in the art until some time in the year 1895, that LeRoy had succeeded in accomplishing it a full year previously.

That the LeRoy projector was never patented or commercialized, in the sense that its inventor sought to standardize his invention, and manufacture or intro-

* A contribution of the Historical Committee, prepared by Merritt Crawford.

duce it for the use of others than himself, is conceded by LeRoy. In the strictest sense, therefore, it cannot be said to have exercised any considerable influence upon the development of the early art.

LeRoy, the showman, used his machine for his own purposes in earning a living. He did not regard it then as an invention, but merely as a novelty, an added feature for an entertainment program. He made no pictures himself, but projected the subjects of others, mostly Edison kinetoscope films, from February 5, 1894, the date of his first public showing, until the summer of 1897.

So his "Marvelous Cinematographe," as he described his early projector, cannot be said to have contributed in an important way to the motion picture's growth.

Nevertheless because of the early date of its disclosure, the fact that certain features of LeRoy's machine played a part in some of the important patent litigation which marked the first two decades of the industry's development, and because it anticipated in many essential features the screen machines which later were destined to popularize the art, LeRoy's invention possesses a definite historical interest.

To sketch briefly LeRoy's background, he was born February 5, 1854, near Bedford, Kentucky. He came to New York, while still a youth, and was apprenticed to one Thwaites, a famous photographer of the pre-Civil War period, whose studio was then at No. 1 Chambers Street, New York City.

In 1876 he posed two dancers, photographing the poses in series, taking over two hundred plates. Then he devised an apparatus, using lantern slides, which successfully projected pictures on the screen and in a crude way created the illusion of motion.

The device was too clumsy and costly for commercial use, and the rattle of the glass slides distracted the attention of the audience, but the apparatus embodied a number of the basic principles that remain today in the motion picture projector, such as an obscurating shutter (oscillating, not rotary), an intermittent feeding mechanism, an illuminant, and lens.

From about 1880 to 1887 LeRoy was employed by a firm of traveling view photographers and on returning to New York worked for various leading photographic studios. In 1887 or 1888 he took up his experimental work again, but his experience with his glass plate projector had convinced him that until some flexible material could be substituted for glass little progress could be made toward obtaining successful animated photography.

As all the world now knows, it was during this period (between 1886 and 1891) that the cinematic art was to have its inception in the inventions and discoveries of Dr. Marey, Friese-Greene, Goodwin, Edison, Eastman, and others, in the creation of the film and camera apparatus, which made the motion picture possible.

LeRoy, who kept abreast of developments in his special field, knew something of the advances which were being made in the direction of animated photography. Early in 1893 he obtained by chance some film made by Wordsworth Donisthorpe, a well-known British experimenter. It was unperforated, but the views it showed in series of a London street scene gave LeRoy an idea.

The film, itself, probably manufactured by Thomas H. Blair & Co., then the leading British camera supply house, was the first that LeRoy had ever seen, although he had been aware that sensitized celluloid sheets had been manufactured commercially by Carbutt and others for several years previously.

With the memories of his old glass plate projector before him, LeRoy set to work to devise a machine suitable to project the Donisthorpe film and late in 1893 he completed his first model.

The apparatus was very crude, being constructed mostly of wood. Friction rollers were used for feeding and intermittent rollers to obtain stop-motion. The results he secured were sufficient to encourage him, but he realized that with the imperfection of the film stock at that time and the difficulties of keeping the pictures in frame, the friction method could not be made practicable without much further experiment.

Meanwhile, the kinetoscope of Mr. Edison, which had lately appeared, was beginning to make film history. Raff and Gammon, Edison's distributing agents, held an exhibition of the novel coin-operated motion picture machines at the Grand Central Palace in December, 1893, and it was here that LeRoy secured the solution of his problem for making a practical projecting device.

As every one knows the kinetoscope used film of the present-day standard, with four perforations on each side of the image and LeRoy instantly realized that it was far better adapted for projection than the friction method. The Edison machine also assured him of a supply of motion picture subjects, a matter which had previously given him much concern, as he had had no definite source of supply for his projector. And without film, of course, it was quite useless.

To complete his invention now required only the substitution of sprocket roller for the friction roller, but LeRoy also made many other improvements and, in fact, rebuilt his frictional machine almost in entirety. The new machine was completed, according to the testimony, on February 3, 1894.

Two days later, in the showroom of Riley Bros.' optical shop, at No. 16 Beekman Street, New York City, two Edison kinetoscope films were projected before an audience of about twenty-five people, mostly booking agents and theatrical folk. It is contended, and there has been no evidence developed to contradict it, that this was the first time, in America, at least, that a motion picture on celluloid film was shown publicly on the screen by means of a projection machine.

All motion pictures shown previously, as far as the records indicate, had either been imperfectly projected with a camera for experimental purposes or had been shown through an aperture to a single individual at a time, and not to an assembly upon a screen.

This date is substantiated, as previously mentioned, by many of the individuals present on that memorable occasion in screen history, in affidavits and by personal testimony. The writer has personally interviewed several of those, who are still living, and there seems to be no question, but that February 5, 1894, will go down in motion picture history as the established date for the first screen show.

As it was not for a considerable period thereafter, that any other projection machines were publicly disclosed, according to the authoritative history by Mr. Terry Ramsaye, "A Million and One Nights," which assigns to the year 1895 the earliest appearance of any of them, LeRoy's "Marvelous Cinematographe" must be given the historical distinction of being the pioneer screen machine.

The pictures screened by LeRoy at this first showing in Riley Bros.' establishment were the *Execution of Mary Queen of Scots* and *Washing the Baby*, two well-known early Edison subjects. Following the exhibition LeRoy explained

to those present where his films originated and stated also that he hoped to secure others from foreign makers like Donisthorpe.

Necessarily, because of the short length of his entertainment (the films shown took about two minutes to run off), he was not enabled immediately to receive any theatrical bookings. There was also probably a question in the minds of his audience as to the certainty of his obtaining a future steady supply of screen material, although they were much impressed by the exhibition itself.

LeRoy did, however, receive numerous single engagements and in ensuing months gave many exhibitions at clubs, social and church organizations, and private entertainments with his screen machine. Among others in the Spring of 1894 were engagements at the Bijou Theater and Verona Hall in Brooklyn.

LeRoy's "pictures in life motion" were principally used as a "filler" on the Sunday evening entertainment programs of the period. Among the pictures he showed at this time were the famous Leigh Sisters in *The Umbrella Dance* and *The Trilby Dance*, the *Serpentine Dance* by Annabelle, and Hoyt's *Milk White Flag*, all of them Edison kinetoscope subjects.

From the Spring of 1894 until July, 1897, he gave numerous exhibitions in many states, using the same projector, but showing a great diversified program of films. He has probably the distinction of taking out the first motion picture "road-show," though the mishaps of that adventure would require a separate article to narrate, and there is in existence an ancient handbill, which attests that on Washington's Birthday, 1895, LeRoy's troupe of featured players and the "Marvelous Cinematographe" with "pictures in life motion," entertained the citizens of Clinton, New Jersey.

It was not until 1897 that it occurred to LeRoy that he ought to patent his projector, as by that time many other machines had appeared, the marvelous industrial development of the industry had begun, and he came to realize, probably for the first time, the possibilities of his invention.

He then consulted a patent attorney and was frankly told that he was just about one year too late, the two years' grace accorded the inventor by law to disclose his invention having expired February, 1896.

Of LeRoy's later contributions to the art and his numerous patented improvements on the projector, which related principally to the elimination of the first hazard and the prevention of eye-strain, *etc.*, I shall make no attempt to enumerate here. I would like to record, however, that it was LeRoy who devised the projection booth for fire protection, which the National Board of Fire Underwriters adopted as the standard back in 1907, and that LeRoy refused to patent it, though it had many patentable features, on the ground that public safety required that means for fire protection should be free and unhampered for all.

During the battle between the so-called "independents" and the Motion Picture Patents Company, beginning in the year 1909, LeRoy also played an important part. His projector helped to establish the fact that the essential inventions for animated projection were in the public domain, by reason of his use of his projector, which thus constituted "prior art." In this he was materially aided by Mr. Alfred H. Saunders, then editor of *Moving Picture News*, the forerunner of today's *Motion Picture News*, who published pictures of LeRoy's machine and a full description of it and its history in his publication, August 12, 1911.

Until some two years ago LeRoy was far more active than many younger men

in the industry. Like many other inventors his life has been one of hardship and disillusionment. But his keen interest in all matters having to do with the art has never wavered. And his collection of early films and historical memorabilia of the motion picture's growth has probably not its equal in America.

On August 28, 1928, he was stricken, while working in his shop, then in West 44th Street, New York, and since that time he has been confined to his home, partially paralyzed. His mind, however, is fully active and his memory of dates and events in film history remarkable. He is proudest, however, of being a "pioneer." and of having played some part in the motion picture's beginnings.

ABSTRACTS

The following abstracts are published by courtesy of the Eastman Kodak Company, publishers of the Monthly Abstract Bulletin of the Kodak Research Laboratories.

Profits of American Studios. W. H. Gordon. *Brit. J. Phot.*, **77**, July 25,1930, p. 446. This article gives study of working expenses and profits of photographers' businesses in the United States for the year 1928 as reported by a business research bureau of an American university. Of the sixty-seven professional firms studied, thirty-three had an operating profit above the average of 10.5 per cent. The total average business done amounted to approximately $14,500. Of this average amount received, 26.3 per cent represented cost of materials, working expenses 63.2 per cent, and average profit 10.5 per cent. Detailed analysis is given of the working expense item, and conclusions are drawn from the entire report. A need is emphasized for photographers to gain more accurate knowledge of business methods, particularly of the use of budget control systems.

Soviet Hollywood. *Kinemat. Weekly*, **162**, Aug. 21, 1930, p. 24. It is stated that work on the Moscow motion picture film plant has been intensified so that it will be ready for production early in 1931 instead of 1933 as originally intended. Two systems of sound-on-film recording are to be used, the inventors being Shorin and Tager.

Expansion of Amateur Cinematography in America. K. A. Barleben. *Phot. Korr.*, **66**, May, 1930, p. 128. The early systems, of which the Movette was perhaps the most important, were not commercially successful and disappeared, but they have led to the now established systems.

Cinematography in the Photographic Studio. A. Jaschke. *Photographe*, **17**, June 5, 1930, p.233. A motion picture camera is recommended for taking pictures of infants, dancers, and like subjects. Finished pictures are made either by direct enlargement preferably on bromide paper, or indirectly by means of a master negative. The equipment necessary for this work is described.

Sound Film Patent Situation. P. Hatschek. *Kinotechnik*, **11**, Nov. 5, 1929, p. 570. German patents are reviewed covering the different elements in the recording and reproduction of sound in synchronism with pictures. The comments are critical as to the covering force of the individual patents.

Dividing Screen. *Kinemat. Weekly*, **163**, Sept. 25, 1930, p. 67; *Bioscope* (*Mod. Cinema Technique*), **85**, Oct. 1, 1930, p. ii. Mention is made of a Morris "Dividing" screen in use at the Scala Theater, Nottingham. The image luminosity is said to be doubled by the use of a thin muslin screen used between the acoustically transparent "Transvox" screen and the felting. (Presumably the felting referred to is placed behind the loud speakers to prevent reverberations from the rear, while the muslin is placed between the loud speakers and the screen.—Abstractor.)

Revolutionary New Set. *Bioscope* (*Mod. Cinema Technique*), **85**, Oct. 1,

1930, p. v. A new sound reproducing equipment, the Brown Magnetorge, is being marketed by Magnetic Talking Pictures, Ltd. Transmission is by means of a "magnetic torque motor," a principle said to be novel to cinema work. A special optical system is employed so that the light, after passing through the sound track, is reflected to a photo-electric cell placed centrally between the two projectors. Brown amplifiers and loud speakers are used. The complete equipment for sound-on-film and disk costs $2750.

Selenium for Talkies. R. H. CRICKS. *Kinemat. Weekly,* **163,** Sept. 11, 1930, p. 55. The Automatic Light Control Company, Ltd., has developed an improved form of selenium cell. A brief description is given of the method whereby selenium is deposited on a glass plate so as to give a very wide short current path of small internal resistance. Tests have shown that the cell is not susceptible to fatigue or temperature changes to any measurable extent, and that the time lag can be corrected by an amplifier with a suitable inductive circuit. The cell is not sensitive to color changes.

R. C. A. Aids the Hard-of-Hearing Fan. *Ex. Daily Rev.,* **28,** Sept. 20, 1930, p. 18. Persons whose hearing is defective are supplied with direct telephone connection to the amplifier. A receiver is held to the ear by means of a lorgnette handle, and a cord extends to a plug for a receptacle on the arm of the seat. The volume of sound can be controlled to suit the user.

New Continuous Printer. L. EVELEIGH. *Kinemat. Weekly,* **162,** Aug. 21, 1930. p. 65. The Vinten continuous printer for sound films is described. Contact is established by a curved gate with a flattened aperture through which the films are pulled at the correct tension by a specially designed sprocket wheel connected by a spring coupling to a flywheel on the same spindle. Uneven running of the sprocket is thus damped by the inertia of the flywheel. A universal fitting allows for the insertion of any type of printing lamp for the picture, while a 12 volt lamp is used for the sound track, provided with an ammeter and a control. The speed of printing is stated to be 120 feet per minute, and arrangement is made whereby batteries of printers can be placed in line, the negative running directly from one printer to the next, thus making any number of prints with only one final take-up. A brief description is given of the novel automatic light change incorporated. This is controlled by a number of circular disks mounted on a spindle with friction clutches. Normally, the disks are held stationary, slipping on their axle while the spindle rotates. By means of electromagnetic releases operated by a chart, any one of the disks is released and rotates with the spindle to make contact and give a predetermined exposure. When the exposure is to be altered, the release of another disk moves the contact block which has been engaging the first disk, so that it completes its rotation into its original position.

Some Experiments in Mobile Color. G. A. SHOOK. *J. Opt. Soc. Amer.,* **20,** June, 1930, p. 35. A convenient "organ" for producing lights varying in form and color is described. Unlike the Clavilux which utilizes a large number of specially constructed lamps, this new instrument has a single light source and three rotating disks on which are placed the various optical devices and colored filters for producing the mobile light forms. The instrument readily lends itself to automatic control.

Devices for Silencing Cameras. *Ex. Herald-World,* **100,** Sept. 13, 20, 1930,

p. 48. A report is given of a subcommittee of the Academy of Motion Picture Arts and Sciences on twenty-one devices used by various cameramen for silencing sound cameras for standard film. Sources of noises in cameras are outlined. If carefully serviced and covered with a good housing, the average camera operates at a sound level 6 to 10 db. less than whispering at 6 feet from the microphone. Sound is propagated through insulated structures by transmission, diaphragm action, and leakage. Details are given of the methods of measurement and of the exact type of construction used for different cameras. Some of the housings are water-tight and air-tight.

Rome's New Talkie Studios. *Kinemat. Weekly*, **163,** Sept. 18, 1930, p. 63. The Cines Pittaluga studios at Rome have been reëquipped for the production of sound pictures. Moviola and Friess outfits are provided for the examination of the sound tracks and films, copies of which can be developed in rooms attached to each studio. RCA sound recording equipment is installed, and Vinten printers are to be employed. Some details are given of the available lighting units.

New Pathé-Cinéma Studios. *Kinemat. Weekly*, **162,** Aug. 21, 1930, p. 53. The Pathé studios in Paris and at Joinville-le-Pont have been rebuilt and re-equipped. RCA Photophone sound equipment is installed both in the form of fixed outfits and in three mobile trucks. Dimensions are given of the six separate studios, some of which are fitted with baths and floor traps. Current at 120 volts is available up to 10,000 amperes, and details are given of the arc and incandescent lighting with which the studios are furnished. Workshops, laboratories, theaters, stores, garages, and a restaurant complete what are said to be the most practical and complete film studios in the world.

Parallax Panoramagrams Made with a Large Diameter Lens. H. E. IVES. *J. Opt. Soc. Amer.*, **20,** June, 1930, p. 332. A description of a method used in making pictures showing stereoscopic relief is given in which the moving lens usually employed has been replaced by a stationary lens of an aperture large enough to cover the field traversed by the moving lens. Among other advantages the exposure time required in making relief pictures is considerably shortened by the use of this new system.

Progress of Air Photography. F. E. CHASEMORE. *Brit. J. Phot.*, **77,** Aug. 22, 1930, p. 509. The cameras used in aerial surveys in 1924 and 1928 are described and compared. The modern air camera is electrically operated and uses panchromatic roll film in either of two lengths, one for 50 exposures and another for 100 exposures. At the side of each picture there are also automatically photographed data such as height and time at which photograph was taken, *etc.* When started, the camera automatically takes a series of photographs at the required time interval until switched off again. The driving power is a small electric motor working from 12 volt accumulators. A fixed slit focal plane shutter gives an exposure time of $^1/_{90}$ seconds at a full aperture of $f/4.5$, variations in exposure being obtained by adjustment of the aperture.

ABSTRACTS OF RECENT U. S. PATENTS

1,780,969. E. Brunner. A process and apparatus for producing artistic designs. This is a machine for producing kaleidoscopic images of one or more negatives. An optical system with lenses and reflectors is employed for producing a real image before a mirror system and then for projecting kaleidoscopic pictures from the mirror system to a screen. Mobile color effects of changing design may be thus produced.

1,788,139. R. John. A positive motion picture film capable of use for enlarged projection may be made in accordance with this patent by producing images of coloring matter applied by transfer. An exposed master positive which has the character of absorbing an aqueous dye solution or retaining greasy ink corresponding to light and shadows is made photographically. This film is charged with color and the color is transferred to a support while retaining the proper relationship between film perforations and frame lines for the different picture areas of the film. The cost is said to be less than photographic copies when this process is employed.

1,775,610. A. Weiss. This patent relates to a film reel for motion pictures having an octagonal opening to engage a film supporting shaft. The shaft may extend through the reel up to one flange which is provided with a similar shaped opening of a different size. The object is to insure the proper positioning of the reel on the supporting shaft and the supporting shaft may be of various forms in cross-section such as round, square, triangular, or octagonal.

1,778,635. C. L. Adisler. A simple type of support for projecting machines in which one pair of legs is movably mounted with respect to another pair of legs. The second mentioned legs carry a supporting casting having a bearing on which a top is pivotally carried. This top may be adjusted angularly about this pivot by means of a worm and worm wheel and the top is counter-balanced by a spring to insure ease and smoothness of movement.

1,783,045. Kellogg. Contact film printer. This machine is designed for moving a plurality of films through a curved path past a printing light. The path may be curved more or less so that suitable adjustment may be made to care for any deviation in the length of a film from a standard, such deviations occurring from shrinkage, expansion, and sometimes from the age of a film. The adjustment for altering the curved film path may be automatically or manually controlled.

1,776,637. J. Ostermeier. A flashlight designed particularly for photographic purposes which will eliminate most of the noise and smoke usually accompanying a flash of the usual type. The lamp is similar in shape to an electric light bulb, but contains thin metallic foil, preferably aluminum, in oxygen and an igniting wire. By making the circuit a flash is produced without smoke or dust and with only a very little noise. The combustion of the foil does not alter the pressure in the bulb sufficiently to break the glass. Only a low voltage is necessary to ignite the foil. A flashlight battery may be used for this purpose if desired.

1,780,945. A. Sagier. This relates to a film frame for a motion picture projector in which a film guideway of two relatively movable plates is provided. The plates facing the objective may be moved by a handle near the objective

for framing and this plate is resiliently mounted on a second supporting plate carrying the objective.

1,777,419. O. A. ROSS. Focus and finding apparatus for motion picture cameras. This camera is equipped with an optical system reflecting and focusing an image from the objective upon a viewing screen intermittently, and in timed relation to taking pictures. Thus an operator can view action through the finder and focus it at the same time.

1,799,653. E. N. BALL. A sound insulated camera is made by building up sound proof walls around parts of the camera and film reels. The sound proof walls are provided with suitable doors to give access to necessary camera parts, and with a window to see through the walls. The housing is built up from a tripod head and particularly guards a sound recording chamber from the noise of the camera mechanism.

1,776,049. E. I. SPONABLE. This patent relates to the splicing of sound records. To overcome the unpleasant sudden change of sound records where films are spliced together a small diamond or arcuate shaped aperture may be cut from the film through the spliced sound record. This leaves all but a narrow portion of the splice intact so that it does not materially weaken the splice.

1,781,053. R. E. DEBAULE. Illuminating system. This system includes a lamp and reflector assembly. An incandescent lamp is illustrated as having the filaments to one side of the center of the bulb, which may be mounted between two adjustable, spaced reflectors, one in front of the lamp and the other behind the lamp. Condensing lenses are supported in brackets extending through a central aperture in the front reflector and are in axial alignment with the filaments of the lamp. The lamp and reflector supports permit accurate focusing.

1,777,682. E. I. SPONABLE. Combined sound and motion picture camera. To dampen mechanical impulses in a camera for taking sound and picture records a yielding guiding connection is provided between the film sprocket and the shutter shaft. This guide may include a plurality of springs, each having one end connected to a flywheel, and each having the other end connected to one of a series of radial posts carried by a rotating member so that the drive is through the plurality of springs.

1,777,828. LEE DEFOREST. For sound and picture photography this patent proposes the use of two cameras, one for the sound record and the other for the picture record. Each of these cameras may be driven by a synchronous motor so that the sound and picture records may be made simultaneously with the cameras which may be spaced at different distances from the scene. These records may then be printed on a single film, using the desired portion of each film for a completed sound and picture record.

1,780,585. A. FRIED. A camera support permitting a camera to be mounted thereon and arranged to facilitate turning the camera on a horizontal and on a vertical axis. To insure smoothness and freedom from "chatter," a gear train is arranged to govern the movement about each axis. Each gear train terminates in a relatively heavy flywheel which limits the speed of the turning or panoraming movement. A handle projects to one side of the device for controlling the desired camera movement.

1,781,501. E. O. ORD. An optical system for use with camera objectives for producing humorous effects. Pairs of prisms are spaced angularly with respect

to each other and may be rotated about the axis of the optical system. Parallelizing lenses—a negative and a positive lens—are mounted to pass light through the prisms. This system permits accurate focusing and is said to give critically sharp pictures.

1,781,923. F. HIRSCH. A shutter for motion picture apparatus mounted on the front of an objective formed of a pair of relatively adjustable fan shaped blades. These blades are operable by a cam and linkage back and forth across the objective to make successive exposures.

1,799,468. E. GOLDBERG AND O. FISHER. Cinematographic camera. This shows a spring driven motion picture camera equipped with two counters to indicate units of exposed film and a stop mechanism which is actuated after a desired length of film has been exposed. The spring energy is never totally expended as the stop will always function before the spring is unwound. This exposes all the frames equally before the spring grows weak.

SOCIETY OF MOTION PICTURE ENGINEERS

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Member of the American Chemical Society, Optical Society of America, and fellow of the Royal Photographic Society and the Institute of Chemistry of Great Britain and Ireland. Extensive publications on photography and motion picture work. In 1926 awarded the Progress Medal of the French Photographic Society.

Elected President of the Society of Motion Picture Engineers, Oct., 1929.

Downes, A. C.: Born February 26, 1882, Ipswich, Mass. Degree of B.S. from Massachusetts Institute of Technology in 1904. 1904–1905 with Hartford Laboratory Company. 1905 to date with National Carbon Company. Member of the American Chemical Society, Illuminating Engineering Society.

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from Colorado College with degree of B.S. in E.E., 1913. 1914 Western Electric Company. 1917 associated with a group investigating devices for submarine detection for a special board of the Navy. 1918 technical staff of Engineering Department of Western Electric Co. 1925 Bell Telephone Laboratories. Now in charge of development of instruments for telephone use. Member of the American Institute of Electrical Engineers. Fellow of the Acoustical Society of America.

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Little, William F.: Born October 4, 1880, Philadelphia, Pa. Received B.S. degree in 1903 and M.S. degree in 1906 from Rutgers College. Associated with Electrical Testing Laboratories in charge of photometric measurements, 1906 to to date. Member of Illuminating Engineering Society, International Commission on Illumination, American Society for Testing Materials, and Optical Society of America.

Marsh, William: Born November 3, 1884, in Kilkenny, Ireland. Attended National Academy, London, England. Served in British Army in Boer War and in India from 1904 to 1911. Served in U. S. Army from 1912 to 1914. Bausch & Lomb Optical Company from 1914 to 1926. Eastman Kodak Company, 1926 to date.

Miller, Palmer: Born May 6, 1903, Dewitt, Iowa. B.S. in Chemistry, California Institute of Technology, Pasadena, California, 1924. Technicolor, 1925–28; General Electric Company, 1928–29; Brewster Color Film Corporation, 1929–30.

SOCIETY NOTES

ANOTHER MILESTONE

Twelve months ago the first JOURNAL was published. As was written in the January, 1930, issue of the JOURNAL by our President, Mr. J. I. Crabtree, the establishment of a monthly JOURNAL had long been the dream of the Board of Governors. The possibility of transforming the quarterly *Transactions* into the monthly JOURNAL was due to the untiring efforts of our worthy executives and editor pro tem, Mr. L. A. Jones.

The rapid and healthy growth of the Society in regard to number of members, and the widening scope of activities of the Society brought about this change. However, this very growth placed an undue burden upon the men who fostered it, from which it was necessary that they be relieved.

Another milestone in the history of the Society has been passed. In order to pave the way for the future growth of the Society, and in order to relieve the officers and editor pro tem of the enormous amount of work which they had heretofore contributed as a labor of love, the Society recently established general offices at 33 West 42nd Street, New York, N. Y. This address is henceforth to be the permanent mailing address of the Society, through which all officers and members of the Society may be reached. The offices are also the business and editorial headquarters for the JOURNAL. The newly appointed Editor-Manager, Mr. Sylvan Harris, is ably assisted by S. R. Renwick and P. K. Sleeman. Members are invited to visit the new offices and call upon the Editor for any required assistance.

THE NEW YORK SECTION

At a meeting held on December 5th at the New York Studio of the Paramount Publix Corporation, Dr. N. M. LaPorte, of the Paramount Publix Corporation, spoke on the subject of wide film and projected a number of reels made on 65 mm. film. A number of 35 mm. Keller-Dorian color films were also projected.

The election of officers resulted in a unanimous vote for reëlection of the present officers who are as follows:

Chairman	M. W. PALMER
Secretary-Treasurer	D. E. HYNDMAN
Managers	M. C. BATSEL T. E. SHEA

THE CHICAGO SECTION

At a meeting held November 6th at the Webster Hotel, Chicago, Ill., the following new officers were elected:

Chairman	J. E. JENKINS
Secretary-Treasurer	R. F. MITCHELL
Managers	R. P. BURNS O. B. DEPUE

Final arrangements were made for the December meeting to be held at the Enterprise Optical Manufacturing Company.

Mr. Earl Pearsall, Jr., who has just returned from Hollywood, spoke on wide film developments and difficulties encountered in current color processes, particularly Multicolor on which Mr. Pearsall has been working.

THE LONDON SECTION

Your President regrets to announce that at a special meeting called by the London Section, December 2nd, it was resolved by a vote of 26 to 3 that the London Section pull away from the parent body and form an independent technical organization. This action is a result of lengthy negotiations which culminated in an ultimatum from the chairman of the London Section demanding various concessions and privileges, including reduced entrance fees, the right of the section to appoint Active members, and a non-budgeted expense account which the Board of Governors of the parent body could not concede.

A canvass of the London membership is being made to determine if it is the desire of those members who were not present at the December 2nd meeting that the Section be continued.

The Society regrets to announce the death of Frederick G. Tutton, October 18, 1930.

SUSTAINING MEMBERS

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RCA Photophone, Inc.
Technicolor Motion Picture Corp.

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JOURNAL

OF THE SOCIETY OF

MOTION PICTURE ENGINEERS

SYLVAN HARRIS, EDITOR

Volume XVI **FEBRUARY, 1931** **Number 2**

CONTENTS

JOURNAL
OF THE SOCIETY OF
MOTION PICTURE ENGINEERS

SYLVAN HARRIS, EDITOR

Published monthly at Easton, Pa., by the Society of Motion Picture Engineers

Publication Office, 20th & Northampton Sts., Easton, Pa.
General Office, 33 West 42nd St., New York, N. Y.

Subscription to non-members $12.00 per year; to members $9.00 per year; single copies $1.50. Order from the Society of Motion Picture Engineers, Inc., 20th and Northampton Sts., Easton, Pa., or 33 W. 42nd St., New York, N. Y.

Entered as second class matter January 15, 1930, at the Post Office at Easton, Pa., under the Act of March 3, 1879.

A NEW SOUND REPRODUCING SYSTEM FOR THEATERS*

G. PULLER**

Summary.—*This paper describes a system for high quality sound reproduction from film in synchronism with the showing of motion pictures in theaters having a seating capacity of 1200 or less. A sound reproducing attachment is mounted upon each standard picture projector and is belt-driven by a common motor unit. The sound reproducing attachment houses a photo-electric cell which converts a light beam intercepted by the film sound track into electrical energy. Suitable preliminary amplifiers mounted upon independent pedestals amplify the output voice frequency energy of the photo-electric cell to a level suitable for further amplification by the main amplifiers. A control cabinet provides for switching and attenuating the sound circuits before being led to the main amplifiers and thence to the loudspeakers.*

The new Western Electric Small Theater Reproducing System described in this paper was introduced by Electrical Research Products, Inc., during July of this year. This system was developed by Bell Telephone Laboratories, Inc., and provides for reproducing sound from film in synchronism with motion pictures in theaters having a seating capacity of 1200 or less.

The system as a whole includes two reproducing attachments which mount on Simplex pedestals of various types and operate in connection with Simplex picture projectors. Each combined reproducing attachment and projector is driven by a motor unit also mounted on the Simplex pedestal. The photo-electric cell output of each attachment is supplied to an associated pickup amplifier mounted on its own pedestal directly in front of each projector. The outputs of the two photo-electric cell amplifiers are switched and attenuated by means of a control cabinet, which usually mounts on the front wall of the booth and acts as a combination fader, switching and signal cabinet. From this cabinet the sound circuit extends through the main amplifiers to the loudspeakers.

Film Reproducing Attachment.—The film reproducing attachment comprises a unit assembly arranged for mounting upon a standard Simplex pedestal of either the L, M, or R type, and provides for

* Presented at the Fall 1930 Meeting, New York, N. Y.

** Bell Telephone Laboratories, New York, N. Y.

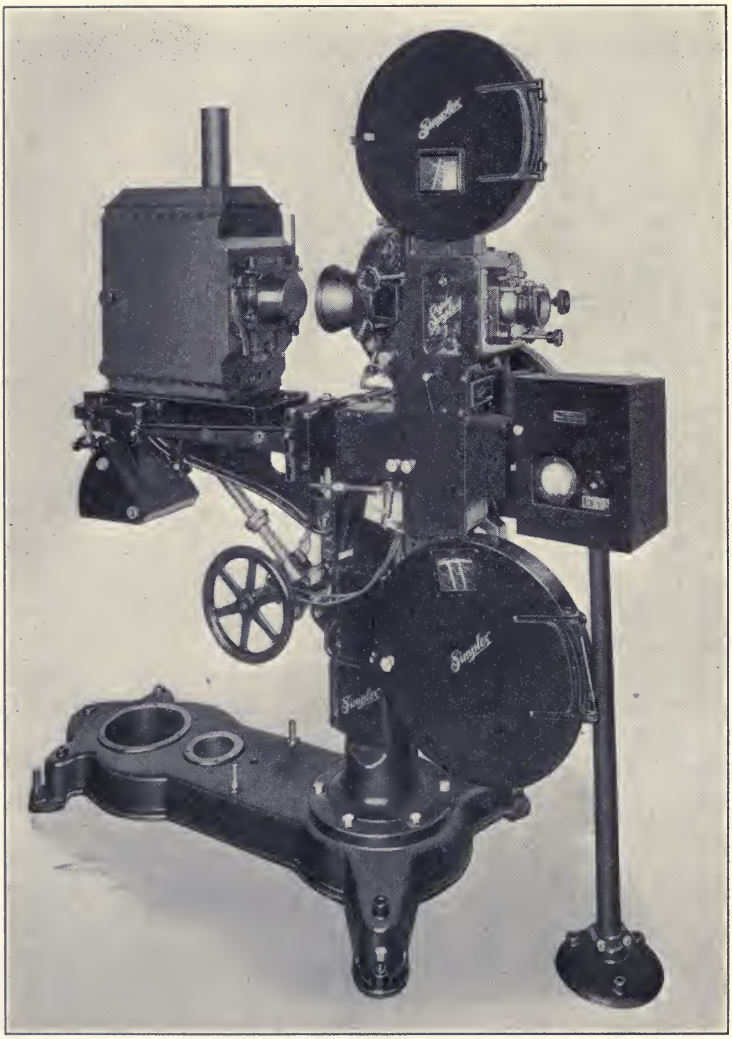

FIG. 1. Film reproducing attachment mounted on standard Simplex type R pedestal.

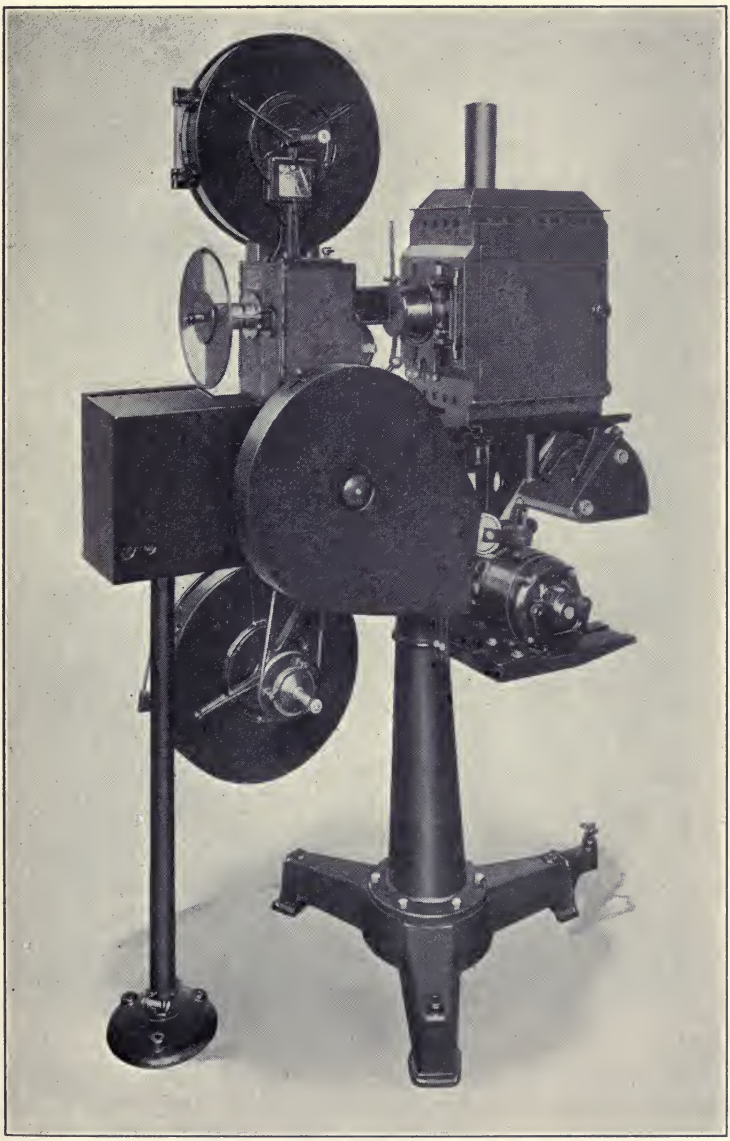

FIG. 2. Film reproducing attachment mounted on standard Simplex type L pedestal.

mounting a Standard or a Super-Simplex projector head and a Simplex take-up magazine. Fig. 1 shows the attachment mounted on the Simplex type R pedestal and Fig. 2 shows the attachment mounted on the type L pedestal.

The operating side of the attachment comprises (*a*) a lamp compartment, (*b*) a film compartment, and (*c*) a photo-electric cell compartment. Fig. 3 shows these three compartments in detail.

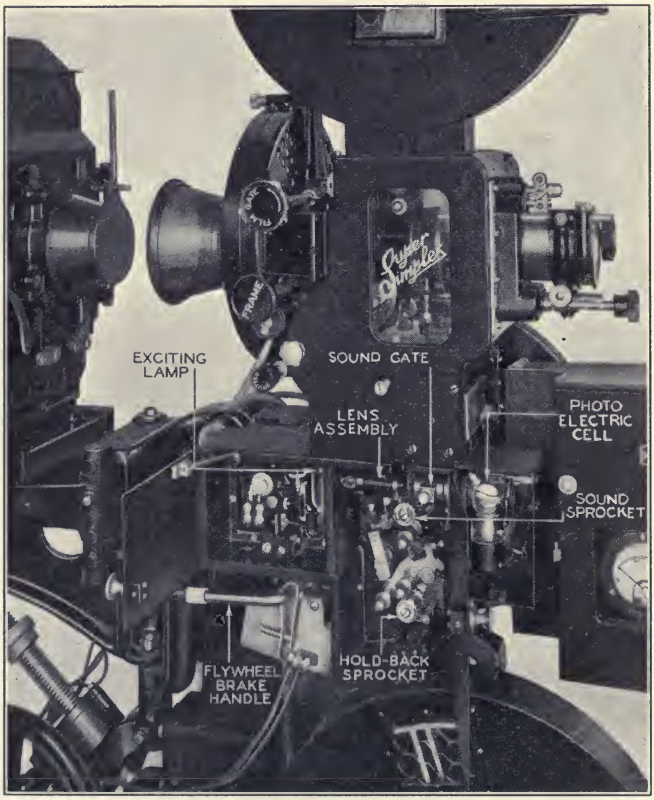

FIG. 3 Lamp, film, and photo-electric cell compartments.

The lamp compartment contains the exciting lamp for illuminating the sound track on the film. The filament of the exciting lamp is a horizontal coil producing an intense illumination. It is important that the current consumption of this lamp be kept within the proper limits as recommended by the instructions. Exceeding the recom-

mended current value will materially shorten the normal life of the lamp. In order to locate this filament exactly with relation to the associated equipment in the film compartment, the lamp is mounted in a special bracket which permits it to be adjusted in any direction and locked in position.

The lamp bracket is replaceable as a unit without disturbing the adjustment, so that duplicate lamps may be adjusted for position in extra brackets and will then be ready for use should a replacement become necessary during the showing of a picture. The various

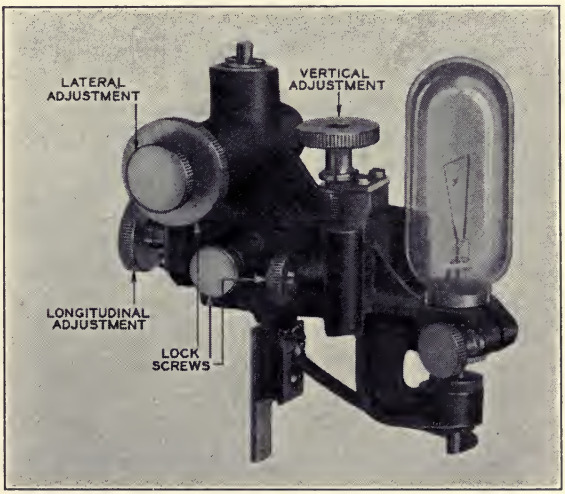

FIG. 4. Exciter lamp bracket and adjustments.

adjustments provided are illustrated in Fig. 4, which shows the lamp bracket removed from its compartment.

The film compartment provides for the passage of the film from the projector to the take-up magazine. Between the film and the sound lamp a lens assembly is provided, consisting of a lens tube mounted in a frame that also mounts an aperture plate with polished guides. These accurately locate the emulsion side of the film as it passes by the lens tube assembly. The lens tube proper contains a combination of condenser and objective lenses by means of which the light from the exciting lamp is projected in the form of a concentrated beam 0.001 inch wide on the film at the aperture plate. It is sealed in its supporting frame after having previously been care-

fully adjusted to obtain a line of light of the proper width on the film. A light beam of greater width would result in suppressing the higher frequencies, which are essential to good articulation and brilliance in music. An opening in the aperture plate limits the length of the light beam to 0.080 inch.

The lens surfaces should at all times be kept free from oil deposits or dirt, as this materially reduces the amount of light transmitted to the film, and results in a reduction in volume. To insure smooth passage of the film by the light source, the aperture plate should be inspected frequently, and any accumulation of dirt or other foreign substance adhering to the guide surfaces should be carefully removed.

A telescoping sound gate with a self-adjusting pressure pad keeps the film in proper contact with the aperture plate when the system is in operation. The gate is arranged to be opened for threading the film by the aperture plate. A loose loop of film is allowed between the lower take-up sprocket in the projector mechanism and the point where it enters the sound gate, which prevents the irregular movement of the film in its passage through the projector mechanism from affecting the uniform velocity of the film as it passes through the sound gate. The sound gate with the lens tube in position can be seen in Fig. 3. The film, after leaving the sound gate, passes over a sound sprocket which draws the film through the gate at a uniform rate.

The film next passes over a hold-back sprocket before finally entering the take-up magazine. A slack of about two sprocket holes should be allowed in the film between the sound sprocket and the hold-back sprocket, the purpose of which is to prevent any uneven pull on the film due to the take-up mechanism from reacting on the uniform velocity of the film as it passes over the sound sprocket.

A film guide roller mounted directly above the sound gate provides an adjustable means for guiding the film edgewise through the gate and retains the sound track of the film in its proper path with respect to the center of the lens tube assembly. Improper adjustment of this guide roller may cause the light beam to intercept a portion of the film having no sound track, and in the event of the light beam intercepting the sprocket holes serious disturbances in the reproduced sound would result. Fig. 5 is a diagrammatic illustration showing the path of the film through the film compartment.

The photo-electric cell compartment houses a Western Electric photo-electric cell which converts the light beam intercepted by the

film sound track into electric energy which is later amplified and transformed into audible sound.

It is, of course, essential that in order to obtain the maximum efficiency of the photo-electric cell, the active element or cathode of the

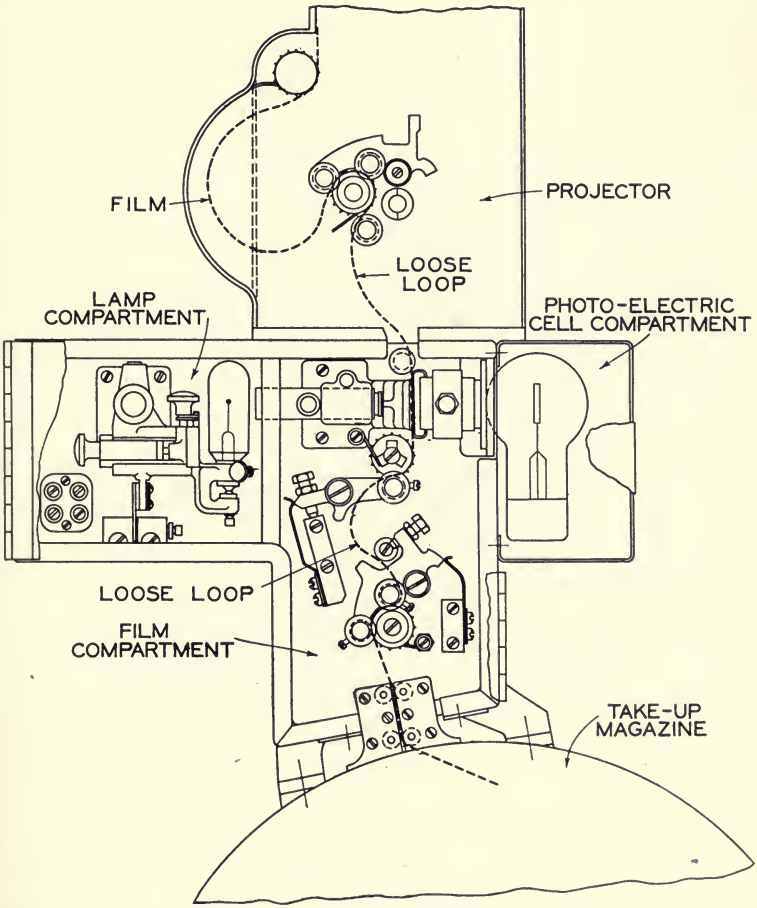

FIG. 5. Diagram of path of film through film compartment.

cell be directly in line with the light path. This is accomplished by supporting the cell at the spherical portion containing the active element—a method of support which reduces microphonic pickup to a minimum and lessens the liability of cell vibration. Microphonic pickup is further reduced by mounting the cell terminal on

a cushioned support. This method of supporting the cell also eliminates the necessity of base terminals at the cell and raises the insulation resistance to a point where objectionable ground noise is eliminated. The photo-electric cell may be seen in its housing by referring to Fig. 3. The photo-electric cell terminal block projects from the rear of its compartment and is in the form of a sleeve through which the lead of the photo-electric cell is brought out, to be later soldered to its terminal in the photo-electric cell amplifier. The

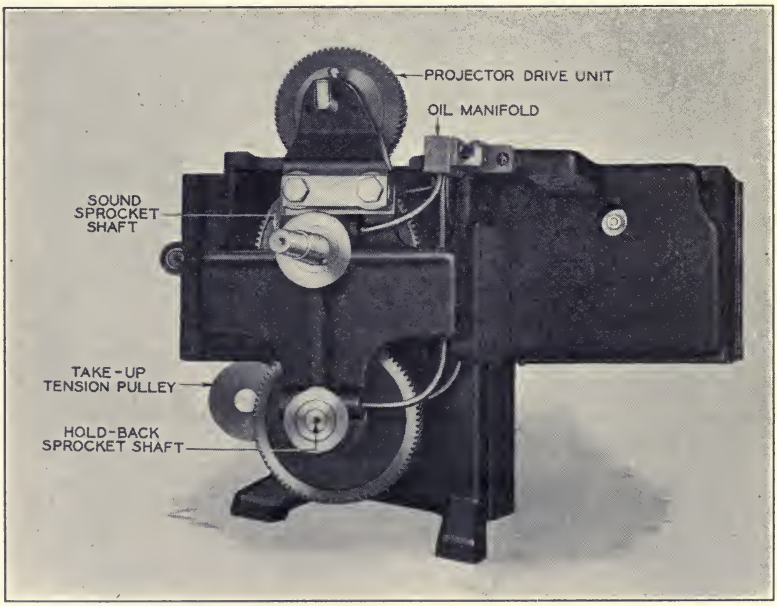

FIG. 6. Driving side of attachment with flywheel removed.

cell and its terminals are easily accessible through the front of the compartment, which is covered by a removable plate.

The driving side of the attachment provides the bearings for the various shafts and also mounts a removable bracket supporting an auxiliary gear unit which meshes with the driving gear of the Simplex projector mechanism. The projector and its associated gear unit are located in relation to the attachment so that in threading the machine the accepted standard length of $14^1/_2$ inches of film from the framed picture to the corresponding sound record at the light

beam can be employed. Fig. 6 shows the driving side of the attachment with the flywheel removed.

The shafts upon which the hold-back sprocket and the sound sprocket are mounted are large in diameter and are provided with ample bearings, which are lubricated by means of wick-filled chambers connected by tubes terminating in a single oil manifold. These two shafts, as well as the auxiliary gear unit for driving the Simplex projector, are interconnected by means of a simple train of three gears, which are the only gears employed in the attachment. The auxiliary gear unit is lubricated by means of its own oil cup attached to the end of the supporting pilot shaft.

A large diameter flywheel of considerable mass is rigidly mounted on the end of the sound sprocket shaft and is driven from the motor pulley through the medium of a pair of round, woven fabric belts which run in grooves on the flywheel rim. This type of drive is quiet in operation and free from disturbing vibrations. At the same time it provides a very efficient filtering action, resulting in uniform rotational velocity of the sound sprocket and, consequently, freedom from objectionable flutter disturbances. Uniform film velocity at the light beam is further assured through the high degree of precision employed in the manufacture of the sound sprocket.

As an additional precaution against the transmission of any disturbances to the sound sprocket, the gear which drives the hold-back sprocket shaft and the auxiliary projector gear unit is mounted so as to float on the sound sprocket shaft. The gear is coupled to the sound sprocket shaft by means of a cushioned yoke, which mechanically insulates the sound sprocket from any irregularities due to inaccurate gear tooth spacing, gear vibrations, or projector load reaction. The units making up this cushioning device are illustrated in Fig. 7.

To facilitate ready removal during shipment and to simplify maintenance, the flywheel is held on the tapered and threaded end of its shaft by a special nut which also acts as a wheel puller when unscrewed.

A tension pulley for keeping the proper tension on the belt driving the take-up reel, is hung from the film reproducing attachment. This pulley revolves on an oil-less bearing which requires no lubrication. Oil on this type of bearing is detrimental to the free rotation of the pulley.

All parts of the attachment which are subject to wear have been made interchangeable and easily replaceable.

Motor-Drive Unit.—The motor used to drive this equipment is a $^1/_6$ H.P. single-phase, squirrel-cage induction motor having a split-phase starting winding which is open-circuited by a centrifugally operated switch when the motor reaches a speed of approximately 1200 rpm. This motor normally operates on 110 volts at a frequency of either 50 or 60 cycles, the normal speeds being approximately 1445 and 1740 rpm., respectively. Suitable pulleys are provided so that the standard sound picture speed of 90 feet of film

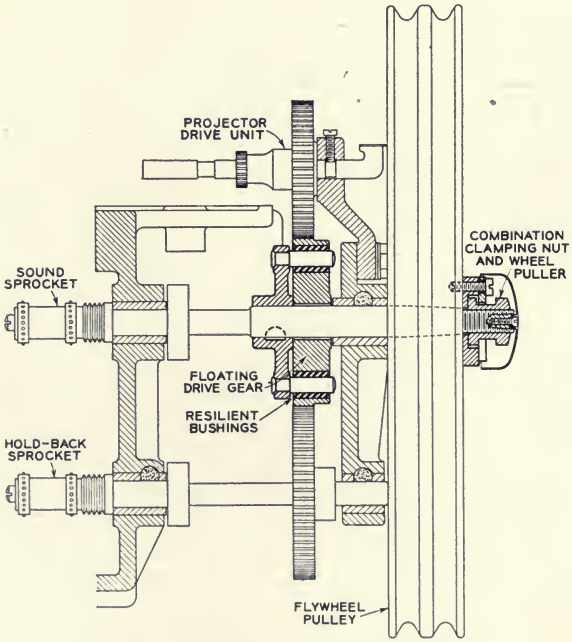

FIG. 7. Details of cushioned driving gear.

per minute may be obtained with either of these motor speeds. The speed regulation of this motor depends upon the frequency of the power supply, which must be held within plus or minus 3 percent in order that the absolute pitch of the reproduced sound will be within sufficiently close limits. In addition, it is essential that the rate of change of frequency of the power supply system should be less than 0.2 of 1 percent per second in order to avoid noticeable pitch changes. The constant speed characteristics of the motor are such that no auxiliary speed control device is necessary. The motor

is mounted in a rubber cushioned frame, which reduces vibrations transmitted to the projector pedestal. Fig. 2 shows this motor drive assembled on the Simplex pedestal.

The bracket which supports the motor is made in the form of a shelf and mounts upon the Simplex pedestal. Two independently acting tension pulleys mounted on it provide constant tension for the belts under all conditions. These pulleys rotate upon oil-less bearings which do not require oil for lubrication.

The fabric belts used are pre-stretched. However, in some cases a slight elongation of the belt may be found. In order to compensate for changes greater than the belt-tightener will accommodate, and to provide for various projection angles, the motor may be moved back on its bracket.

Photo-Electric Cell Amplifier.—The photo-electric cell pickup amplifier amplifies the output voice frequency energy of the photo-electric cell to a level suitable for further amplification by the main amplifiers. It comprises a two-stage, transformer-coupled amplifier employing two Western Electric No. 239-A vacuum tubes. The amplifier is mounted in a self-supporting housing entirely separated from the projector proper, thereby preventing any machine vibrations from directly setting up objectionable disturbances in this amplifier. The amplifier pedestal may be seen by referring to Figs. 1 and 2. To further aid in minimizing vibration pickup the amplifier is suspended by springs in a cradle mounted upon a rubber pad. The front of the housing is hinged to give access to the amplifier and vacuum tubes. The filament current of the amplifier tubes may be observed and adjusted without opening this door.

The lead from the photo-electric cell compartment to the pickup amplifier is carried through an insulating sleeve which enters the amplifier housing through an opening in a sliding plate. The close proximity of the pickup amplifier to the photo-electric cell provides a short, rigid lead between the two, which prevents adverse reaction of this lead on the electrical output.

As it is essential that the lead between the photo-electric cell and the pickup amplifier be as short and rigid as possible, this lead is first soldered to its proper terminal in the pickup amplifier, after which it is pulled almost taut through the insulating sleeve into the photo-electric cell compartment, the lead being then cut so as just to permit soldering it to the terminal provided for this purpose.

The height of the pedestal supporting the pickup amplifier is

adjustable so that the amplifier may be placed in proper relationship to the photo-electric cell compartment on the attachment, as determined by the projection angle employed.

The sliding plate on the amplifier housing, through which the photo-electric cell lead enters, may be raised or lowered slightly to take care of small, final adjustments in the projection angle.

Switching and Control Cabinet.—The switching and control cabinet serves as a combination fader, switching, and signal cabinet. The cabinet itself is of sheet metal and has perforated sides and a hinged cover. On the cover are mounted ammeters and rheostats for indicating and adjusting the current supply to the exciting lamps and the necessary switches for controlling the current to the photo-electric cell amplifiers. In the cabinet are a volume-control potentiometer operated by a shaft extending out through both sides of the cabinet, and a three-position switch, similarly operated, for applying the output of either photo-electric cell amplifier across the potentiometer. The potentiometer permits adjustment of the input level to the main amplifiers in 3 db. steps. Green and red signal lights are provided to indicate to the operator the "ready" and the "play" positions, respectively, of these circuits. The control cabinet is shown in Fig. 8.

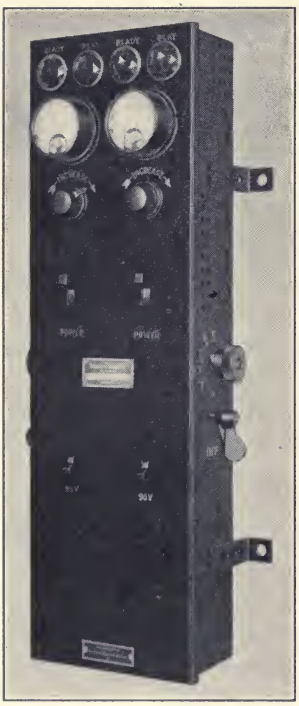

FIG. 8. Switch and control cabinet.

The cabinet is intended to be mounted on the front wall of the booth so as to be in a convenient and accessible location for one operator attending two machines or for two operators stationed one at each machine. This location also provides all the operators in the booth with a means for inspecting the circuits and machines in actual operation. From the cabinet the circuits are led to master amplifiers and thence to the loud speaking telephones. These units may be any of the usual types, as dictated by the primary power and installation requirements.

Flywheel Guard.—A guard for the flywheel and driving belts may be provided when required. This guard consists of a sheet steel housing and is supported on two brackets suitable for any projection angle employed. Fig. 2 illustrates this guard in position.

Flywheel Brake.—Under normal conditions the momentum of the heavy flywheel pulley causes the machine to continue to run for an appreciable time after the power to the motor is shut off. Where a shorter stopping period of time is desired a combination brake and switch unit is provided. The design of this brake is such that when the operating handle is depressed the power is first shut off, then pressure is exerted through a spring to a brake-shoe applied to the inside rim of the flywheel pulley. The use of a spring prevents the possibility of stopping the machine too suddenly and damaging the mechanism. Raising the handle operates the switch to turn on the power and start the motor. Fig. 3 shows an illustration of this flywheel brake mounted.

General.—The system in general is of rugged construction, simple to operate, and is capable of reproducing sound of high quality and free from flutter. The attachment permits the same projection angles to be used as are normally obtainable when the standard Simplex projector is mounted on the types L, M, or R pedestals.

While Simplex projectors and pedestals have been referred to throughout the text, it is understood that there are certain other makes and types of projectors and pedestals with which this system may also be associated.

The especially notable features which have been provided for in the attachment are its simplicity, the ready accessibility of the essential parts, and the ease with which it may be threaded with film.

IMPROVEMENTS IN DESIGN OF DYNAMIC SPEAKERS*

I. B. SERGE**

Summary.—*The writer points out that by using a smaller number of reproducing units, fewer technical difficulties are involved in sound installations. With this in mind, a super-electrodynamic speaker has been designed, paying proper attention to the following requirements:* (*1*) *high air-gap flux density,* (*2*) *size of voice coil,* (*3*) *material and design of magnetic circuit,* (*4*) *design of air-gap face to provide large uniform air-gap density,* (*5*) *small leakage flux. The acoustical coupling between the loudspeaker and the auditorium which it is to serve must be considered in installing sound equipment, and is a matter upon which the success of the installation finally depends.*

During the convention of the Radio Manufacturers Association at Atlantic City last June, a meeting was held by the Institute of Radio Engineers. A lengthy discussion on the need for better sound reproducing units was held. Although many engineers are working along new lines in sound reproduction, at the present time the dynamic type of sound reproducing unit is used universally.

The first dynamic reproducers were designed for home use, and were capable of giving more sound output than necessary. During the past three years, the design of dynamic reproducers for home use was characterized by making them smaller and smaller, and today in the so-called midget set, the weight of copper is in some cases less than one pound. On the other hand, loudspeakers designed for auditorium use were generally similar to those used in the home, with the exception that the amounts of copper and iron were increased, affording a slight gain in efficiency. This demanded a multiplicity of units in auditorium installations, resulting in the involved problem of inter-connecting them so as to maintain their efficiency.

The sound picture industry has come to realize that better recording and reproducing systems must be developed in order to satisfy the theater-going public. In this paper we are particularly interested in developments being made to improve the design of the dynamic

* Presented at the Fall 1930 Meeting, New York, N. Y.

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loudspeaker for auditorium or sound picture installations. The main points of the present development will be reviewed briefly.

It should be understood that most acoustic problems are considered on the basis of a point source of sound. In actual practice where reproducing units are not capable of handling large power inputs, the acoustical engineer must employ a number of units, properly phased to approximate the results desired. Obviously the use of a small number of reproducing units leads to few technical difficulties and approaches the ideal of a single point source. Herein lies the first problem—to develop units having large power ratings so that ideal conditions may be approached. To obtain higher acoustical levels, the designing engineer turns to the dynamic type of loudspeaker. As the power input is increased, the size of the moving coil of the unit must also be increased, in order that the proper heat radiation and mechanical impedance relations may be realized. The moving coil impedance is then chosen to give the best conversion efficiency possible. The conversion efficiency (the ratio of mechanical watts radiated to electrical watts input) varies as the square of the flux density in the air-gap, so that the next problem is that of maintaining a high flux density in the air-gap of the magnetic circuit. By increasing this density the force acting on the cone will increase in direct proportion. This can be done, but the design becomes increasingly more expensive as the air-gap density is increased. There are several reasons for this:

First, the flux density in the air-gap is limited by the saturation density of the magnetic structure; second, it is often difficult to obtain the most suitable materials for this structure; third, in many instances the magnetic structure is not so designed that the maximum useful flux is obtained in the air-gap for a given total flux in the magnetic circuit. In other words, leakage factors are disregarded. The result is that some portion of the magnetic circuit becomes saturated. This requires an excessive magnetizing current in the field coil to obtain the maximum possible density in the gap. Often the desired air-gap density cannot be maintained without subjecting the field to dangerous temperatures. The designer must then pay careful attention to the size of the magnetizing coil, so that the core spindle does not become saturated.

The face of the air-gap must be increased to provide as large a uniform-density air-gap as economy permits. Most dynamic speakers have too small a face in the air-gap, which results in a

variation of impedance detrimental to the efficiency of conversion.

The next step is to so choose a set of dimensions that the leakage flux will be small. In many dynamic speakers, only about 20 per cent of the available flux passes through the air-gap. The remainder leaks between the core and pot and the core and pole plate. With careful design it is possible to increase the useful flux to a value nearly twice as great as this.

The next step is perhaps the most important, *viz.*, the selection of proper magnetic materials. The ideal speaker should have different materials for the core head, core spindle, pot, and pole plates. What alloys should be used is a matter to be determined both by the electrical engineer and the metallurgist. Very encouraging results have been obtained by the use of special alloys, the magnetic specifications of which are generally supplied by the steel manufacturers.

Finally, the designer must determine the proper number of turns and the resistance of the field windings of the speaker unit. Inasmuch as fewer units are to be used with the improved dynamic speaker, greater power dissipation is permissible in the field winding. Radiation must be provided for the heat produced. In unusual circumstances forced ventilation may have to be resorted to. Mechanical limitations in the design leave a narrow margin for extra radiation factors.

The next question which arises is: will the cone attached to the dynamic speaker, made of thin, light materials, withstand the high conversion ratio of electrical to mechanical energy? Considerable difficulty has been encountered in the past in properly developing the moving coil suspension and the suspension for the cone edge. Practical experience has helped overcome these difficulties and it is now possible to build cones which will withstand quite high conversion ratios.

In the present design it was found that after taking into account all the details outlined above, the sensitivity of the speaker was increased considerably and a fairly flat frequency characteristic was obtained.

However, the inherent limit of the dynamic speaker—cut-off at high frequencies—is still present. For this reason, special high frequency units must be produced if it is desired to reproduce frequencies above 6000 to 6500 cycles per second. A combination of two sound reproducing units with their associated filters and separate amplifiers will cover the audible range desired. This combination,

in the opinion of the author, represents the sound picture installation of the future.

The success of the present type of dynamic speaker, as well as those to be developed in the future, depends upon the acoustical coupling placed between the reproducing unit and the auditorium which it is to serve. The so-called baffle horn is very effective and quite satisfactory. However, it is important to understand that each installation is a separate problem, as far as dimensions of the coupling medium and its shape are concerned.

DISCUSSION

MR. COOK: In connection with Mr. Serge's discussion of the power limits of a loudspeaker, I would like to mention two considerations which have come to the attention of many engineers more forcibly in the last year. One of these defects is quite severe. It is often felt desirable to augment the bass response of speakers by putting a peak in the bass region. This can be a handicap as well as an advantage. If the thickness of the front plate does not permit sufficient movement of the cone coil in a region of constant flux density, it is evident that the acoustical response will not be proportional to the input. A resonance peak in the low frequency region makes this limitation more severe. The second cause of distortion which limits the power rating, occurs at the seal of the cone. It is desirable to make this seal more flexible, and if this is carried far enough, the possibility of having the edge vibrate in what might be called "bell" vibrations, is encountered, and the edge is no longer a circle. If the edge seal is cut away altogether and the cone allowed to vibrate in free air, the power rating for undistorted output drops very rapidly. Thus it is not permissible to have such a seal that the cone can move without some edge restraint and still retain the rating obtained when a slight edge restraint is used.

REPRODUCING SOUND FROM SEPARATE FILM

OPEN DISCUSSION AT THE OCTOBER, 1930, MEETING AT NEW YORK, N. Y.

PRESIDENT CRABTREE: The matter of obtaining a wide screen picture and better sound reproduction should be freely discussed by our members. To what extent would putting the sound and picture on separate films contribute to these ends? There is no question that the quality of sound reproduction must be considerably improved, especially that of music, if the public is to remain interested very much longer. The reproduction of speech, I think, is quite good, but the quality of music is very poor, in my estimation.

In the average projector the film is subjected to heat, oil, dirt, scratching, and to an intermittent motion, all of which are not conducive to good sound quality. It will be necessary to treat the sound track more carefully in the future if we are going to simulate orchestral music with any degree of realism. One way of doing this would be to have a separate device for handling the sound track; in other words, a separate machine would be required, wherein the speed of the film could be much higher than at present, aiding in the reproduction of higher frequencies. It would then be a simple matter to obtain smooth motion, and the film would not be subjected to dirt and heat as in the present projector. These possibilities have been pointed out previously at our meetings, but they must not be lost sight of. In the future it may be necessary to use multiple sound tracks. The Progress Committee reported that in Hollywood sound has been reproduced simultaneously from two or more identical sound tracks, so that the resultant sound was an integration of the individual effects. I cannot help but feel that in the near future some one may demonstrate that by utilizing two or more sound tracks the entertainment value of the picture can be greatly enhanced, and as soon as that is done, the industry will have to consider it very seriously. Of course, this is looking several years ahead, but that is the duty of this Society.

The main objection to this method is the possibility of lack of

synchronism and of mixing up the sound record with the picture record, as has been done on occasion with the disk records. However, there is not the danger of sudden lack of synchronism, such as when the needle jumps out of the groove in a record. The only possibility would be a film break, but I haven't seen a film break in a theater during the past six months.

There are other matters, such as extra cost and difficulty of transportation, but when we remember that to put on a traveling show requires a train load of baggage, and to put on a motion picture show requires only a few pounds of baggage in the form of film, I don't think that the industry should reject a system having ultimate possibilities because of a little extra cost of handling.

There is also the matter of rehearsal. Some theaters advertise a big show two or three weeks in advance, and five minutes before the show the film is delivered at the projection booth. The projectionists have no opportunity to rehearse the film so that if an incorrect package is delivered, the show cannot be put on.

Sufficient time should be allowed in delivering the film for such a rehearsal; if this were done I believe the possibilities of getting the sound and picture record mixed would be negligible.

MR. JAMES: While in Chicago, I was fortunate enough to view a demonstration of sound on a magnetized metal base. The demonstration was given in the Hart Theater on Hart Street. I was skeptical about how long the magnetism would be retained by the metal base but was informed that it had been placed on the base three years ago and had been run one thousand times. The music was beautiful and the speech splendid. I suppose it was a special alloy.

PRESIDENT CRABTREE: This is an adaptation of the "telegraphone" which Mr. Taylor discussed at length at our Lake Placid meeting.

MR. STERN: Through my work in the laboratories I have had considerable experience in developing sound tracks, and long ago came to the conclusion that the treatment of the sound track positives separately from the picture print, as is done in negative recording, would have considerable advantages over the present method. Mr. Crabtree has pointed out many of these advantages in his introduction.

This would aid in regaining the lost space that is now used by the sound track. Moreover, the sound track requires different development in the positive and negative processes. There are three major sound recording systems used by our producing companies: (1) the

DeForest and Fox-Case recording systems, in which negative stock is developed in a borax negative bath for a good average contrast; (2) the Western Electric system, in which recording is done on positive stock, developed in a soft positive bath for less contrast; (3) the RCA method, in which recording is also done on positive stock, developed for extreme contrast. By printing these sound tracks on the same positive with the picture it is impossible to give the desired quality of contrast to both the picture and the sound track. As a consequence, the quality of one or the other has to be sacrificed, and it is usually the photographic quality of the picture.

Bearing these facts in mind, and desiring to utilize the entire film for the picture, I designed a means of placing the sound track on a separate film so that the latter might be utilized in the same projection machine with the picture positive.

First, one sound track is printed on 35 mm. positive film in the present-day printing machine. Then, by taking another negative sound track and turning the already once printed positive stock around and running it backward, another sound record is printed. Both sound records are adjacent to the perforations. The positive is then developed and dried in standard developing machines, and when ready to leave the laboratory is slit into halves, each half accompanying its respective reel of pictures. The halves are wound on reels which are wider than the present ones, having in them separating metal disks, on one side of which are wound the picture films, with the accompanying sound track films on the other side.

In this case everything is standard—picture cameras, recording cameras, reproducing machines, and the projection machine—with the exception of the following minor changes: the upper and lower magazines, the two feed sprockets and rollers, and a shift-base for the sound reproducing unit are replaced, in order to accommodate both sound-on-film and sound-on-separate-film. The same projection machine can be used for projecting silent films or sound-on-disk films. While discussing this process with producers and engineers I gained considerable knowledge of the different viewpoints on projecting sound track on separate film. All are agreed that by projecting the sound track separately better reproduction is obtained. Some prefer a wider sound track; others prefer recording at greater speed. Others have doubts as to whether the two films can be kept in synchronism or how the two films can be wound at the same time. As to synchronizing, the starting point will be marked on both

films in the same way as it is marked on the sound film of today. Each reel of sound film that leaves the laboratory has its footage numbers printed on the edge of the film. In case of a break in one of the films all that the operator has to do is to note the edge number of the picture film that is on the aperture plate; the corresponding number on the sound film is then placed under the sound producing aperture. In case the film is damaged and a few frames have to be cut out, the corresponding frames of the sound records can be cut out; or, better still, the sound track may be left intact, the missing frames being replaced with black frames as is done now with sound-on-disk films. In case of censorship elimination; the exact amount of sound film is taken out with the picture film, avoiding the jump that is noticed where the sound track is printed on the same film. If, in the present method we wish to use the base tints, we have to match and splice positive stock for the exact length of each color before printing—an impracticable procedure. If this process is adopted beautiful base colors and tones can be utilized in the same way as was done in the silent pictures.

Another feature that Mr. Crabtree pointed out is that of recording sound at greater speed. I advocate a speed of 75 feet per minute for photographing and projecting pictures, with a speed of $112^1/_2$ or even 150 feet per minute for sound track recording, rather than reducing by optical printing to the projecting length of the picture.

MR. TEITEL: Referring to the matter of coloring film or tinting intermittent sections of film without coloring the sound track, I would like to say that I have designed a machine in which coloring members come in contact with the film, instead of the film coming in contact with the coloring matter, so that one scene may be black and white, one toned, one tinted, another toned and tinted, and another in full color, all in one continuous operation, without touching the sound track. The coloring member comes in contact with the film so that it is not necessary to kill colors by having the entire reel colored, and so the necessity of cutting and re-splicing various sections for colors is avoided. I hope this machine will be ready for demonstration at our Spring meeting.

MR. OTIS: Multicolor has coöperated with Electrical Research Products, Inc., in a series of experiments on the effect of toning the sound track red or blue.

Using the potassium photo-electric cell, the red track could not be made to produce as good quality as the blue track; but the blue

track gave quite satisfactory results. When E. R. P. I. releases their new caesium cell it will be possible to not only duplicate, with Multicolor blue, the quality of the black and white sound track, but also to secure a track producing, by two fader steps, a greater volume than the present black and white track.

PRESIDENT CRABTREE: I think Mr. Jones gave the effect of tinting the film with different dyes on the output of a potassium cell at one of our recent meetings. Further work could be done on the effect of different tones—dye tones and organic tones on film.

MR. ROSS: It seems to us that there are so many advantages in recording sound on separate film for exhibition that eventually the industry will be forced to it. We call attention that, to properly produce the sound effects in *Hell's Angels*, a separate film having two sound tracks is employed. Dramatic critics at S. M. P. E. meetings have forcibly pointed out the necessity for producing realistic "off-stage" effects which now are produced directly rearward of the screen. These realistic "off-stage" effects can be accomplished by employing separate sound film having a plurality of sound tracks, each related to a group of loudspeakers located at points from which the sounds are to be produced and which may be at remote portions of the stage or auditorium. Another example:—When recording a plurality of sources of sound, as, for example, a singer's voice and musical accompaniment, distortion occurs in recording due to the super-imposing of the two sound waves, so that faithfulness in reproduction during exhibition is lacking. It is therefore advisable to record the singer's voice onto one track and the accompaniment onto another track. Another example:—Musical accompaniment often attends dialog for emotional effects. When the musical selections are super-imposed on the dialog sound track in printing, as is the general rule in dubbing, the dialog suffers in faithfulness and again it is advisable to record the dialog and musical selections on separate sound tracks.

Any sound that one might wish to produce from points other than the immediate foreground depicted on the screen may be handled in this manner. Loudspeakers may be placed at remote portions of the stage or auditorium. There are decided advantages for this arrangement which are quite evident to anyone who has tried it.

As an example: Some one might be singing in a distant garden, in which case a loudspeaker at the rear of the stage (perhaps off

to one side) would produce the desired "off-stage" effect. It would not be difficult to change over present standard 35 mm. projectors to handle separate sound films. The present single-reel upper and lower magazines can either be converted or replaced by new two-reel upper and lower compartments. The sound head could be supported between these compartments. The projectors, so altered, would not take up any more room than the present sound equipped projectors.

PRESIDENT CRABTREE: It is my understanding that stirring music is felt throughout the body, not merely in the ear, so that loud-speakers located in the vicinity of the audience might produce such emotional effects.

There is also the matter of binaural effects. According to experts it is practically impossible to obtain a binaural effect by the present method of sound reproduction, but multiple sound sources appear to solve the problem. I understand that the Bell Laboratories have made experiments along this line.

MR. TAYLOR: There are many interesting possibilities in multiple sound tracks, but that is apart from the questions brought up for discussion. Do you want them on the same film or on separate films? These questions are somewhat unrelated. If we can handle film 70 mm. wide and do not need to use the whole of it for the picture, there will be ample space for several sound tracks. One early advantage of the separate film was that existing 35 mm. film, utilizing the total available space for the picture, could be run as a sound picture, with the sound on a separate film, as in the spectacular picture *Wings*. As a matter of economy and convenience it seems highly desirable to continue with sound and picture on the same film as long as possible.

PRESIDENT CRABTREE: There are serious objections to widening the film. There are the difficulties of handling a film as wide as 70 or 80 or 100 mm.; it takes a Samson to handle it. There is also the matter of submitting the film to heat and scratching. We must get away from that to get the ultimate in sound reproduction.

MR. EDWARDS: There is absolutely no handicap with a separate sound track from the production standpoint, but there is a serious objection to it in the theater today. We must not lose sight of the fact that the theaters are already built, and the space in the projection department in more than 80 percent of the theaters is very limited. The introduction of separate sound tracks, while quite feasible in some cases, would not be so in 80 percent of those today. Further-

more, it must be remembered that where there are two machines to be run in synchronism the different starting speeds of two practically similar mechanisms have to be considered.

PRESIDENT CRABTREE: I agree with Mr. Edwards. The thing to do is to enlarge the projection room. The exhibitor spends money on billboards in front of the theater; why not spend money to give the projectionists more room? The industry from now on must spend more money on the equipment required to put the show on the screen. We, as a society, should be looking ahead, so that whatever we adopt now will anticipate future requirements. That is the purpose of this discussion.

It would be an economic waste for the industry to adopt a wide film with sound on the same film if within six months it is shown to be better to have the sound on separate film. It is only by getting everyone's opinion that we can outline the best thing to do. In my opinion it is a very important problem.

MR. EDWARDS: What we must get after is an exchange of ideas on the part of the producers. It is well known to every theater man that it is easier to get $1000 for stage presentation than $10 for the projection room. Until this is changed, we are only shooting in the air.

MR. JAMES: Is it a fact that we are bound to place sound on film or wax? Isn't there some other material more permanent? We are living in a progressive age and there should be some other method of producing sound.

PRESIDENT CRABTREE: That is a fair question. There has been nothing better found to date, or I am sure it would have been adopted.

MR. STERN: It was my good fortune to canvass the producers and discuss the matter of putting sound track on separate film. One of the reasons that the industry is being forced to adopt a larger film is that by putting the sound track on the same film with the picture and cutting the top and bottom of the picture in the camera, the lost space represents approximately 20 percent of the original area. The result is that everything in the picture is smaller in proportion. Furthermore, most of the theaters are employing larger screens than they used in the silent picture days, whence the small picture area is enlarged so much more on the larger screen that the graininess becomes objectionable. If the whole field is utilized for the picture alone, putting the sound track on a separate film, there will be no necessity for a wide film.

One thing I failed to mention previously is that, in my plan of projecting sound on separate film, the picture runs intermittently, while the sound track runs continuously. Replying to Mr. Edwards, in the newer theaters two projection heads are usually employed for pictures with sound track on separate film—one for the picture and one for the sound track. The two heads are tied together by a shaft so that there is no chance of one starting before the other.

MR. PHELPS: It seems to me that President Crabtree's mention of the binaural effect is worthy of further consideration. I am going to ask if the effect could not be achieved by using two sets of loudspeakers, at opposite sides of the stage, in conjunction with two sound tracks. I think this has dramatic possibilities such as, for example, two characters carrying on a conversation from opposite sides of a wide screen. I should like to hear something on this point.

MR. IRBY: In connection with this, several patents have been issued recently calling for binaural recording as well as reproduction and the tests reported were favorable.

MR. HILL: Regarding the recording of two sound tracks on separate film and then reproducing each sound track separately by loudspeakers placed on either side of the stage, this does not work out very satisfactorily because of the fact that each ear picks up the sound from both loudspeakers.

The results of several tests, which have been made, show that if a head set is used for reception and one sound track output applied to each head piece, good binaural effect is produced, due to the fact that the sound from one sound track is received by one ear only. If, however, loudspeakers are used, the binaural effect is almost entirely lost.

MR. PALMER: I do not see any particular difficulty with regard to space requirements or the synchronizing requirements arising from using a separate sound track. The apparatus for the projection of sound on the separate track need not be any larger than the present film recorder, which takes up very little space. As far as synchronizing is concerned, there is no difficulty in doing this with the projection machine by the present method used in the studio for keeping the sound recorders in step with the camera.

MR. EDWARDS: At the Chinese Theater in Hollywood, when the sound recorders were installed the room was packed so that it was almost impossible for the men to walk about. The equipment consisted of standard bases and heads and two magazines; even the lamp brackets were left on, and with the amount of space taken up a newly

designed sound head would be fine. I am not speaking of conditions as they should be, but as they are.

MR. MACNAMARA: By courtesy of the Gaiety Theater last night, we witnessed from the projection room the presentation of *Hell's Angels*, and the last speaker's statements were well demonstrated. Minimum amount of space has been allowed in the projection room to permit the men to go from one machine to the other. The extra mechanism—the gearing for the disk recording—was replaced by another for film recording, so that there would be no chance of slipping out of synchronism.

MR. BARRELL: Regarding the remarks made by Mr. Stern, there is no doubt in my mind that it is preferable to use the old silent frame size. A visit to the art museum will indicate that this proportion is favored by artists. Moreover, by increasing the picture size on the screen we increase the apparent graininess of the film. A few months ago I read of a German invention of a film in which the graininess was so small that enormous magnification could be used. There is no question that the picture today is suffering on account of the introduction of sound. I wondered what was being done to reduce graininess and make it possible to place sound or picture in a smaller field than we have at present. We shall work until doomsday striving for proportions better than those of the old silent picture. The seventy millimeter width is adaptable only for certain types of story; it is suitable only for scenery such as Niagara Falls. We must take the tools we have at present, and improve them. Reduce the size of the sound track if possible, and use the time-tried and thoroughly artistic picture frame used for twenty years. We can get into it everything required. We are continually reducing the size, letting the graininess appear, and ruining the quality of thepicture.

MR. SHEPPARD: I am only going to refer to the last speaker's mention of a process giving extraordinarily high resolution. That process is an old one involving the use of silver aluminates. Its main difficulty is that the speed is so much less than that of the present film, that it would not be of practical use for the present purpose. The question of resolving power *versus* speed is always with us. We have to make a compromise.

MR. HOLMAN: I think these arguments are about the best I have ever heard for continuous projection. The practice of putting sound and picture on the single strip is a matter of convenience.

With continuous projection, there is no such trouble from scratching. It is possible, with continuously moving film strips, to drive the film with one row of perforations, thus preserving the old silent picture area and providing a sound track 50 percent wider than that used today. Most of the discussion serves very well to show up the advantages of the continuous projector, and a little thought will disclose how many of the industry's serious problems will be solved by adopting continuous projection.

MR. RAVEN: In connection with Mr. Barrell's remarks about the destruction of the picture value due to tremendous magnification and his reference to the granules of the film showing up, I think one of the main faults at the present time, on large as well as small pictures, is that we have perforated screens. Taking a smooth, opaque surface, we puncture it with millions of small perforations, and while they cannot be detected at a distance with the naked eye, they are there, and we might just as well have so many tiny black spots on the screen.

MR. NORLING: Graininess seems to be objectionable mostly because the grains are in constant motion on the screen. The small holes in the sound screen are fixed, and are invisible a short distance away from the screen, so that obviously the small holes do not add to the graininess of the picture.

MR. ROSS: Mr. Edwards has called attention to the congested condition of the projection rooms at the Gaiety and Chinese Theaters, where sound was projected on a separate film in the exhibition of *Hell's Angels*. Will Mr. Edwards not be fair enough to admit that the sound heads were temporary apparatus made up to meet an emergency? We have called attention to the fact that by converting the present single-reel upper and lower magazines into two-reel compartment magazines, the present projectors will be no larger than those now equipped for sound employing a single film. We believe that if projector manufacturers would devote as much attention to the redesigning of projectors for separate sound and action film as they have to the adoption of single sound films, all the old projectors could as easily be converted for separate sound films as for single sound films, and at no greater expense or sacrifice of space in the projection booth.

PRESIDENT CRABTREE: It may be a coincidence but the best sound quality I have ever heard was in a Broadway theater where the sound and picture were placed on separate films.

An advantage of separate sound and picture films is that each can be developed to its correct gamma much more readily. At present a low degree of development of the picture and sound negatives is in vogue, a practice which is not always conducive to production of the most uniform results.

SOME APPLICATIONS OF THE COMPARISON MICROSCOPE IN THE FILM INDUSTRY*

O. E. CONKLIN**

Summary.—*Four adaptations of the comparison microscope are described. One is an instrument for comparing two $^3/_4 \times 1$ in. pictures. Another is a sound track photometer. The third is an instrument for measuring graininess, and the fourth is for checking film dimensions. The principles of application and methods of use are described.*

Where comparisons are to be made between two objects, the ordinary microscope is at a disadvantage since it is not usually convenient to look through it at two things simultaneously. The comparison microscope meets this difficulty. It has two objectives which focus on the two objects, and a prism which brings their images together so that they can be seen through a single eyepiece. Usually these images are separated by a sharp dividing line whose visibility indicates the degree of likeness of the objects. If they are exactly alike, the dividing line may even disappear, just as it does in a photometer.

The Bausch & Lomb Comparison Microscope has been the starting point in designing four instruments, namely, a picture comparator, a sound track photometer, and instruments for measuring the graininess of film, and film dimensions.

The picture comparator, shown in Fig. 1, is simply a comparison microscope arranged for comparing motion picture frames. It can be used for making printer light tests, developer tests, or any other tests which involve a comparison between two standard size pictures.

To obtain the wide field required for this work objectives, set to reduce four times, and a special 20 power eyepiece, are used. We are indebted to Mr. Rayton of the Bausch & Lomb Optical Company for the latter.

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* Presented at the Fall 1930 Meeting, New York, N. Y.

** Redpath Laboratory, DuPont-Pathé Film Mfg. Corp., Parlin, N. J.

The films to be compared are placed one under each objective. The illumination comes from a 100 watt lamp shining on two diffuse reflectors, which can be rotated so as to balance the light. Half of one picture and the other half of the second picture are viewed together, so that if they match perfectly they appear as one picture. Adjustments are provided for moving the halves of the picture into alignment, and for bringing the dividing line to any part of the picture.

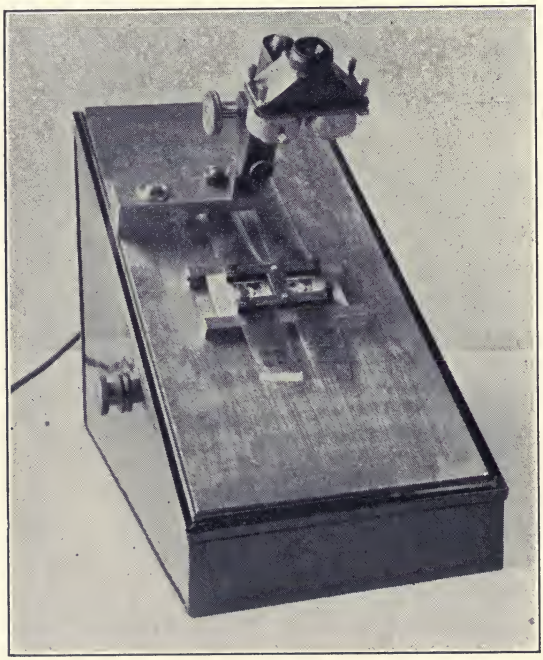


FIG. 1. Picture comparator.

In designing a photometer for measuring sound track densities it seemed desirable to have the sound track visible in the instrument so that it could be properly centered and the operator could be sure that the density of the correct spot was being measured. The comparison microscope can be readily converted into a photometer meeting this requirement. It is only necessary to focus one objective on the sound track and the other on a comparison wedge having a known density scale. Since, due to the magnification, the sound

track will appear grainy, the comparison wedge should also appear grainy. In other words, the wedge should be a strip of film, shading from a light to a heavy density. It can be made by mounting the film in a stove pipe, and exposing one end to a light. The wedge is calibrated on a Martens Photometer, being mounted between strips of glass in such a way as not to touch either strip, and framed in brass. In this way the difficulties of cemented wedges are avoided. After assembling, a density scale is ruled on the frame.

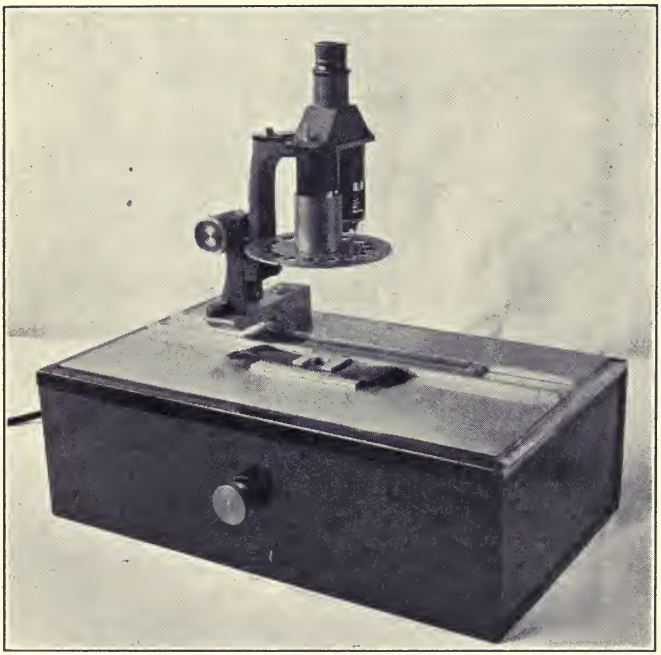


FIG. 2. Sound track photometer.

Fig. 2 shows the sound track photometer. Its mechanical features are obvious. The disk which is mounted directly below the objectives contains a set of colored filters which are placed over the wedge when measuring the densities of tinted, positive film.

The setting is made by sliding the wedge until it matches the sound track. Densities up to 2.00 can be measured with an accuracy of 0.05. This may not be sufficiently accurate for research purposes,

but in a practical laboratory the instrument provides decidedly better results than are obtained by guess-work.

Hardy and Jones[1] described an instrument for measuring graininess which depends on determining the magnification at which the graininess just disappears. With this instrument the Kodak Research Laboratory has investigated the fundamental facts relating to graininess and several interesting papers have been published.

Recently in the Redpath Laboratory an instrument for measuring graininess was developed, based on the principle of matching graininess rather than making it disappear. This instrument evolved from the picture comparator.

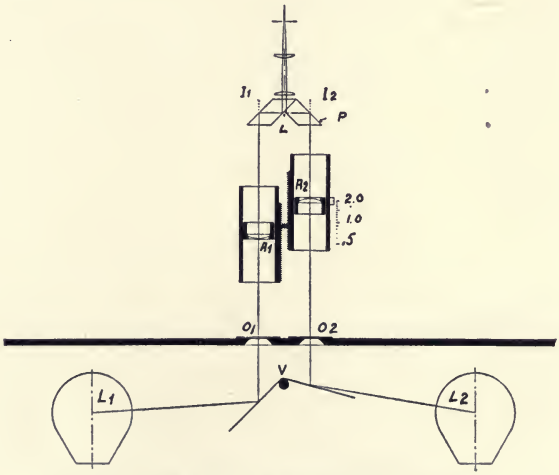
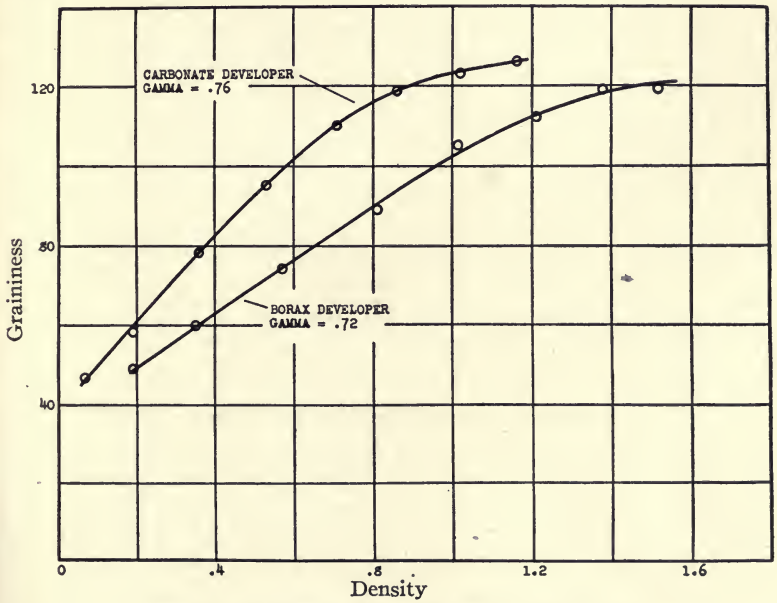


FIG. 3. Diagram of graininess comparator.

In using the picture comparator it was discovered that when two densities were made to appear equally bright by adjusting the illumination, differences in the graininess of the films could be easily observed. It occurred to us that by increasing the magnification of the fine grained film, and decreasing the magnification of the coarser grained film, the apparent graininess could be balanced. The relative magnification of the two images would then give a measure of the relative graininess.

Fig. 3 shows how this is done. Light from two lamps, L_1 and L_2, falls on the opposite sides of the reflector V. The brightness of the films can be adjusted to equality either by moving the lamps or by

rotating the reflector. The objectives are mounted in sleeves which can be raised or lowered by means of two racks with one pinion between them. One objective is raised while the other is lowered an equal amount. Now, it is obviously possible to mount the objectives so that each of them gives unit magnification. When so mounted, the movement of the sleeves keeps the magnification of one objective equal to the reduction of the other, the one optical system being always the reverse of the other. It follows that the distance between object and image is the same for each side of the instrument,



Density—graininess curves for panchromatic film.

FIG. 4.

and therefore both images will come into focus at the same time. Usually very little focusing is necessary. For example, in changing from equal magnification to a relative magnification of 1.5, the focusing adjustment must be raised only 2 mm.

These relationships hold with sufficient accuracy over a relative magnification range of 0.7 to 1.5. By providing a series of standards of known graininess the range of the instrument can be extended indefinitely.

The graininess scale is based on a standard strip of film developed

to a uniform density. Its graininess is arbitrarily rated 100. In making a graininess test, the sample is placed under one objective and the standard under the other. The fields are then brought to equal illumination, and the relative magnification is adjusted until the graininess of the two appears equal. One hundred times the relative magnification of the standard then gives the graininess of the sample.

Fig. 4 shows some data on panchromatic film obtained with this instrument. Graininess is plotted against density, for a carbonate developer and a borax developer; the curves indicate less graininess with the borax developer. Lack of time has limited us to confirming some of the published conclusions about graininess, whence we have no new data to present on this subject.

The fourth application of the comparison microscope is the measurement of film dimensions. In order to maintain accuracy in the perforation of film it is necessary to check samples taken at frequent intervals. Experience has shown that the ordinary micrometer microscope is too slow for this work and will not maintain its accuracy under constant usage. Another instrument which may be used for film measurements is the comparator. Its accuracy is quite constant since there is no micrometer screw to wear out. In it the sample is fastened to a sliding holder which carries a finely ruled scale. The comparator usually has two microscopes which focus, respectively, on the sample and the scale. The distance between parts of the sample seen through one microscope can then be read on the scale seen through the other. However, the ordinary comparator is somewhat slow for routine work, since the eye must transfer from one microscope to the other and readings must be taken in full. We have, therefore, resorted to the comparison microscope again and converted it into a special type of comparator, which we have named the perforation comparator. It differs in two respects from the ordinary kind. First, it is provided with a series of scales ruled directly in film dimensions. In this way absolute measurements are avoided and only the deviations from standard dimensions are recorded. Second, the sample and the scale are seen together through a single eyepiece, the scale line appearing directly on the edges which are being checked. For example, perfect perforation is indicated by a scale line appearing on each perforation edge as the film is moved along under the microscope. Similarly in transverse measurements, scale lines appearing on the edge of the

film and on each side of the perforations indicate correct centering of the perforations. Where deviations occur, means are provided for measuring them.

Fig. 5 is a diagram of the instrument. It consists essentially of a comparison microscope in which a sliding prism (1) has been introduced so as to shift the image of the perforation edge with respect to the scale line. To compensate for chromatic aberration, a fixed prism (2) is introduced in the same light path, and in the other light path is a plate of glass (3) equal to the combined thickness of the two prisms, thus making the light paths equal in length. The eyepiece is of the Huyghens type and is focused some distance above the compound prism so that the images of the sample and scale overlap. An index moving with the sliding prism (1) indicates on a scale reading in thousandths of an inch the amount of movement necessary to bring the perforation edge and scale line together.

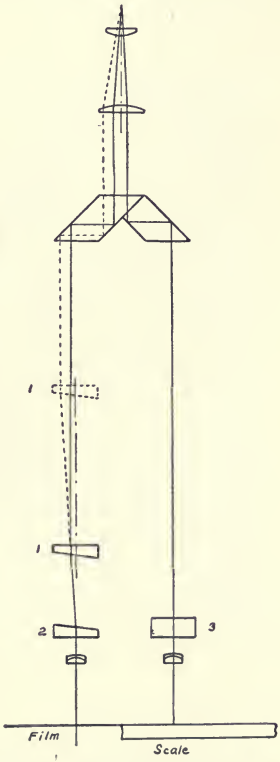


FIG. 5. Diagram of perforation comparator.

Fig. 6 shows the perforation comparator. A separate carriage is provided for each type of film. Each carriage is designed to permit longitudinal and transverse measurements with a single setting of the film. The samples slip into a slot 0.008 in. wide and are held by pinching the slot with a single screw. Two slots below, the carriage holds it in position for either longitudinal or transverse measurements and two comparison scales are mounted parallel to these slots on the top side of the carriage. The scales are ruled on highly polished brass by means of a Geneva Society dividing engine and afterward plated with chromium. They are illuminated by a beam of red light, and the light transmitted through the perforations is green so as to furnish good contrast.

On looking into the instrument one sees a scale line coinciding more or less accurately with the edge of a perforation. The sliding

prism is then moved until the coincidence is exact and the reading of its index is recorded. Then the carriage is moved until the next perforation edge and the next scale line appear together under the microscope. Usually another setting of the sliding prism is necessary to make them coincide. This process is repeated for each perforation and the differences between successive settings show how much the measured dimensions deviate from standard dimensions.

Table I is the record of measurements of twenty perforation pitches as would be recorded from micrometer microscope readings and

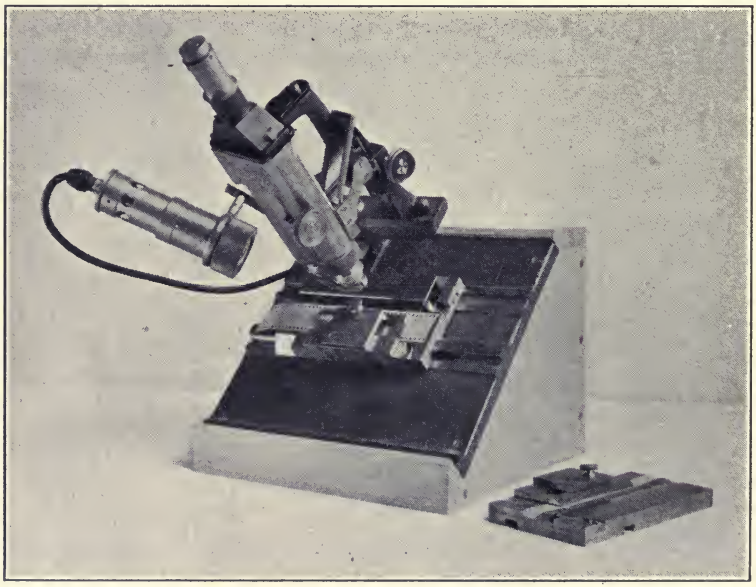


FIG. 6. Perforation comparator.

from readings of the perforation comparator. The micrometer microscope measurements involve setting five-figure numbers one under the other and subtracting each number from the one above it. The difference is the pitch which is a four-figure number. The perforation comparator measurements involve setting down a series of two-figure numbers. Since the numbers are simple and are nearly alike decimal points may be omitted. The differences are one-figure numbers which indicate to what extent the pitch varies from the standard. Only one-third as many figures are read and recorded as in the first case.

TABLE I

Showing the Figuring Involved in Checking Twenty Perforation Pitches by

Micrometer	Microscope	Perforation	Comparator
4.8632		28	
4.6761	0.1871	27	+1
4.4894	0.1867	30	−3
4.3023	0.1871	29	+1
4.1150	0.1873	26	+3
3.9278	0.1872	24	+2
3.8410	0.1868	26	−2
3.6539	0.1871	25	+1
3.4667	0.1872	23	+2
3.2797	0.1870	23	0
3.0926	0.1871	22	+1
2.9056	0.1870	22	0
2.7189	0.1867	25	−3
2.5317	0.1872	23	+2
2.3449	0.1868	25	−2
2.1578	0.1871	24	+1
1.9708	0.1870	24	0
1.7841	0.1867	27	−3
1.5974	0.1867	30	−3
1.4102	0.1872	28	+2
1.1232	0.1870	28	0

In practice inspectors check forty perforations per sample for regularity, and check the width and centering of the perforations in five places. Two inspectors working together with one instrument average 220 samples a day.

The author takes pleasure in acknowledging the counsel and assistance of Dr. D. R. White in the development of these instruments.

REFERENCE

[1] HARDY, A. C., AND JONES, L. A.: "Graininess in Motion Picture Negatives and Positives," *Trans. Soc. Mot. Pict. Eng.*, No. 14 (May, 1922), p. 107.

SOME OBSERVATIONS OF STEREOSCOPIC PROJECTION*

JOHN BELLAMY TAYLOR**

Summary.—*The Stereoscope is nearly a century old. Stereoscopic photographs were made almost simultaneously with the first practical photographic pictures, and stereoscopic projection devices for still pictures have been known for over seventy years. Motion pictures in relief, when viewed through red and green filters, one for each eye, have been shown too often to be now a novelty.*

Fundamentally, stereoscopic vision requires that two eyes, related physiologically and psychologically, each view separately distinctly different pictures. Unless the taking, printing, projecting, and viewing of pictures are all done in such a way as to prevent the left eye from seeing what the right eye sees, there is no license to characterize the system as stereoscopic. This paper discusses several available methods for independent left and right eye vision.

The aspect or "picture" of a scene or group of articles depends on the point of view. Two individuals cannot at the same moment occupy precisely the same position; therefore they see things differently. In a smaller degree, but just as truly, distinctly different pictures will be viewed by the left and right eyes of each individual observer. These two "L" and "R" pictures may have differences which are slight, or even insignificant, when viewing flat or distant objects. In general, however, nearer objects will hide from view objects which are more distant, although what is hidden from the left eye may be seen by the right eye, and *vice versa*. Thus we are able to see completely around a small object and partially around a larger obstruction. To illustrate simply, hold up a pencil at arm's length. With both eyes open, the pencil hides nothing, but if the left eye is closed, the pencil covers and hides certain features behind it, while right eye closure obliterates other features.

If a camera is to make a picture record of what is seen, should the lens take the position of either eye and perhaps fail to show something which is visible to the other eye? Or, should the camera lens take a third position which will provide a picture with some other part of the background hidden by foreground objects? We are led to

* Presented at the Fall 1930 Meeting at New York, N. Y.

** Research Laboratory, General Electric Co., Schenectacy, N. Y.

consider two cameras, one to simulate each eye. Or, more conveniently and practically, we may employ a special camera with two lenses making negative pictures, different but coördinated, affording positives or prints which we call a stereoscopic pair. If we look at the pair of pictures in such manner that the left eye sees only the picture taken through the left lens, while the right eye at the same time sees only the other picture, the combination of the two views gives the same impressions—physiological and psychological—as were received when viewing the original scene. In the composite or stereoscopic impression, the foreground is distinctly separated from the background; upon closing either eye portions of the background will be lost to view.

From extreme youth we have become accustomed to seeing different overlapping pictures. Instead of being annoyed by double images not in exact register, we sense, from the lack of register, solidity and form, nearness and farness. Continual shifting of alignment of the eyes unconsciously brings into register that portion of the two views toward which attention is principally directed.

The question arises as to why each eye cannot select its proper picture from a printed pair without having to use viewing machines. This can be done over a limited range of picture size and distance, but it involves long training in muscular control in order to bring about a combination of directing and focusing which is unnatural. The mirrors, prisms, or lenses in a well designed and adjusted stereoscopic outfit present the two views to the "L" and "R" eyes independently, without eye-strain.

The stereoscopic effect is real; it is not one of suggestion or imagination. If we view in the ordinary manner, a stereoautochrome, taken in the woods, we see merely a jumble of trees, twigs, leaves, and grass. When viewed in the stereoscope the two pictures not only clear up into what is large and small, near and far, but certain elements (quite indistinguishable from similarly colored background in a single view) leap into prominence when each eye, independently of the other, views its respective picture.

Since the usual stereoscope allows but one person at a time to view the picture, why could not a pair of pictures be projected onto a screen, to be viewed by a group or a large audience? This can be done, and has been done on occasion. The fundamental requirement for the individual stereoscope must be preserved, *viz.*, the "L" and "R" eye of each observer must see the "L" and "R" picture, respectively;

the "L" eye must be prevented from seeing the "R" picture, and the "L" picture must be hidden from the right eye. Several methods are recognized for consideration:

(1) Project the "L" and "R" pair to show side by side, and view them by trained muscular accommodation. Even with specially acquired ability, the angular limits would greatly restrict the choice of position or number of seats in a theater. This arrangement, while perhaps the simplest, is considered undesirable for obvious reasons, and is adjudged to be without commercial value.

(2) Project the "L" and "R" pair to show separately; provide each observer with a viewing device of mirrors, lenses, prisms, *etc.*, to direct and restrict each eye to its proper picture. Near and distant observers would require a variety of optical equipment. Those toward the side of the house, or otherwise situated asymmetrically in relation to the "L" and "R" pictures, would require individual optical compensating means for one or the other eye.

(3) Modification of the parallax stereogram of Dr. Ives. In the parallax stereogram, the "L" and "R" pair appear to be superposed, but are, in reality, intermeshed in a series of alternate lines, and are seen through a properly spaced grating which uncovers the lines of the "L" picture to the "L" eye. The eyes must be at a predetermined distance from the grating and picture. This greatly restricts the possible audience.

(4) Color separation. Project the "L" and "R" pair in different overlapping colors onto the screen. Each observer looks through spectacles or lorgnettes of colored glass or dyed film, *e. g.*, green before the left eye and a complementary red before the right. The complementary colors, separately received, give a fairly satisfactory psychological white and grey monochrome, *i. e.*, the method is not adapted for color effects. There may be undesired color effects from unbalanced or irregular vision. A question has been raised concerning the possible eye-strain from long continued use of a different color for each eye. Because of the cheapness of the viewing screens, this is believed to be the only stereoscopic projection system so far shown to the largest audiences. It has been regarded as a novelty rather than of permanent commercial value.

(5) Separation by polarization. The "L" and "R" pictures may be projected, overlapping each other, by polarized light (through Nicol prisms or other devices), the one picture being polarized in a plane rotated 90 degrees from the other. Analyzing devices, properly

adjusted to match the polarizing planes of the projected pictures, exclude the "L" picture from the right eye and *vice versa*. Since the polarization is largely broken up after reflection from the usual diffusing screen, the method requires a metallic screen, or one giving specular reflection. This system may be characterized as of scientific rather than practical interest.

(6) Separation by alternate "L" and "R" projection and viewing. This idea is quite old. The validity of the method of blinking the eyes synchronously with the projected pictures was demonstrated by shifting peep holes in extensions on the side of a double projecting lantern having a rotating shutter before the lenses. The two views appear on the screen to be superposed, but one is cut off before the other appears. Persistence of vision was thus relied on to give a continuous impression in a projected picture years before the film motion pictures were developed. One of the early writers suggested electrical blinkers in front of the eyes, worked from contacts on the projector shutter mechanism.

Over twenty years ago, the writer constructed and demonstrated privately a stereo-projection system in which the 60 cycle house lighting service was used to maintain synchronism between the alternate "L" and "R" screen pictures and a portable electric lorgnette. This shutter device, on a cord long enough to permit viewing (while observing the picture as seen in relief on the screen) was used at various distances and angles.

Actually, a side view of a screen gives no more distortion for a true stereoscopic picture in relief than it does for a single flat picture. However, while moving about, some of the effects obtained were quite unexpected.

The autochrome process came onto the market at about the time of the stereo-projection development cited, and afforded means for showing stereo pictures in color by projection on the screen.

In spite of the realistic and striking effects possible, it has always seemed questionable as to how the public would react toward stereoscopic motion pictures requiring a special viewing device for each observer. This question can be best answered only by trial, although this involves special development all along the line, *viz.*, cameras, printers, projectors, and viewers.

Can a stereoscopic effect be obtained without two pictures and a separating device? In the opinion of the writer, the only proper answer is, "No." The illusion of reality in a picture may rest upon

many things, none of which may properly be called stereoscopic. For example, perspective, relative size, shadows, color, progressive haziness, motion, *etc.*, all aid in estimating distance in a single picture. But none of these meet the *true* stereoscopic test, which is seeing with one eye something which is hidden from the other.

DISCUSSION

MR. PALMER: I have heard statements made that when viewing stereoscopic pictures in which the pictures are separated optically, there are certain people who are color blind with respect to viewing the picture in this way. I wonder if in Mr. Taylor's investigation of the subject he has found this to be the case.

Again, is the stereoscopic effect enhanced by viewing the picture from the focal point; that is, the point where the negative image was at the time the picture was made?

MR. TAYLOR: I have never found that anyone having two normal eyes would have difficulty in seeing the picture in the box form if the lenses were focused.

As to viewing angle, if we should want to make a stereoscopic picture and see it as it appears in nature, the proper relation between the focal length of the taking lenses and the distance from which the finished stereogram is viewed, must be maintained. I have taken a picture out-of-doors and mounted it; then, looking at the view with one eye and at the picture with the other eye, it was possible to have the picture register almost exactly with the scene itself. Sometimes it is desirable to exaggerate the stereoscopic effect. The eyes of a man are a certain distance apart. The eyes of a cow or horse are farther apart. If we should want to see as an animal sees, we should have to adjust this distance to suit. This procedure is followed by astronomers where they make a separation of 186,000,000 miles, taking the picture first from one side of the ecliptic, and six months later from the other side. On very distant objects the two lenses may be separated by a yard or two. This gives a relief effect with mountains which is exaggerated, but which may be desirable in stereoscopic surveys.

MR. EDWARDS: Don't you think the reason why some people cannot see stereoscopically is that they get into the habit of favoring one eye, and they really use only one eye.

Sometimes, with a single, flat picture taken with a single lens we can obtain a stereoscopic effect. Why can we not obtain that effect in a motion picture? We know that the illusion can be created by having a stationary foreground and a moving background.

MR. TAYLOR: Some people look into a microscope and do not see anything because they do not know what points to focus on. That is to some extent a matter of training. This can be overcome with a little training.

As to the statement that single pictures show the stereoscopic effect, I have never seen them, although many factors in motion pictures contribute to the illusion of reality. Sometimes one may think that nothing is lacking and say the effect is stereoscopic, but this seems a misuse of the term.

MR. MORRALL: Some time ago I took some pictures of a room in which a man was working with material which covered him with dust. The lighting was the same as they used in a preceding scene, where the dust was not present. When

projected, I was amazed to see a stereoscopic effect in the picture. This might be attributed to the fact that the coating of dust reflected light in such a way that it caused the stereoscopic effect.

MR. ROSS: I agree with Mr. Edwards that in motion pictures we frequently do find stereoscopic effects. The effect is produced on the West Coast by what is known as "back-lighting." Experiments show that back-lighting produces this illusion whereas without back-lighting the illusion is not present.

MR. TAYLOR: I have already stated that many things, such as light and shade, relative size, and motion help to estimate distance, but it will be unfortunate if we confuse the two ideas.

MR. FRITTS: On viewing a normal scene, the eyes are focused at a definite point and the rest of our vision is strained, in the sense that the eye is trying to accommodate its vision to all visible planes. It has been suggested that this may have something to do with the appreciation of depth. In certain experiments which we have made, a picture having a marked foreground and distance was viewed through a large uncorrected lens. The eye, under those conditions, is subject to eye-strain on the borders, which is akin to the eye-strain of normal vision, giving the effect of depth. Is this correct?

MR. TAYLOR: Without the actual set-up, I can only conjecture. This may be a case of factors other than stereoscopic, which aid in judging distance.

MR. PHELPS: When looking at a contact paper print and then at a lantern slide of the same negative, projected on a well-illuminated screen, my eye seems to tell me that there is more depth in the projected image than in the paper print.

MR. TAYLOR: Perhaps because the lantern slide more closely approximates the proper light and dark ratios. In real life, we have a large ratio, and in a good slide we can more closely approximate this. No print has natural ratios. In the case of transparencies we come nearer to the proper values.

METHODS OF SECURING A LARGE SCREEN PICTURE

OPEN DISCUSSION AT THE DECEMBER, 1930, MEETING OF THE NEW YORK SECTION

Mr. La Porte: During the past ten months we have been engaged in the development of apparatus for taking, processing, and exhibiting of pictures. We have used up to this time the 65 mm. width, not because that width is the only width, nor that we should not consider changing it, but for reasons which are of particular interest. We had previously worked with a width of 56 mm. That width was chosen on the basis of the present 35 mm. height using standard perforations and doubling the width in order to make the width-to-height ratio equal to two to one.

For economic reasons it did not seem that a two to one ratio picture having a width of 56 mm. would be a practical proposition in the theater, since it would require an additional projector, and very few theaters can double the number of projectors and the physical equipment in the booth. For that reason it seemed that the wide film projector would have to be one designed in terms of the 35 mm. machine, and would have to be adjustable or in some way interchangeable, so that the same projector could be used for both widths.

On that basis, we increased the height of the 35 mm. frame by one perforation, which brought the number of perforations up to five, or 25 percent more than before. In order to retain the wide aspect of this picture—the two to one ratio—we had to double the width of the frame, and by including the wide sound track and margins we finally arrived at the 65 mm. width.

The standard perforation was retained, as we have encountered little trouble from it during the many years we have used the 35 mm. film, and reports from exchanges, where film that has been out through 200 or more projections came back, showed that a very small fraction of one percent was damaged beyond further use.

The increased load due to the wider film is very well taken care of by the additional perforation and an additional carrying contact. The problem of sound propagation was also considered; the greater

the number of perforations and teeth, the higher will be the frequency of any noise induced by the sprocket wheel, and the smaller will be the interference per tooth.

Another thing to be considered was that the recording machines, printers, and other apparatus within the studio would be retained, and upon retaining a standard perforation, these could be used in their present forms without being redesigned or rebuilt.

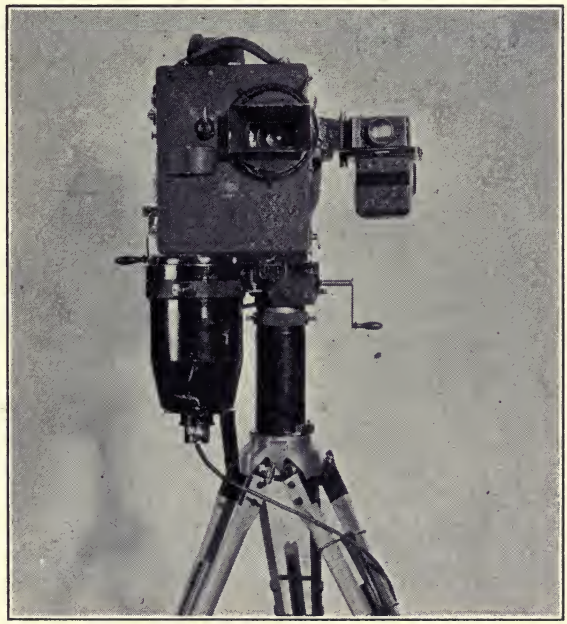


Fig. 1. 65 mm. camera mounted on tripod for location use, showing motor, housing and finder.

Apparatus and pictures were made for the 65 mm. width, retaining the two to one ratio, with a frame that measured 23 by 46 mm. The exhibition of the first test films indicated that in order to obtain a picture of sufficient width in many houses, the picture would have to be higher than the balcony sight-lines. Also, the fact that in very much smaller houses—the narrow houses—where the width is limited to from 20 to 24 feet, a two to one ratio would limit the height to about ten or eleven feet and would give the picture somewhat the

appearance of a strip, the effect increasing as the width of the screen is decreased.

There has been considerable discussion among the directors, particularly on the West Coast, some of which has appeared in the *Proceedings* of the Academy of Motion Picture Arts and Sciences, relative to the size and, more particularly, the shape of the picture. The recommendations have varied from a width to height ratio of three to five to a ratio of two to one. The general consensus of opinion was that the best ratio lay between 1.6 to 1 and 1.8 to 1.

In connection with the pictures to be shown this evening, we have adopted what may be termed a compromise, in view of the West Coast discussions. The frame is 41 mm. wide and 23 high, giving a ratio of 1.78 to 1.

The cameras used are special cameras designed for this particular work. An outstanding feature of these is the adjustable shutter opening of 230 degrees maximum. This opening was used, not so much for this wide film as for future work on wide film in color, which we believe will eventually appear. As we know, in color work we must take into account a number of light losses with any process.

There are two limitations: first, the amount of light that can be secured on the set and, second, the relative average aperture of the lenses, an increase in aperture meaning a decrease in depth.

To overcome these difficulties and maintain a speed of 24 frames per second it appeared to be necessary to increase the time of exposure by increasing the shutter opening. Then, working with wide film, and with the shallow field of the wide angle lenses, we are enabled to down, and by the reduced aperture obtain increased depth in the picture.

The idea of a projector capable of accommodating either the wide film or the regular 35 mm. film has been retained, and a double sprocket with interchangeable aperture has been adopted. The sound heads have been provided with similar sprockets and the gates have been made adjustable. Two projectors having similar characteristics will be shown tonight, one using the barrel type of shutter and the other one using a very small shutter fitted to work with a lens of 1.9 aperture, having a blade smaller than 6 inches.

In addition to the equipment for processing the wide film, there has been installed a reducing optical printer that will reduce the 65 mm., or larger, negative to 35 mm. or any intermediate size.

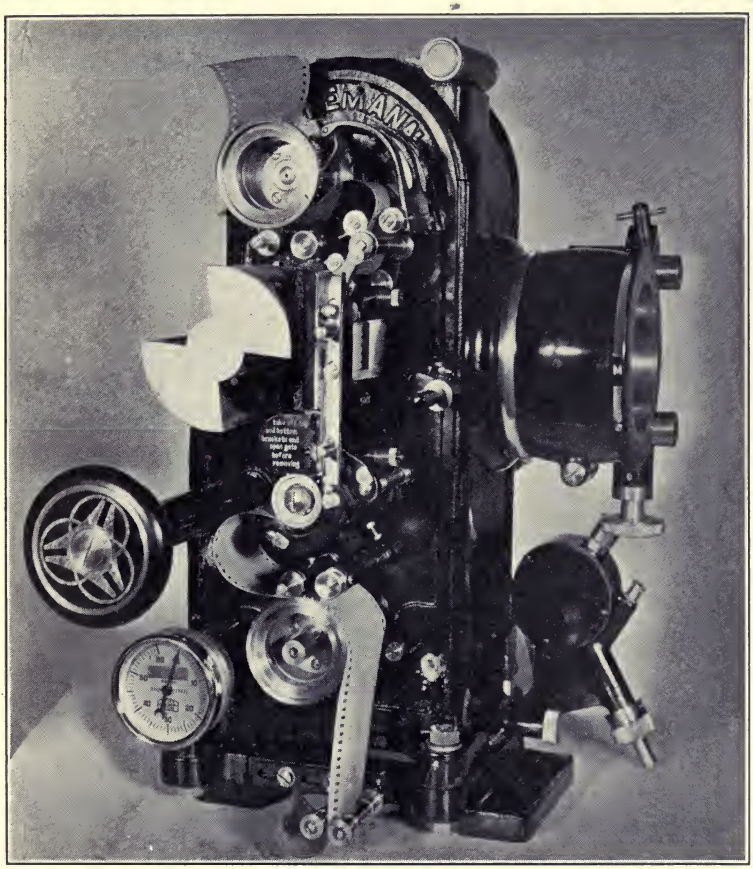


FIG. 2. Combination projector, right-hand side, housing removed, threaded with 65 mm. film.

A wide film scenic picture was then shown, after which the discussion was resumed.

MR. LA PORTE: The preceding subject was made entirely outdoors without limitation as to the amount of light. The next subject is a short one representing studio technic.

In this picture some of the advantages of the wide film are demonstrated. More story can be told in a given footage of wide film because it is not necessary to take right and left angle shots and a straight-through shot followed by a closeup, but rather the entire field can be kept in view throughout the entire exposure.

In taking this picture long shots, medium, and what we might call "short shots" were taken, but no closeups at all, in an endeavor to keep the images on the screen in about the same proportions that we obtain in 35 mm. projection.

A film illustrating studio technic was shown, after which the apparatus shown in the photographs was available for general inspection, and was described by Mr. Del Riccio.

MR. DEL RICCIO (demonstrating equipment): The steering mechanism of the tripod permits it to be driven either along a curved or straight line. If driven with the curving clutch thrown in, the lens will point in the direction taken by the tripod. If the angular clutch is thrown in, the lens will face only in one direction as the tripod moves backward, forward, obliquely or sidewise. An attachment to the tripod automatically focuses the camera as it moves, regardless of direction. With this focusing arrangement the cameraman can watch the action through the film as he takes the picture. The director can watch through the finder and manipulate the tripods. This results in a saving of time when making "follow shots." The camera can be elevated to a considerable height by means of extensions.

The rear part is in two sections enabling a quick change to be made when a magazine is exhausted. The entire mechanism of the camera is housed in one small chamber. The shutter is behind the disk. The camera can be focused either on the film or on the ground glass which drops behind the focusing tube. A series of cams automatically closes the magazine whenever the ground glass is moved behind the lens or a small door in the side of the rear part is opened to examine the loops. We have but one set of teeth to move the film. The other set is waiting for the decision of the Society of Motion Picture Engineers as to how wide the films are going to be.

The camera is focused, the diaphragm is set, and the lenses are locked—all from the rear of the camera, where the adjustments are accessible to the cameraman while focusing. As the lens is focused the finder is automatically focused, and its optical axis is set to conform with that of the objective.

A new movement has been introduced in this camera—a sideward motion that is required when operating on floors that are not level.

The shutter is three-bladed, having a maximum opening of 230 degrees. An exposure is obtained which is somewhat greater than the exposure used when taking sixteen pictures per second.

MR. LA PORTE: Three-color pictures, made by the Keller-Dorian process, will now be shown. Some of these were made in New York. One was taken at Mr. Zukor's home, some were made in Europe, and others in Florida. Interspersed among these are various studio films.

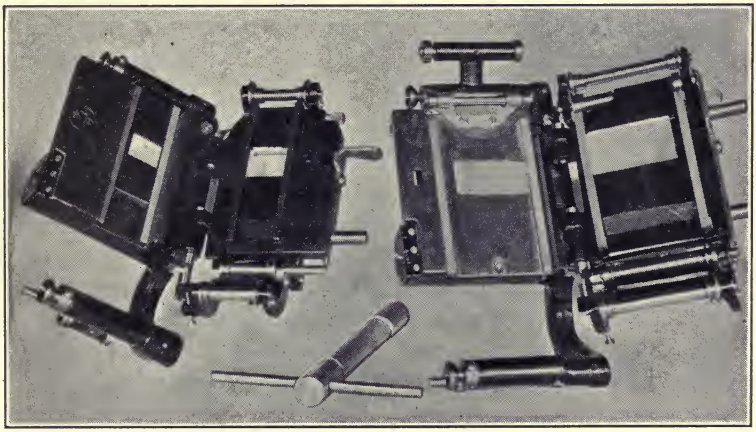


FIG. 3. Combination projector. Film gates for 35 mm. and 65 mm. film.

All excepting the last reel are originals. The latter is composed entirely of a series of copies, such as we would have for release. In order to demonstrate the difference between the first, second, third, and subsequent films, several sequences have been picked out that show very definite motion and could not be repeated or re-photographed. From six to ten copies have been spliced, one following the other, so that the several repeats can be compared with one another. This has been done with several sequences.

CHAIRMAN PALMER: This reel is printed from an original negative. All of the color films you have seen up until now have been reversed originals.

The three-color film was then shown after which the discussion was resumed.

MR. BAUER: What kind of negative was used in making these pictures. Was a bi-pack negative used?

MR. LA PORTE: The Keller-Dorian process was used, with lenticulated films, very similar to the Eastman Kodacolor process, with several minor variations. The lenticulation is horizontal instead of vertical. Copies are made by a new optical printing process. There is no particular reason why the copies cannot be printed by contact.

MR. BAUER: There is an apparent lack of registration in some of the pictures. How do you account for this?

MR. LA PORTE: I believe this is a matter of focus—not registration. This is a new process; the results are not offered as finished products. They have been used to establish the correct technic of taking, developing, and printing.

MR. EDWARDS: Is there a limitation in balancing for color? I notice that there is a distinct tendency toward the green.

MR. LA PORTE: There is no reason why we should not be able to reproduce any color. The filter has a considerable bearing on this matter. The projection filter must be corrected twice: first, for the light used in projecting, in order to bring down the blue balance and second, to compensate for the slight amber tone or filter effect of the film stock itself. Furthermore, the screen we are using is old. It has recently been washed but is still rather yellow.

MR. EDWARDS: With regard to the dimensions of the wide picture, it seems to me that the width to height ratio of the wide picture would give to many people, especially those in the front of the theater, an impression of trying to watch a three-ring circus. The eyes may experience some difficulty in covering the whole width of the screen. Of course, this would not be true for those sitting at the rear of the theater.

MR. LA PORTE: That is correct; however, the same difficulty is found with the speaking stage. It is not any more necessary to view the three rings of the circus at once than it is to see the whole width of the stage at once.

MR. ROSS: If I understand rightly, the Standards Committee of this Society is considering the 50 mm. film as a standard to meet all requirements. Mr. La Porte has just referred to the appearance of the wide picture in a small theater as a "strip" on the screen. This, obviously, is the result of projecting a 1 to 1.8 picture onto a screen in a square stage opening. I believe it may be necessary to adopt two standards of film width, *viz.*, 35 mm. for release prints for small

theaters and negatives for shooting interiors, especially intermediate and closeup shots, and 65 mm. for release prints for *de luxe* houses and for shooting exteriors and long shots. It would be a mistake to adopt a single standard of 50 mm. for release prints for both large and small theaters, as this would place an undue burden upon the smaller houses. It is my further belief that eventually sound will be placed on a separate film with two or more sound tracks. In producing *Hell's Angels* it was found necessary to employ a separate sound film with two sound tracks in order to properly record the sound effects. Furthermore, the industry is learning that the public is tiring of dialog pictures and that greater variety both in action and sound is required. Musical accompaniment greatly increases the emotional influence of dialog pictures; however, when a musical record is superimposed upon a dialog record, the latter is distorted. For this reason the musical accompaniment should be placed on a separate sound track. The separate sound film with multiple sound tracks also allows for the off-stage effects now lacking in the present talkies. It would be a simple matter to add sound film magazines on either side of the action film magazines, the sound head being placed between the sound magazines. By adopting a separate sound film, the present 35 mm. release prints can be employed for both small and *de luxe* houses, excepting where wide film is to be shown. This, however, does not preclude the use of 65 or 70 mm. negatives for recording, to obtain better 35 mm. release prints, especially where the projection entails low throws and where graininess must be reduced to a minimum. This condition is generally met in the *de luxe* houses. Furthermore, if the 65 or 70 mm. release prints are to be projected in the *de luxe* houses eventually, these houses, with their larger box-office receipts, can more easily afford the installation of new 65 or 70 mm. projection equipment.

MR. LA PORTE: We would not want to exceed the limit of magnification of 300 diameters which we now apply to the 35 mm. film. It is preferable to keep down to, say, 275. This means that a 35 mm. reduction can be magnified to about a 24 foot picture; anything beyond that should be obtained from wider film. There should always be considered the cases where a larger screen is desired but where the house is not large enough to accommodate it. In order to compromise, we may extend the magnification to 300 diameters or a little more. A picture smaller than 24 feet in width should be projected from a 35 mm. film. This will take care of over

60 percent of all theaters. For pictures larger than that the wide film should be used.

MR. ROSS: I would like to say that, if the 50 mm. width is adopted as standard, this will require the use of three different films. There

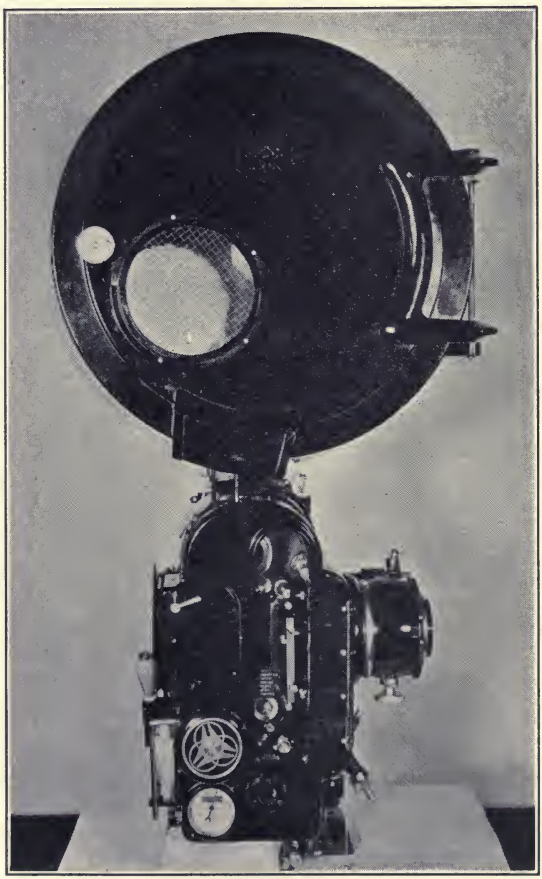


FIG. 4. Combination projector. View of right-hand side.

will always be the 35 mm. release prints until 35 mm. apparatus becomes obsolete. If a 50 mm. width is adopted, we shall also have that size film to handle. Recording is now being done on the 35 mm. film and probably always will be.

MR. LA PORTE: I do not believe there is any reason for three stand-

ards; if we consider 50 mm. film at all, we must look upon it as a substitute for the 65 and 70 mm. widths, or that it will eventually displace 65, 70, and 35 mm. widths, becoming a single universal standard.

MR. RICHARDSON: Referring to Mr. La Porte's remarks, I believe

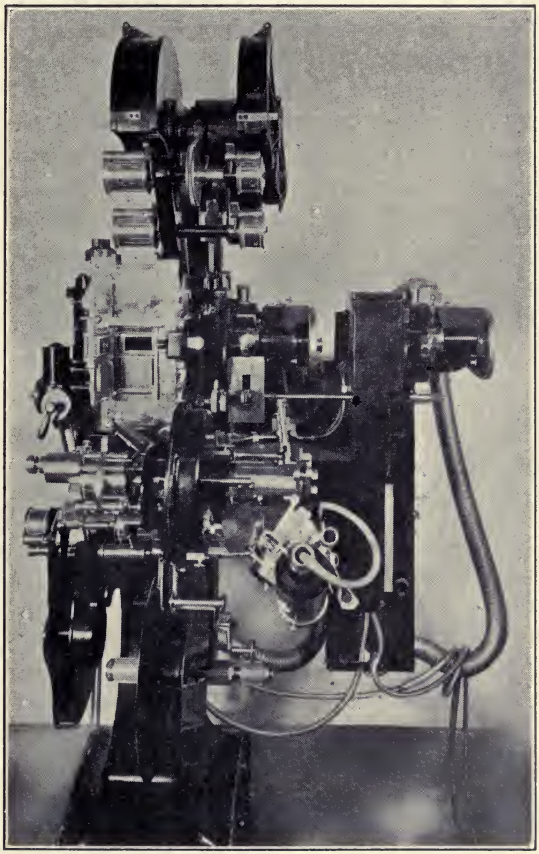


FIG. 5. Printing machine showing working parts.

it was said that the standard tooth has ample dimensions for the heavier film, since the fifth tooth compensates for the added weight. I question that statement. After the film has shrunk a trifle, it is questionable whether more than one tooth on each side will be pulling the film down. The next tooth may be at least half a thousandth of an inch out of contact with the film, and the fifth tooth may be any-

where from two- to three-thousandths of an inch out of contact. Here at the studio we are dealing with projectors in perfect condition in the hands of experts. In the field the conditions are, in many cases, quite the reverse.

If a film is run in the studio a great many times, without showing appreciable wear, it does not follow that it would perform similarly on machines in which the intermittent sprocket, the intermittent movement, and everything else about the projector is more or less worn. When this occurs the projectionist sets the tension down to hold the film steady. The result is that the film very quickly becomes unfit for use.

The handling of this heavy film under such conditions demands a wider sprocket tooth to provide more wearing surface. This may weaken the film, but I do not think that the latter effect is very serious.

Regarding the picture size, it must be remembered that any addition to the height automatically increases the distortion in nine theaters out of ten, because these theaters have projection angles that are often as great as 27 degrees. If the wide film is made fairly high in proportion to its width, the picture will be rather queer looking, even in the theaters where the projection angle is 23 degrees. And, finally, I still believe that if the standard sprocket tooth is used we may have good reason for regretting it.

MR. LA PORTE: You have probably misunderstood me. I said, a standard pitch. We use the Bell & Howell standard shape and pitch in the negative. In the positive we use the standard pitch. An asymmetrical punch is used, of standard size on the sound side of the film, and 0.135 in. wide on the other side, carrying a corresponding tooth. Another set of punches was made with a width of 0.130 in. on each side.

Microscopic examination of brand new film today, regardless of width, shows that the film is driven by only one pair of teeth at a time, one on each side, and that it must move into position in order to bring the next pair into contact with the film. With a film that is slightly shrunken, instead of the second pair taking hold next, the third pair may take hold, after which the second pair may take hold. If the punches are accurate in their spacing, the relaxation of the film will change the spacing enough to furnish half-thousandth steps. It is the difference and change of tooth pressure point that will increase the smoothness with which a sound sprocket can be

driven by increasing the number of impulses, thereby raising the frequency. There is a slight shift every time a tooth takes hold, and even though there may be four or five teeth in contact, only one pair of the group is driving.

The "crossroads" exhibitor will use a 35 mm. version, or reduction, of the wide film. He will continue with his present projector. He must install a large screen and a more highly corrected objective to give him the wide angle without distortion.

MR. RICHARDSON: When illuminating a wide screen through a 35 mm. aperture, it is necessary to pass the same amount of light through the aperture that would have to be passed through the larger

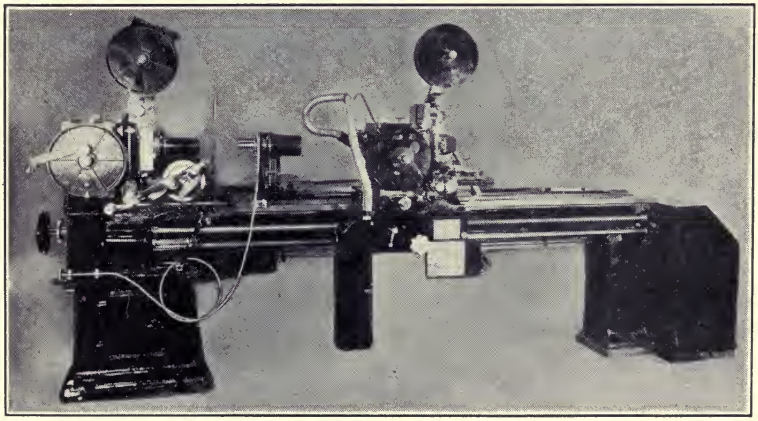


FIG. 6. Optical printer set up for reduction of 65 mm. to 35 mm. film.

aperture. Under this condition, I would say, we would be coming back to the same condition that obtained before the shutters were changed. We would be likely to warp the film due to heating.

MR. LA PORTE: That again depends on how much the screen is widened. In projecting a 35 mm. film through a 60 degree angle, it is not necessary to double the width of the screen, thereby having to illuminate double the field, because there is always a limit to the size of the screen. In addition to changing the objective, the light spot can be made oval instead of circular.

I am not taking the position that, with 35 mm. equipment for three by four film, one can shoot a wide version of 35 mm. without reasonable change of equipment and investment; however, the investment

is small compared with what was required in installing sound equipment. Furthermore, it is a capital item—not an expense item.

MR. RICHARDSON: I fear that, due to the excessive magnification required, the grain of the film will show up quite badly.

MR. LA PORTE: At a magnification of 300 diameters we can obtain an 18 × 24 foot picture from a 35 mm. normal aperture; if we retain the same magnification the graininess will not show up worse in the wide picture than it does now.

MR. RICHARDSON: You are, in effect, putting on a picture 24 feet wide; about the widest we have attempted is 22 feet wide.

MR. LA PORTE: We have plenty of pictures 24 feet wide. However, we must talk in terms of magnification. If the picture is 20 feet wide today, there is no reason why we should add 50 per cent to the width in order to include the 60 degree angle that we desire for the wide film. We are not seeking a larger picture; we are looking for a greater included angle of projection.

We are seeking improved results in regard to the field which the picture covers—the ability to tell more story without having to continually change from one angle to another. In order to accomplish this we go to the large size film.

In the matter of reducing the graininess, film manufacturers have been continually working on the problem. We have better emulsions and greater speed today than we ever had. There is no indication now, that, in the course of the next twelve months, we may not see higher-speed emulsions, with a very decided reduction in grain.

MR. STERN: In the demonstration of the wide picture there were shown on the screen a semi-long, a short, and long shot, eliminating the closeup. It was brought out in the discussion that a similar condition existed on the speaking stage. There is quite a difference between the technic of the stage and of the screen. In the theater, when we desire to view something closely, we use opera glasses. These are replaced in motion picture technic by closeups and semi-closeups. The long shot in a motion picture story establishes the situation; as we tell the details of the story the shots become closer; in the real serious situations we come to the closeups.

I have lately observed in the theaters that often, when we see a closeup of a person, an individual off stage, who is not shown at all, speaks the lines. This illusion carries very well, and therefore if we adopt the wider film I believe we shall have to establish an entirely new technic for our business.

MR. LA PORTE: The technic of taking a picture is a matter that only directors are qualified to discuss. It was at my request that in taking this picture, closeups were avoided and, although a few were made, they were afterward cut out.

The idea I tried to convey was that, by keeping the field entirely in view and not having to angle around, footage might be saved, or more story covered in the same footage. Whether wide film will be used depends on how the public will react to it.

MR. HIBBERD: Is it your opinion that the 35 mm. film should be made on a larger negative and reduced optically for use in small theaters with the extended screen, or directly taken on 35 mm. negative.

MR. LA PORTE: The negative would be a 65 mm. negative.

MR. HIBBERD: If, instead of increasing the graininess, due to the fact that the image is recorded on a larger negative film and reduced, do you think that the structure would be improved?

MR. LA PORTE: If a negative is made on a strip of film 65 mm wide and another is made on the same stock 35 mm. wide, the emulsion being the same, the 65 mm. negative will have almost twice as many grains as the 35 mm. When the 65 mm. film is reduced the grains are reduced in proportion.

MR. HIBBERD: I was trying to point out the fact that the negative grain is the more serious. The positive grain is so fine that what is really seen when enlarging beyond a certain point, is the negative grain.

PROCESSES OF PHOTOGRAPHY IN NATURAL COLORS*

GLENN E. MATTHEWS**

Summary.—*Although a simple process of color photography yielding a print which faithfully reproduces the colors of nature is greatly needed, most of the research at the present time is being directed to the perfection of color motion pictures. Another equally important field is the use of color photography in photomechanical printing processes, as colored illustrations have come into very extensive use during the past fifteen years. The work of different investigators may naturally be divided into (1) still photography, including color photographs to be viewed by transmitted light and by reflected light, and (2) motion picture color photography.*

Almost from the first years in which motion pictures were used commercially, about 1895 to 1900, experimenters have been working on methods of producing them in natural colors. The only practical processes enjoying any extensive commercial use in the theaters, however, are subtractive processes in which the color is incorporated in the film. These subtractive processes, however, are only two-color methods and therefore a true spectral record is not realized.

One additive process has had extensive application for amateur motion pictures for over two years. Within the past year a large number of color motion pictures have been released with sound accompaniment so that the ultimate is being approached in motion picture photography, namely, pictures in color and sound.

Processes of color photography all date back to the classic experiment of Clerk Maxwell before the Royal Institution, London, in May, 1861. On this occasion Maxwell demonstrated that any shade of colored light could be produced by combining various amounts of three primary colors, red, green, and blue-violet. He used three separate lanterns and placed colored solutions before the lens of each. Ferric sulfocyanide was used for the red solution, cupric chloride for the green, and an ammoniacal solution of copper sulfate for the blue. When the light from all three lanterns was projected on the same spot on the screen, a white area appeared; when the red and green beams were superimposed, a yellow spot was obtained; with red and blue, a magenta spot, and with green and blue, a blue-green spot. (See Fig. 1.) This is called the *additive* method of color photography.

* Presented at the Fall 1930 Meeting at New York. (This is a revision of an article published in the 1930 *American Annual of Photography*.)

** Kodak Research Laboratories, Rochester, N. Y.

Maxwell also made a photograph of a colored ribbon, which he projected with the three lanterns. The difficulty of this work can hardly be appreciated unless it is recalled that of necessity he was using wet collodion plates.

Eight years after Maxwell's demonstration a small French booklet was published in Paris written by Louis Ducos du Hauron. This contained a description of almost all the basic principles of color processes which have subsequently been worked out. Credit should therefore be given this French inventor for his foresight. In the intervening years until his death in 1920, he continued to experiment and work out further details of color processes, but was unable to realize much commercial success from any one of these methods.

Of the many references published on color photography, Wall's

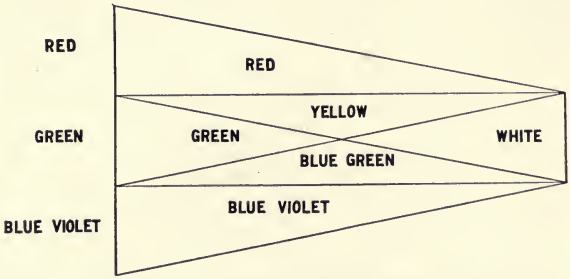


FIG. 1. Diagram of additive color process showing mixture of three primary colors producing white light.

History of Three Color Photography, which was published in 1925, is perhaps the most valuable, since it represents a compendium of information on all phases of the subject.

CLASSIFICATION OF PROCESSES OF COLOR PHOTOGRAPHY

It is convenient to divide processes of color photography into two classes, the *additive* and *subtractive* methods. In the former a colored result is produced by starting with a dark screen (one on which no light is falling) and adding components of white light until the desired color is obtained. An example of this method is Maxwell's experiment. In the subtractive process it can be considered that a white screen is used and that certain parts of white light are subtracted or taken away until the desired color is obtained.

The triangular diagram in Fig. 2 illustrates the principles of the subtractive process. As noted in this figure, when a strip of magenta gelatin which will absorb green light is placed over a strip of blue-

green gelatin which absorbs red light, only blue light is transmitted. Thus, a blue image may be obtained either by projecting through a blue filter or through a combination of magenta and blue-green filters. Similarly, a red image may be obtained by putting a yellow image on top of a magenta image, or a green image by putting a blue-green image on top of a yellow image. The art of painting makes use of a subtractive process since it consists in applying colored pigments to a canvas until the resulting combination gives the desired result. It is considered that the principles of color in relation to light, absorption and reflection of light, the composition of light filters, and the color sensitiveness of photographic materials are treated adequately in textbooks and the reader is referred to such sources if a review of these principles is desired.[1]

For purposes of presentation, the subject has been classified as follows:

I. *Still Photography*
- A. Transparencies
  - 1. Additive Processes
    - (*a*) Three-Color
    - (*b*) Two-Color
  - 2. Subtractive Processes
    - (*a*) Three-Color
    - (*b*) Two-Color
- B. Prints
  - 1. Additive Processes
  - 2. Subtractive Processes
    - (*a*) Three-Color
    - (*b*) Two-Color

II. *Motion Picture Photography*
- A. Transparencies
  - 1. Additive Processes
    - (*a*) Three-Color
    - (*b*) Two-Color
  - 2. Subtractive Processes
    - (*a*) Three-Color
    - (*b*) Two-Color
- B. Prints

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[1] Reference sources are as follows:

A Text-Book of Physics, L. B. Spinney, *Macmillan Co.*, N. Y.

General Physics, Henry Crew, *Macmillan Co.*, N. Y.

Colour and Methods of Colour Reproduction, L. C. Martin, *Blackie & Sons, Ltd.*, London.

Light for Students, E. Edser, *Macmillan Co.*, N. Y.

The Photography of Colored Objects, *Eastman Kodak Co.*, Rochester, N. Y.

I. STILL PHOTOGRAPHY

A. COLOR TRANSPARENCIES

1. *Additive Processes*

(*a*) *Three-Color Triple Exposure Methods.*—One of the earlier methods which received some commercial recognition was the three-color additive process of Professor Miethe of Berlin. His camera had a repeating back, or means of successively exposing the three-color separation negatives through the requisite filter placed in front of the plates. The positive plates printed from these negatives were projected by means of a complicated triple lantern. This process, however, and a similar one designed by F. E. Ives, another pioneer in color photography, had the objection that the pictures were not taken simultaneously and required an intricate lantern for projection. To overcome these difficulties, Ives designed a camera wherein two

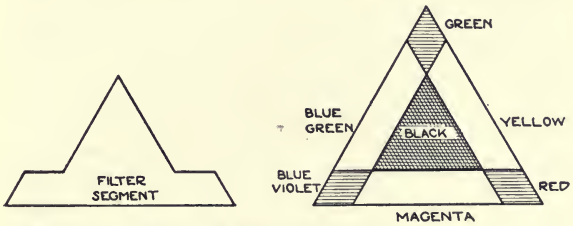

FIG. 2. Diagram of subtractive color process. Three-color filters, magenta (or minus green), blue-green (or minus red), and yellow (or minus blue), respectively, cut in shape of segment (left) are superposed to form a triangle (right). Where the different pairs overlap at the corners, the primary colors, red, green, and blue-violet, are produced. Where all three filters overlap in the center triangle, no light is transmitted because each filter absorbs one of the primary colors.

special mirrors split up the light entering the single lens and exposed the three plates simultaneously. By a similar principle the three-color impressions could be examined in a special viewing outfit. Ives also designed a method for making stereoscopic pairs of three-color positives (Kromograms) which were viewed in a device called the "Kromskop." Cameras for making three-color negatives have also been designed by Butler, Sanger-Shepherd, René-Gilbert, and others.

Screen Plate Processes.—One of the novel processes suggested by Du Hauron was that the surface of a plate might be covered with tiny filters, red, green, and blue, and then the sensitive emulsion coated on

top. By photographing through the back of the plate an image would be obtained which would be cut up into tiny sections similar in size and shape to the filter sections. Several systems of making these "screen" plates have been worked out. The methods may be divided into two groups according as they yield (*a*) a regular pattern, or (*b*) an irregular pattern. Examples of the former would be methods of ruling a series of red, green, and blue lines on the plate surface or producing a mosaic of tiny red, blue, and green squares. The latter or irregular method is represented by processes in which colored particles one layer thick are dusted on the plate surface.

In 1892 the first recorded attempt to make a screen plate of the

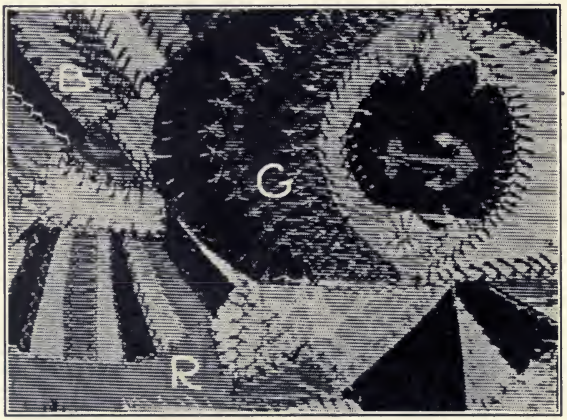

FIG. 3. Reproduction of a McDonough screen plate picture showing line image. *R*—red; *G*—green; *B*—blue.

regular type was made by J. Joly of Dublin. He obtained rather pleasing results by ruled-line methods. His line screen was on a separate plate and after the negative had been exposed, a positive was printed and placed carefully in register behind another line screen. About the same time, J. W. McDonough of Chicago, Ill., introduced a process somewhat similar to Joly's method. Fig. 3 is a reproduction of a slide made by the McDonough process.

The most successful commercial process, however, is the Autochrome, which was introduced by A. & L. Lumière in France, in 1907. This is an irregular screen process wherein minute grains of potato starch, varying in form and size, are dyed in separate batches, blue, green, and red, with dyes especially selected for the purpose. The

dyed grains are mixed in the ratio of four green to three red to two blue, and are dusted on the surface of the plate. The interstices are filled with a black powder and the layer rolled in under pressure. The plate is then varnished and coated with a panchromatic emulsion. When finished, there are over four million of these color filters per square inch. (See Fig. 4.) Although the three colors should combine to give the effect of white when looking through the screen, they

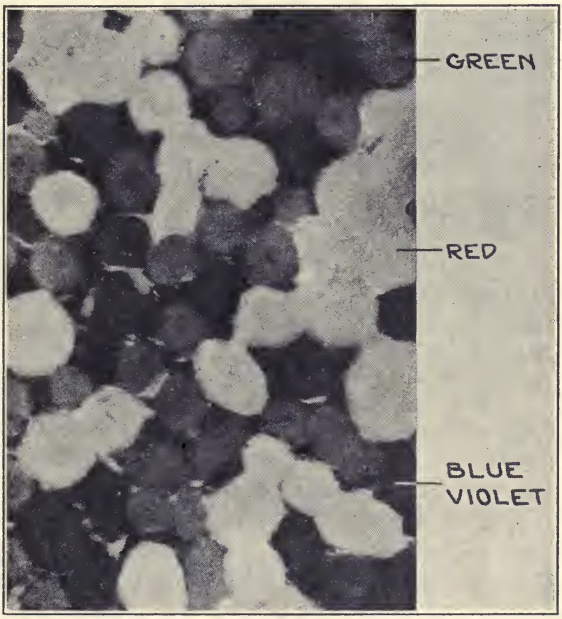

FIG. 4. Photomicrograph of Lumière autochrome starch grain screen plate. (Reproduced from "Photography in Colors," G. L. Johnson, Dutton and Co., New York, 1922.)

actually appear a salmon pink. Exposure is made through the glass slide so the light will have to pass through the colored screen before reaching the emulsion. After the exposure, the plate is developed and then bleached in acid permanganate, which dissolves the silver negative image but does not attack the unexposed emulsion. An exposure to white light now makes the remaining area developable, and after the second development a positive image is obtained. The process of bleaching, exposing, and redeveloping is known as a

reversal process, because the original negative is converted into a positive.

The Agfa color screen plate was originally announced in 1916 but was not introduced until 1923. This plate has a three-color screen similar to that of the Autochrome except that dyed particles of gum arabic rolled out in collodion are used. Color screen methods were first applied with some commercial success to roll film and film packs by the Lignose Company of Berlin, in 1927.

The Paget screen plate introduced about 1912 was very popular for several years. The color screen and the sensitive emulsion were on separate plates, thus eliminating some of the difficulties of screen plate manufacture. In the event that the picture was spoiled, the screen could be used again. When binding up the transparency it was somewhat difficult to register the color screen. Although withdrawn from the market for a few years, the plate was introduced again during 1927 under the name "Duplex Color Plates."

The Finlay color process, introduced during 1930, uses a separate taking screen and a specially sensitive panchromatic emulsion. It is claimed that exposures may be made in one-fifth to one-fiftieth of a second at $f/4.5$ for street scenes in good sunlight, and one-hundredth of a second for seascapes. Contact positives are printed from the negative and bound into register for inspection. The first aerial color photographs were made by this process by a staff photographer of the National Geographic Society during the summer of 1930. The pictures were exposed from army dirigibles, the engines being turned off to reduce vibration during the exposure.

Numerous other screen processes have been worked out but very few of them compare with the Autochrome in quality and fineness of the screen particles, the uniformity of the product, and the beauty of the color rendering. Even the Autochrome process has certain limitations, however, for it is necessary to use a very thin emulsion coating, and such a coating has a narrow range of gradation or ability to reproduce a scale of tones. The plates are also very dense and require stronger illumination than ordinary plates for projection.

Bi-Pack and Tri-Pack Methods.—Several methods of exposing two or three films simultaneously have been suggested. The films (or plates) are arranged as a pack so that the two upper films (or interposed filters) transmit certain portions of the light in exposing the different layers, and a set of three-color separation negatives is obtained. The order of exposure varies with different processes but

the usual procedure is to place the blue-sensitive film uppermost, then the green, and then the red. It is impossible to obtain critical sharpness by such a method although some rather pleasing results have been produced.

(*b*) *Two-Color Additive.*—The majority of transparency processes are three-color processes but a few two-color additive methods have been worked out. A two-color line screen process has also been suggested.

2. *Color Reproduction by Subtractive Processes*

Thus far methods have been discussed in which the final picture is made by superimposing, or adding, lights of two or three primary colors. In nature, however, substances are not colored in this way but, instead, they absorb or subtract certain component parts of the visible spectrum of white light and reflect the remainder. It is this composite reflected portion which is the color the normal eye records as the natural color of the object.

(*a*) *Three-Color Methods.*—When preparing a three-color transparency by the subtractive process, it is necessary to make three positive color records either on thin gelatin coated films or tissues, and superimpose these in register. Methods of securing these positive color records may be classified, as follows: (*i*) dye mordanting and toning methods, (*ii*) carbon (or pigment) transfer, (*iii*) imbibition, (*iv*) hard and soft gelatin methods, and (*v*) relief processes.

(*i*) *Dye Mordanting and Toning Processes.*—In these processes, positives are printed from a set of three-color separation negatives and the silver image on each positive is changed to a compound salt which will mordant or absorb basic dyes. The final dye images are distributed throughout the original gelatin film so that the entire film must be transferred to the final support.

It is quite difficult to secure true complementary colors by chemical toning methods, but nevertheless, some very pleasing results have been produced. Iron toning is occasionally used to produce a blue image, and mercury (iodide) gives a yellow image; there is no satisfactory toning method known for making a red image, although the reddish-brown image obtained with uranium toning has found some adaptation. Toning methods are sometimes used in conjunction with other color processes.

(*ii*) *Carbon or Pigment Transfer.*—This process makes use of a property that bichromated gelatin possesses, of becoming tanned or

hardened when exposed to light. If a plate is coated with bichromated gelatin and is placed behind a negative, as in Fig. 5, and then exposed to light, only those parts of the bichromated plate which the light does not reach will remain unhardened and therefore soluble in hot water, while the parts exposed to the light will be insoluble in hot water.

Exposure is usually made through the back of the film or plate in order that the delicate highlights may not be washed off during the hot water development. After the soluble parts have been removed the image remaining may be dyed up by choosing dyes which are absorbed by tanned gelatin. The dyes must be complementary[2] to the filters through which the negative was exposed; thus the green filter picture is dyed magenta, the blue filter picture is dyed yellow,

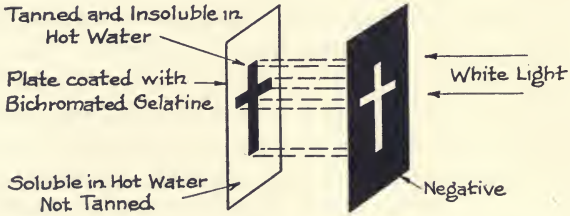

FIG. 5. Effect of light on a bichromated gelatin plate.

and the red filter picture is dyed blue-green. When the three positives thus obtained are cemented together in register, a transparent color reproduction of the original subject will be obtained.

(*iii*) *Imbibition Processes.*—Transparencies by the imbibition process consist of dye images in a single gelatin layer. When a dyed relief image in gelatin is brought into intimate contact with a plain gelatin surface, the dye tends to wander to the other surface, or become imbibed by the gelatin. Such imbibed images are inclined to be fuzzy and expedients are therefore taken to prevent spreading of the dye. Registration of such images is also very difficult but very pleasing results have been obtained.

(*iv*) *Hard and Soft Gelatin Process.*—A method was introduced in Germany in 1906 known as the *pinatype* process, which utilized the fact that certain dyes will stain soft gelatin in preference to hard gela-

[2] Complementary dyes are those which absorb the light which the filter dyes transmit.

tin. The process as originally introduced was tedious as it required nine separate printings. Three transparencies are prepared from the original three-color separation negatives and three print plates on bichromated gelatin from the transparencies. The print plates are then dyed up with dyes which are only absorbed by soft gelatin and a positive image is produced on the print plate which contains an invisible negative image of tanned gelatin. The dye image may subsequently be transferred to another surface if desired.

(*v*) *Relief Processes.*—There are three methods commonly employed for producing a relief image in gelatin, (*a*) the use of the tanning action of a bichromate solution on the gelatin around the particles of silver comprising an image. The gelatin relief can then be stained up and used as a matrix. (*b*) The use of an oxidizing solution such as hydrogen peroxide, which dissolves away the image and attacks the gelatin immediately around each silver particle comprising the image. The gelatin film is then washed, fixed, and dyed. (*c*) The use of the tanning action of an oxidized developer on gelatin to form a relief image which is subsequently dyed up. In (*a*) and (*c*) the silver image is removed by treatment with a reducer before dyeing. In addition to the above methods of securing a relief, the tanning action of light on bichromated gelatin may also be used, as described under carbon or pigment transfer methods.

(*b*) *Two-Color Methods.*—Because of the complication of a three-color process, several investigators have tried to perfect a two-color subtractive process. The possibility of getting satisfactory results with the subtractive method is somewhat greater than with the additive method. With the latter, two colors must exactly balance each other, or be complementary to one another, in order to obtain true whites and blacks. In the former or subtractive method, whites are obtained by the absence of color and blacks by using both colors in full strength, so that colors may be used which are not exactly complementary and the range of usable colors is greatly extended.

The method of preparing transparencies or lantern slides by this process is essentially the same as for a three-color subtractive process. The final result consists of two plates, films or tissues, which have been dyed by some suitable method and then superimposed in register.

The Kodachrome process of color portraiture, worked out by J. G. Capstaff and introduced in 1915, made use of the property possessed by certain dyes of staining soft in preference to hard gelatin. Two plates were exposed behind their respective filters, developed, and

then converted without fixing into dyed positives. This process used a tanning bleacher which removed the original negative image and simultaneously hardened the gelatin in proportion to the amount of silver image present.

For portraiture, a two-color subtractive process is admirably adapted. It is also useful for photographing certain flowers, still life, or fashion scenes in which reds, greens, or orange predominate. It is unsuitable, however, for landscape work where there is an excess of blue, blue-green, and violet. For clinical photography and photomicrography it finds useful application.

B. COLOR PROCESSES YIELDING PRINTS TO BE VIEWED BY REFLECTED LIGHT

Although most of the color transparency processes are capable under certain conditions of yielding color prints, the majority of the print processes of commercial interest have been worked out primarily as print processes. The average individual prefers a photograph that can be examined in the hand or hung upon the wall to one which must be held before an illuminator or projected upon a screen.

1. *Additive Print Processes*

Numerous attempts have been made to perfect an additive color print process but none have met with any practical success. Subtractive processes are much simpler to work and the majority of print processes therefore have been subtractive methods.

2. *Subtractive Processes*

All of the methods described previously under subtractive transparency processes are adaptable to making prints. The final stage of the process usually consists in superimposing two- or three-color tissues or gelatin films in register or transferring the image by imbibition to a paper support.

(*a*) *Three-Color Methods*

(*i*) *Dye Toning Processes.*—More or less degradation results by this method as the colors often wander and the print is usually rather dark, because the light has to penetrate several layers of film and be reflected back through them. Ives' Hichrome process is one of the best examples of this method.

(*ii*) *Transfer Processes.*—Under the general term transfer processes, may be grouped those methods of producing color prints wherein bichromated tissues containing the respective color records are

transferred from their original support to a paper support. Three-color carbon prints are prepared by applying a mixture of gelatin and pigment to a thin piece of film support, sensitizing the gelatin in bichromate solution, exposing under the respective color negative through the film side of the tissue, dissolving off the soluble gelatin in hot water, and mounting, gelatin side down, on a piece of smooth white paper. After the sheets have remained in contact a short time, the film support is stripped off, the operation usually being carried out under water. The yellow tissue is ordinarily mounted first, then the blue-green, and then the magenta. Some of the finest examples of this process produced in America are those of J. W. Allison of New York and Jeffery White of Detroit, Mich.

In the original Raylo process introduced in 1923, three exposures were made successively and automatically on one plate, through the three primary filters, yielding a negative. The method of printing gave any number of 5 in. by 7 in. pictures on paper and is a novel application of the carbon process. A sheet of film base coated with three patches of pigmented gelatin was stretched in a frame, exposed to the enlarged images of the negative, and then developed in the usual way in hot water. By means of a special registering device, the final superimposition of the three tissues was claimed to be accomplished with ease. More recently, the inventor of the Raylo process, Mr. H. C. J. Deeks, supplied prepared pigmented aceto-cellulose sheets for printing from any set of three-color negatives. Each sheet is coated with a light sensitive silver halide emulsion containing the pigment. After exposure and development in a tanning developer, the relief image is washed with hot water and the silver image is removed by bleaching and fixing. The prints on these pigmented tissues are then transferred to a paper support.

In the Ozobrome methods, bromide prints made from the original three-color negatives are brought in contact with the respective color tissues soaked a short time previously in a bichromate-ferricyanide-bromide bath, and the bromide print stripped off the tissue, which now bears the image of the print. The tissues are then developed, fastened to a temporary support, brought into register, and finally transferred to a permanent paper support.

(*ii*) *Imbibition Processes.*—Color prints by the imbibition process are made by starting with a blank sheet of gelatin coated paper and causing the coating to take up successively or "imbibe" dyes from color images from the "print plate" covered with unhardened gelatin

Any number of prints may be made from one group of print plates. The dyes used in this process will only stain soft gelatin. In another imbibition process, the Sanger-Shepherd, the reverse is true since it depends on dyes which will stain hardened gelatin. Very pleasing results may be obtained with both two- and three-color imbibition processes.

(*iv*) *Relief Processes.*—A novel wash-off relief process using imbibition to prepare the final print was introduced in Germany in 1925 under the name "Jos-Pe." Printing plates were prepared from a set of three-color negatives by projection onto glass plates coated with a gelatino-bromide emulsion. The plates are exposed through the back and developed in a developer which differentially hardens the gelatin according to the amount of silver image formed. A relief image is obtained by washing the fixed-out plates in hot water. Prints are made from these dyed-up printing plates by imbibition, registration being simplified since the printing plates are quite transparent.

(*v*) *Bleach-Out Methods.*—An ingenious method for changing a color transparency into a color print, which unfortunately, has thus far had very little commercial success, is the bleach-out process first worked out by J. H. Smith in 1895 and known as "Utocolor." This process had been suggested in 1867 by Du Hauron and Charles Cros from purely theoretical reasoning. It depends on the property certain dyes possess of bleaching out when exposed to specific wavelengths of light. Paper is coated with an intimate mixture of three such dyes, red, yellow, and blue. The color transparency is placed in contact with the paper and by virtue of the bleaching properties of the dyes, the paper is changed into a color print. Uneven bleaching, distortion from heat, and fugitiveness of the dyes are some of the difficulties encountered. Although these limitations are serious, this method offers great possibilities if it is ultimately worked out satisfactorily.

(*vi*) *Three- and Four-Color Photomechanical Reproduction.*—The most outstanding use of color photography for many years has been the making of three-color reproductions in books and magazines by photo-mechanical methods. Two methods are used, depending upon the accessibility of the subject, (*A*) the Indirect and (*B*) the Direct methods.

In the former, three-color separation negatives are prepared, transparencies are made from these negatives, and screen negatives on wet

collodion plates are finally obtained from the transparency by interposing in the camera in front of the sensitive photographic plate, a glass plate evenly ruled with a fine cross line screen (about 150 lines to the inch).

The direct method avoids the making of the first negative and the transparency, since the three screen negatives are made by direct photography of the colored subject. For each separate screen negative, the red, blue, and green, the screen is rotated, making each pattern at an angle of $22^1/_2$ degrees to 30 degrees from the others. When the lines of the screen cross at smaller angles, a disagreeable pattern or moire is produced in the final printing. Engraved copper color plates are prepared from each color separation negative and printed by inking up with suitable greasy ink pigments.

(*b*) *Two-Color Subtractive Processes.*—Several two-color processes for preparing color prints have been worked out, using most of the methods described under three-color processes. Very pleasing results have been produced with two-color imbibition and by carbon transfer methods.

II. MOTION PICTURE COLOR PROCESSES

Processes of still photography always lack one important characteristic—motion, for life as the eyes see it, is associated closely with movement. This fact led several investigators about 1890 to attempt to reproduce motion by means of photography. As we know today, a standard motion picture film consists of a series of slightly differing pictures printed on a narrow film strip, 16 pictures to each foot of film. When intermittently projected at a rate of one foot or more per second, the eyes, by persistence of vision, see these images gradually dissolving one into another, because the impression of one picture does not quite disappear before the succeeding one overlaps it.

A. COLOR TRANSPARENCIES

1. *Additive Motion Picture Processes*

(*a*) *Three-Color Methods.*—Soon after motion pictures were introduced attempts were made to perfect a color process of cinematography. One of the earliest tri-color additive methods was worked out in England by W. Friese-Greene. It consisted in taking the pictures successively on a single film strip through primary filters incorporated in a rotating sector wheel, and reconstructing them by projection in a

similar manner through color filters. It was found, however, that a projection speed of 70 pictures per second was necessary, which proved entirely impracticable because of the excessive wear on the machine and the film. To reduce this abnormal speed the pictures were taken at normal speed simultaneously through three lenses on three separate films and projected in much the same way. This method had its drawbacks also, since three times as much film was required and optical errors were introduced, which made it impossible to exactly superimpose pictures taken from different points of view and at

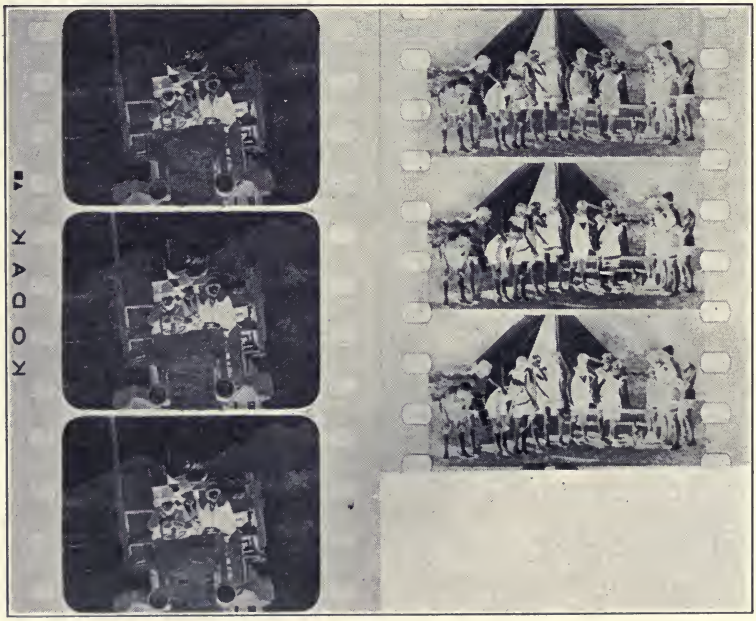

FIG. 6. Comparison of Gaumont three-color negative (right) and standard 35 mm. negative films.

different times. These are known as *parallax* and *fringing* errors, respectively.

Gaumont tried to overcome the need of using extra film by making the three records simultaneously on one film and reducing the size of the records so that they occupied 2.25 times instead of 3 times the space of a standard picture. (See Fig. 6.) Both the camera and the projector were equipped with a special three-lens projection system and the three primary filters were placed in front of the lens on the

camera and the projector. The results given by this process were very pleasing, but it had the objection that special equipment was required for showing the pictures and it used more film than standard motion picture photography.

In almost all of the three-color additive processes, the film is moved intermittently, but J. Szczepanik designed a complicated camera and projector, about 1925, in each of which the film is moved continuously. Intermittent motion is dispensed with in the camera by having an endless chain of 18 lenses moving synchronously with the film behind a collimating lens, three pictures being exposed at any time through primary filters. The projector is even more complicated, and reference should be made to the literature for details of its construction.

Other three-color additive processes which were being exploited during 1929–30 were the Wolff-Heide and the Herault processes.

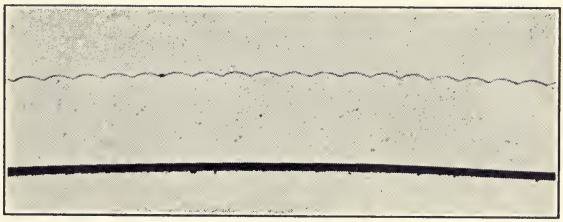

FIG. 7. Photomicrograph of cross section of Kodacolor film (thick black line is the emulsion).

Natural color motion pictures for the amateur became available in 1928 when Kodacolor film was announced for use in 16 mm. equipment distributed by the Eastman Kodak Company. The method is a commercial expansion of a process worked out in principle by R. Berthon and A. Keller-Dorian of France, between 1908 and 1925. In this latter year, rights were purchased by the Kodak Company for development, particularly as an amateur process of color cinematography.

Kodacolor is a three-color additive process which realizes the principles of a line screen method without the added difficulty of ruling a screen on the film support. The process is based on a means of impressing a series of microscopic cylindrical lenses into and across the support side of panchromatic film. (See Fig. 7.) A banded three-color filter is fitted into a holder in front of the lens of the camera and projector. The film is threaded in the

camera with the emulsion side away from the lens so that the light, before it reaches the sensitive emulsion, must be transmitted by the tiny embossed lenses, each one of which thus images the bands of the color filter on the film. If the subject is white, all three color filters allow light to pass and three lines are exposed under each lens element. If the subject is red, that is, if it reflects red light, only the red parts of the filter transmit the light, and the emulsion areas illuminated by this section of the filter will be exposed. With colors that are made up of more than one primary color it follows that more than one part of the tri-color filter will transmit the light.

Perhaps this may be made a little clearer if only one lens element and one color of light, say, blue, is considered as shown in Fig. 8.

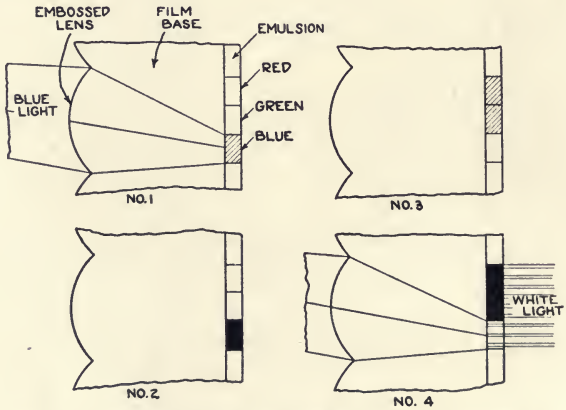

FIG. 8. Action of blue light on single lens element of Kodacolor film.

Here it is seen that the blue light exposes an area about one-third that under the lens element (No. 1). On development this area becomes opaque (No. 2). The film is then bleached, and the remaining silver salts are given a controlled exposure (No. 3) and developed up. Now the area affected by the blue light becomes clear and transparent, while the areas corresponding with the red and green filter segments are opaque (No. 4). When white light is directed on this single lens section, it passes through the area where the blue light exposed the film, and since the optical system is reversible, it follows that the light will strike the blue segment of the filter and form a blue spot on the screen, since no light reaches either the green or red filter segments.

In other words, all the tiny line areas transmit all, part, or no light, according as the subject reflects all, part, or none, of the corresponding colored light. The various colors are recombined on the screen to reproduce the natural colors of the subject photographed.

Examination of an actual picture will make this principle clearer. Fig. 9 shows, on the left, a picture on Kodacolor film (actual size) of a child wearing a red hat. The child's head stands out in silhouette against a blue sky. In the enlargement on the right, of one picture of the series, the characteristic line composition of a Kodacolor picture is readily discernible.[3] Note that the lines are alternately dark and

FIG. 9. Picture on Kodacolor film of child with red hat against a blue sky; and enlargement showing line composition. Note displacement of lines in hat area (*A*) compared with sky area (*B*).

light where the red hat is reproduced (shown by arrow *A*), thus allowing light to pass through the image so that it will be transmitted only by the red part of the color filter. In the area representing the blue sky, the lines are dark and light, but they are displaced slightly from their position in the area of the red hat. This is best seen in the parts of the sky next to the hat (shown by arrow *B*). The sky area reproduces as blue on the screen, since only the blue part of the filter will receive and transmit the light passing through that part of the picture.

[3] When Kodacolor pictures are projected on the screen, the lines, of course are invisible at the normal viewing distance.

Motion portraits made by the Kodacolor process using artificial light in a specially constructed studio were shown at Buffalo, N.Y., in May, 1929.

(*b*) *Two-Color Additive Processes.*—Difficulties attending three-color processes prompted W. Friese-Greene and others to try to devise satisfactory two-color additive processes. One of these known as "Kinemacolor" enjoyed some commercial success. Like Friese-Greene's first method, it used a rotating disk or shutter of color filters before the lens. The pictures were taken alternately through red and green filters at twice the normal speed and projected at the same speed. Considerable trouble from color fringing was found with these methods. About 1925 C. Friese-Greene, the son of the previous inventor, produced a process called "Spectrum Films" which employs a special color shutter in the taking camera that is claimed to reduce some of the trouble from these optical errors.

The Busch two-color additive process utilizes a twin lens camera for photographing the pictures, one above the other, on each single frame of the negative film, which runs horizontally through the camera. Contact prints are so projected that the image pairs are superimposed on the screen. This process has been recommended especially for photographing surgical cases.

Another method of securing two-color additive effects consisted in dyeing up the alternate frames of a Kinemacolor or allied positive, red and green, respectively, and projecting the film at twice the normal speed. This gave an effect similar to that of using a rotating color sector wheel before the projector lens.

An additional two-color additive process which was being exploited during 1929–30 was the Raycol process.

An amateur color process known as Vitacolor also appeared recently, incorporating the old Kinemacolor principle (see below), except that a multicolor sector wheel is rotated in front of the camera and projector lenses are used instead of a shutter with only three primary colors. Alternate frames are exposed through this color sector at 26 to 28 pictures per second.

2. *Subtractive Motion Picture Color Processes*

(*a*) *Three-Color Methods.*—Three-color subtractive processes present very great difficulties, as it would be necessary, by dyed bichromate or dye mordanting methods, to apply three successive color layers and recoat with gelatin after each application. Subtractive

processes using three colors were introduced during 1928–29, called the Zoechrome and Splendicolor methods. Most of the commercially workable processes, however, are two-color subtractive methods.

(*b*) *Two-Color Methods.*—In these, color may be incorporated in one emulsion layer on opposite sides of the film or in two layers on one side of the film. Several methods have been worked out; some use a dye mordant treatment, some an imbibition process, and others chemical toning methods. Three methods of taking pictures have been adopted: simple alternate exposure through red and green filters; the use of twin lenses corrected to the wave-lengths of the respective filters; the use of optical systems of semi-transparent mirrors which split the beam of light and expose the two images simultaneously. The last method overcomes all parallax and fringing errors.

P. D. Brewster adapted the bi-pack scheme to cinematography. He used a double coated negative film containing a transparent emulsion sensitive to the blue-green on the side of the film toward the lens, and on the other side, either a panchromatic emulsion or one sensitive to the red, orange, and yellow. After processing the negative film in the usual way, the images were bleached and dyed with basic dyes of the same color as used for the filters. The color negative obtained was used to make prints on double coated positive film. A prism beam-splitter was used in the printer and the two images printed through the respective filters onto opposite sides of the film. The final silver images were bleached and dyed in the same colors as the printing filters. The color positive could be projected in the usual way on a standard projector.

Several methods of producing two images on single coated film have been worked out by Ives, Kelley, Fox, and others. A typical example is one in which the first image produced is toned blue with an iron toner and, before fixing, a second image is printed in the remaining silver halide. During development, the alkali present in the developer converts the blue image to a colorless salt. The second image is then treated with a vanadium mordant bleach and dye toned. When the film is passed through an acid solution, the original blue image is restored.

Numerous processes have been patented on the use of double coated stock for printing the positive record.

A typical two-color subtractive process is "Kodachrome" worked out by J. G. Capstaff of the Kodak Research Laboratories. By

means of a beam-splitter optical system, complementary images are exposed simultaneously on panchromatic negative film. A master positive print is made by contact from the original negative. By using a special projection printer, a duplicate negative print is made from the master positive. In the print the complementary images are in exact register on opposite sides of a double coated film. This duplicate negative is bleached until the images have disappeared, the bleach bath hardening the film only in the parts where the image previously existed. The two sides of the film are then dyed in colors complementary to the filters through which the original negative was exposed, the dye entering the film only in the unhardened areas, thus producing positive dye images. The color film may be projected the same as standard black and white motion pictures.

Another two-color subtractive process is the "Technicolor" founded on the Comstock patents. This was worked out originally as a relief process, but about 1928 was changed to an imbibition process. The negative or master film is photographed as before, two pictures at a time, one "frame" or picture carrying the component of one set of colors, the next its complement—or if desired three-color components are used. The developed negative is printed by a mechanism which jumps the negative so that the red separation images appear in a continuous film, the blue images in another continuous film—in other words, the positive film is moved forward one frame at a time and the negative two frames at a time. These two films are developed to produce a relief image, and are then run along a steel plate successively under great pressure, in contact with the film to be used for projection, the dyed images being "printed" much as the red, blue, and yellow plates are printed in making color reproductions in book printing. This process has enjoyed extensive commercial success and is at present being used in conjunction with sound motion pictures. During 1930, a method was worked out of making color sound prints having a silver image sound track with a contrast or "gamma" of unity, which was claimed to result in improved sound reproduction.

In the Multicolor (two-color) subtractive process, two negative films are run simultaneously through any standard camera with their emulsion surfaces in contact. The front negative is orthochromatic, with the surface layer dyed orange-red to act as a filter for the image recorded on the rear panchromatic film. Double coated

yellow dyed positive film is used for printing the pair of images in register on opposite sides of the film. The images are colored by a combined dye toning and chemical toning method and are varnished before projection to protect them from scratching.

Besides the two-color subtractive processes mentioned previously, the following methods were enjoying some application during 1929–30: Color Craft, Photocolor, Sennett color, Harriscolor, and Sirius.

B. MOTION PICTURE PRINTS

Several processes have been developed for making motion picture prints on paper, to be projected by reflected light, but thus far no such motion picture color print processes are known. A great loss of light obviously occurs with projection of prints.

CONCLUSION

No attempt has been made in this article to cover the subject of heliochromy or color photography by the use of the principles of interference of light rays, as worked out by Lippman, Hill, R. W. Wood, and others. This process is very complicated and thus far has had no practical application. The chemistry of dyes is being extended each year and some simple bleach-out process may be found.

Although three-color processes offer the only solution for complete and true color reproduction, a number of very pleasing two-color processes have been demonstrated, especially in the field of motion pictures.

A simple process for making natural color prints still remains to be worked out, but methods of exposing three-color separation negatives have been simplified by the introduction of a screen roll film and film packs, as well as of a tri-pack roll film. In the professional field, color photography processes are being used chiefly by a few skilled photographers as a basis for reproductions for advertising. In connection with photomechanical processes, however, color photography has come to be used extensively.

Motion pictures in color are now in common use, and during the summer of 1929 an entire feature picture in color was released with musical accompaniment and dialog. Color motion pictures in the home are also a reality, as at least two processes are known to be in use.

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BOURQUIN, H.: "Color Cinematography by the Wolff-Heide Process," *Phot. Korr.*, **64** (June 1, 1927), p. 186. Pictures exposed at 28 frames per second on film, every alternate frame of which is sensitive to red and blue, respectively. Alternate frames of print dyed and film projected 28 frames per second. (Later changed to three-color process; print frames dyed red, blue, and yellow, respectively. Projected with continuous projector. Report of the Progress Comm., *J. Soc. Mot. Pict. Eng.*, **15** (Dec.. 1930), p. 759.)

POWRIE, J. H.: "Line Screen Film Process for Motion Pictures in Color," *Trans. Soc. Mot. Pict. Eng.*, **XII**, No. 34 (1928), p. 320.

CAPSTAFF, J. G., AND SEYMOUR, M. W.: "The Kodacolor Process for Amateur

Color Cinematography," *Trans. Soc. Mot. Pict. Eng.*, **XII**, No. 36 (1928), pp. 940–7.

RODDE, M., "The Hérault Trichome Process," *Bull. soc. franç. phot.*, **15** (Mar., 1928), p. 80. Successive frames tinted and film projected 24 pictures per second on a continuous projector.

MEES, C. E. K.: "Motion Pictures in Natural Colors," *Camera Craft*, **35** (1928), pp. 303–5. Describes Kodacolor process.

"Keller-Dorian Color Film System," *Licht Bild Bühne*, **21** (Oct. 6, 1928), pp. 19–20.

ANTHONY, E. C.: "Vitacolor Movies," *Movie Makers*, **3** (Dec., 1928), p. 771.

MEES, C. E. K.: "Amateur Cinematography and the Kodacolor Process," *J. Frank. Inst.*, **207** (Jan., 1929), pp. 1–17.

CORY, A. B.: "The Kodacolor Process," *Amer. Ann. Phot.*, **43** (1929), pp. 9–11.

"Third Dimension in Colored 'Talkies,' " *Photo Era*, **63** (Aug.-Sept., 1929), pp. 103, 162. Rotating sector wheel used in exposing pictures alternately in camera. Ordinary positive print projected onto composite perforated metal screen made up in four layers, each of a different color.

HATSCHEK, P.: "Color Film Using Embossed Prisms," *Filmtechnik*, **5** (Apr. 13, 1929), p. 154. Exposure is made through the base side of a film embossed with minute prisms, each of which forms a spectrum on the emulsion. Projection is made after the images have been developed by reversal. No filters are used in either the camera or projector.

TUTTLE, H. B.: "Some Experiments in Medical Motion Pictures in Color," *J. Soc. Mot. Pict. Eng.*, **15** (Aug., 1930), p. 193. Describes lighting equipment for making Kodacolor pictures of surgical cases.

"New Three-Color Process," *Kinemat. Weekly*, **155** (Jan. 9, 1930), p. 25. Describes Horst system in which three pictures are exposed simultaneously with the aid of a prism arrangement. In the positive each frame carries three images.

Two-Color Additive Processes

FRIESE-GREENE, C. H.: "The Friese-Greene Color Process," *Phot. J.*, **49** (1925), p. 487.

FRIESE-GREENE, C. H.: "Color Cinematography by Photographic Impression," *Bioscope Sup.*, **67** (Apr. 29, 1926), p. III.

MARTIN, K.: "The Color Film of E. Busch Akt.-Ges. in Rathenow," *Phot. Korr.*, **63** (Jan. 1, 1927), p. 12.

BOURQUIN, H.: "New Film in Natural Colors," *Der Bildwart*, **5** (July, 1927), p. 432. Alternate pictures dyed red and green.

LEHMAN, E., AND KOFES, A.: "Possibilities of Two-Color Photography," *Kinotechnik*, **9** (Aug. 5 and 20, 1927), pp. 397 and 428. Comparison of additive and subtractive processes.

NAUMANN, H.: "The Busch Two-Color Film in the Service of Medicine," *Phot. Korr.*, **65** (April, 1929), p. 117.

STEINER, J.: "Color Cinematography according to H. May's Process," *Phot. Korr.*, **65** (May, 1929), p. 149. Rotating sector wheel used before the camera and projector.

TIETZE, P.: "An Apparatus for Color Cinematography for the Purposes of Medical Instruction," *Internat. Review Educational Cinemat.*, **1** (Sept., 1929)

p. 270; also *Kinotechnik*, **11** (Feb. 20, 1929), p. 99. A description of the Busch process.

EGROT, L. G.: "Raycol Process," *Kinemat. Weekly*, **152** (Oct. 10, 1929), p. 63. Two images are exposed simultaneously by means of a prism beam splitter. Images occupy diagonally opposite corners of a standard frame and are one-quarter normal size. The black and white positive is projected through a special lens system which superimposes the images on the screen; only one image (the red sensation) is projected through a filter, the other being projected in black and white.

EGROT, L. G.: "Busch Color Process," *Kinemat. Weekly*, **152** (Nov. 7, 1929), p. 52. Film runs horizontally through a camera fitted with a prism beam splitter. Images are one-half normal size, one above the other on each standard frame. Images are projected through separate lenses and appropriate filters, and are superimposed on the screen.

Three-Color Subtractive Processes

"Thornton Three-Color Cinematography," *Brit. J. Color Sup.*, **20** (Feb. 5, 1926), p. 8; also *ibid.* (July 2, 1926), p. 28.

BENNETT, C. N.: "Zoechrome," *Bioscope*, **72** (Aug. 11, 1927), pp. 9–10; also *Kinemat. Weekly*, **132** (Mar. 21, 1929), pp. 69–70. Every other negative frame is a regular black and white exposure; alternate frames have three small pictures ($^3/_4$ standard size) exposed through red, blue, and yellow-green filters. Black and white negative printed and developed; film varnished and recoated with emulsion; each small image printed in register and dye toned.

"The New Three-Color System," *Kinemat. Weekly*, **144** (Feb. 21, 1929), p. 58. Describes Splendicolor Process.

Two-Color Subtractive Processes

RIGHTER, F. L.: "Chemical Engineering and the Motion Picture Industry," *Chem. Met. Eng.*, **32** (July, 1925), p. 627. Describes Technicolor Laboratories in Hollywood.

"Two-Color Cinematography by Metallic Toning," *Brit. J. Color Sup.*, **19** (Nov. 6, 1925), p. 43. Describes Kelly-Color Process.

EVELEIGH, L.: "Technicolor," *Bioscope Sup.*, **66** (Jan. 21, 1926), p. III.

IVES, F. E.: "Subtractive Color Motion Pictures on Single Coated Film," *Trans. Soc. Mot. Pict. Eng.*, No. 25 (1926), p. 74. A review of several processes.

KELLEY, WM. V. D.: "Imbibition Coloring of Motion Picture Films," *Trans. Soc. Mot. Pict. Eng.*, No. 27 (1926), p. 238.

"Technicolor Films and Their Projection," *Bioscope*, **81** (July 17, 1926), p. 189.

NAMIAS, R.: "The Application of the Two-Color Process to Cinematography," *El. prog. fot.*, **8** (May-June, 1927), pp. 103 and 132.

KNOCHE, P.: "New German Two-Color Films," *Kinotechnik*, **9** (Nov. 20, 1927), p. 596.

IVES, F. E.: "Something More about Progress in Subtractive Process Cinematography," *Trans. Soc. Mot. Pict. Eng.*, **XI**, No. 30 (1927), p. 211.

JONES, L. A., AND TUTTLE, C.: "The Reproduction of Mobility of Form and Color by the Motion Picture Kaleidoscope," *Trans. Soc. Mot. Pict. Eng.*, **XII**, No. 33 (1928), p. 140.

"Polychromide Color Process," *Bioscope*, **77** (Oct. 17, 1928), p. X. Describes Hamberger's process.

"Pathéchrome Process," *Ex. Herald-World*, **93**, Sect. 1 (Nov. 24, 1928), p. 34.

"Color Camera Making Rushed to Get Set for Increased Use Next Season," *Ex. Herald-World*, **96** (July 6, 1929), p. 70. Describes new two- or three-color Technicolor process; also some data on Pathéchrome process.

"Sirius Color Film," *Licht Bild Bühne*, **22** (Aug. 17, 1929), p. 14. Two-color negatives exposed with the use of a prism beam splitter system. Positives printed on opposite sides of double coated film and pictures are dye toned.

CRESPINEL, W. T.: "Illustrating Multicolor," *Internat. Phot.*, **1** (Aug., 1929), p. 30.

BROWN, G. B.: "Color Camera Outdoors," *Internat. Phot.*, **1** (Sept., 1929), p. 34. Describes the making of an all outdoor picture by the Technicolor Process.

STULL, W.: "Multicolor Introduces Improved Color Film," *Amer. Cinemat.*, **10** (Dec., 1929), p. 9.

FOX, D.: "Ninety Million Feet of Color Photography Set as Color Craft Yearly Output," *Ex. Herald-World*, **98** (Jan. 4, 1930), p. 26. Two negatives used emulsion to emulsion in exposing film and double coated positive film for making the prints which are subsequently dye toned.

BAKER, J. L.: "Color of the Future," *Internat. Phot. Bull.*, **11** (Feb., 1930), p. 13. Describes Photocolor process. Negatives are made with a twin lens camera and positives are dye toned on double coated film.

PECK, A. P.: "Movies Take on Color," *Sci. Amer.*, **142** (Apr., 1930), p. 285. Short illustrated article on Photocolor process.

"Report of the Color Committee," *J. Soc. Mot. Pict. Eng.*, **15** (Nov., 1930), p. 721. Describes Colorcraft, Multicolor, Harriscolor, Technicolor, and Sennettcolor processes.

AN ENTERTAINMENT CITY*

ALFRED N. GOLDSMITH**

Summary.—*The development of sound motion pictures, utilizing electrical reproduction of sound, has caused a convergence of the technic of radio broadcast transmission and reception and the technic of the sound motion picture studio and theater. The approaching advent of home sound motion pictures and television broadcasting may be expected to bring the engineering methods still closer together.*

Paralleling this engineering approach, there are indications of a similar and coöperative integration of the corresponding industries. The establishment of a great entertainment center in New York City, based on this evolutionary plan, is described in the paper. In this "Entertainment City" are to be combined radio broadcasting studios, recording facilities, auditoriums, executive offices of corresponding entertainment enterprises, and a group of large theaters and concert halls of various types.

The scope of a great industry tends ever to broaden. To this rule, the motion picture industry is no exception. It is being brought into touch with industry through the industrial picture, with the school through the educational picture, and with the home, through the rental library of entertainment films. And now contact has also been established between motion pictures and radio, through the laboratory development of television. It seems as if a considerable portion of the telephone and television programs of the future will originate on sound motion picture films, thus opening a great new field for the motion picture industry. Coöperation between motion pictures and radio has already led to one concrete plan of amazing magnitude in which these arts will be developed and exhibited in a "city" to be shortly created.

New York, within a few years, will be the proud possessor of a city within a city, popularly called the "Radio City." This city—a great community dedicated to the thought that the appreciation of art dwells in the people, and that the mass dissemination of art, education, and entertainment, is one of the greatest constructive functions of a modern democratic civilization—will rise in the center of New York.

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* (Abridged.) Presented at the Fall 1930 Meeting, New York, N. Y.

** Radio Corporation of America, New York, N. Y.

The public is already aware of the group of organizations and leaders of thought associated in this enterprise. This assembly of gigantic buildings, with private streets, plazas, transportation facilities, and similar features, is to be erected through the planned coöperation of Mr. John D. Rockefeller, Jr., and the Radio Corporation of America and its subsidiaries. The group of companies involved will have their headquarters in these buildings, and there will be an unprecedented concentration of facilities for the dissemination of sight and sound by radio and by record—through the air, the film, and the disk.

In the new Entertainment City, the plans of which can now be more readily considered, Radio Keith Orpheum will have a sound motion picture theater, variety theater, musical comedy theater, and a dramatic theater. The National Broadcasting Company will have studios adapted for service to its radio networks. The RCA Victor Company and RCA Photophone will have auditoriums, projection rooms, and other facilities necessary for sound recording for home and theater, respectively. Various miscellaneous radio and sound recording and reproducing facilities will exist, in addition to, perhaps, a great symphony hall, in which concerts by leading orchestras may be given to the public, not only by broadcasting, but to an actually present audience.

In this group of buildings there will be concentrated facilities for radio telephony, radio facsimile, radio television, and the recording and reproduction of sound and pictures.

A city of this sort must rest on a solid scientific foundation. Back of its activities must be research men, investigators, development engineers, and extensive laboratories. The products of the toil of all these men are necessary to keep such a city in the forefront of artistic as well as scientific progress. The coördination of science and art toward a single aim—the welfare of mankind—will be illustrated in an unusually fine form.

As a sociological experiment, it is believed that the Entertainment City will be watched with close attention by careful students of public affairs. Through the Entertainment City the artists may spread their inspiration before the multitude for acceptance or rejection, as the world may determine. Artists whose wage is too high for the entertainment of small audiences, artists of difficult temperament or with an aversion to travel, artists, who, for all the usual reasons would be unavailable to the majority of the people, may

reach the individual in any part of the nation. The Entertainment City may, in fact, serve as a model of an artistic and cultural nucleus for many of the cities of the future. What the effects of such a project will be on architecture is a fruitful subject for speculation. As time goes on, the world's workers will presumably find increasing leisure. The successful utilization of leisure is a major problem, toward which the Entertainment City contributes at least a portion of the answer, in addition to contributing to the general cultural level of the people.

Doubters will ask whether humanity can indeed assimilate and appreciate all that will be offered to it. Presumably we must not look for a Utopia of today and tomorrow. However, unless human evolution and progress are the pathetic dreams of self-deluded weaklings, a community of art serving the planet and the nation will be in considerable measure constructive and helpful, uplifting and inspiring to the people of the world.

We of today can hardly judge the full meaning of the City of Art. Looking backward a century, the historians of a hundred years later will understand better than we of today, how basic a step has been taken. Perhaps there are giants among us in these days as in the past. Romance, determination, and courage are not dead when such a project can be brought into being. New frontiers of achievement glow before the founders of the Entertainment City to inspire them to push onward in this great experiment to which they have dedicated their best effort.

Such a project should hold the attention of all of us who are motion picture engineers. As scientists and engineers, we are giving our best to the service of humanity. Ours is not the reward of fame, with its flaming letters of light in a thousand cities. Ours is not the recompense of fabulous wealth which is lavished on the studio favorites of the nations. But better yet, and of far more enduring worth, is our opportunity, through wisdom and skill, through continued intelligent and directed work, to be at once the true servants and the inspired leaders of humanity—to bring joy into countless lives through our toil and through our effort, in the truest and finest sense, to help a grim and saddened world, and "to brighten the corner where we are."

BANQUET SPEECHES

PRESENTED AT THE SEMI-ANNUAL BANQUET OF THE SOCIETY HELD AT THE HOTEL PENNSYLVANIA, NEW YORK, N. Y. OCTOBER 22, 1930

PRESIDENT CRABTREE: Our Society chose to convene in New York City this fall with the deliberate object in view of effecting a closer relationship between ourselves and those who are producing motion pictures. New York City is destined to become increasingly important as a production center and it is to the interest of our members to become as fully acquainted as possible with the problems of the producers. On the other hand, it is to the interest of the producer that he keep abreast of the achievements of the scientists and technicians, who, in the first place, made motion pictures possible, who made the shadows talk, and upon whom the industry will have to rely to an increasing extent to feed the insatiable appetite of the public for something different in entertainment.

Our Society was founded in 1916 by Mr. C. Francis Jenkins of Washington, D. C., with three objects in view: (1) the advancement of motion picture engineering and the allied arts and sciences; (2) the standardization of the mechanisms and practices employed in the motion picture industry; and (3) the dissemination of scientific knowledge by publication. The new Society began to hold semi-annual conventions, at which technical papers were read and discussions invited, and this scientific information was published in the quarterly *Transactions* of the Society. These appeared in unbroken succession until January, 1930, when they were superseded by the monthly JOURNAL.

Our Society contains about 1000 members having diversified interests and qualifications, including research scientists from the universities and industrial research laboratories, practical engineers from the factories, studios, laboratories and theaters, and executives from all branches of the industry.

I am afraid that the term "engineer" has, in the past, frightened a number of otherwise eligible persons from joining our Society. We

interpret the word to apply to anyone who contributes to the building of a motion picture, so that there is no reason why those who contribute literary, dramatic and artistic talent should not become members of the Society, as well as those who direct the business of production and distribution of motion pictures.

Few persons realize the complexity of the motion picture organism, which is dependent for its existence on more of the arts and sciences than any other industry with which I am acquainted. No artistic conception of author, dramatist, director, or actor can be given to the public through the medium of the motion picture except by the application of chemistry and physics which, in turn, embrace heating, lighting, acoustical, mechanical, and electrical engineering. The manufacture of the film itself requires a knowledge of all these sciences as well as a knowledge of the nature of light. The cameras, arc and camera silencing devices, lighting and sound recording equipment used in the studios, and even the make-up for the actors, are the result of the combined efforts of almost every type of engineer and research worker in existence today. The development of the film in the laboratories to produce images in black and white and in color was made possible by the concentrated efforts of chemists and physicists. It is only as a result of intensive effort on the part of the research laboratories devoted to photography that it has been possible within the past year to develop the film with the scientific precision necessary for sound films. The construction and use of the machinery for projection requires the application of mechanical, electrical, and optical principles, while the modern theater is a scientific structure requiring the application of all the above sciences, including acoustical engineering.

In such a complex structure involving so many personalities, it is necessary that all the component parts should work in harmony. Those concerned with artistry should encourage the research and progress which is necessary to present their art most effectively to the public, while the engineer should remember that his instruments are only a vehicle for presenting the creations of the artist to the audience.

Membership in our Society is of four types: Associate, Active, Sustaining, and Honorary. Any one who is interested in motion pictures is eligible for Associate membership. Active membership is granted to those who have gained distinction in their particular field of endeavors. Sustaining members are those who contribute

substantially to the support of the Society, while Honorary membership has been granted to those scientists of international fame who, by their inventions and achievements, have been largely responsible for the building of this great industry.

Committee work is the backbone of the activities of any technical society. Our standing committees are composed of the best experts in their particular field, and deal with Color, History, Progress, Projection, Sound, Standards, and Theater and Studio Lighting.

We have local sections in New York, Chicago, London and Hollywood which foster a spirit of coöperation among the members who cannot always attend conventions of the parent society. The Hollywood section keeps the parent body in touch with production activities on the West coast and maintains contacts with the Academy of Motion Picture Arts and Sciences.

We are proud of our accomplishments during the past fourteen years. Our *Transactions* and JOURNAL represent the most comprehensive source of motion picture technical information in the world. The potential value of this knowledge to the industry is incalculable and the actual cost of the research work required to obtain it amounts to billions of dollars. It may be of interest to note that the advantages of optically reducing a picture on wide film down to 35 mm. film were outlined and practically demonstrated before our Society and recorded in our *Transactions* in the year 1924.

The bi-annual report of the Progress Committee gives, in condensed form, the essential technical developments in the fields of production, distribution, and exhibition throughout the world. The Society, through its Standards Committee, has made possible the interchangeability of the essential parts of apparatus throughout the industry and has published details of these in booklet form in collaboration with the American Standards Association. The Society has also collaborated with the British, French, and German technical societies on all matters relating to standards.

The specific problems of the producer have also received their fair share of attention. Improvements in microphone placement, the increasing use of single microphones, remote control, and methods of dubbing have resulted in many cases from the stimulation of ideas received from discussion at the Society meetings. The Studio Lighting Committee has assembled information on the use of exposure meters in the lighting of sets, and tests to date have indicated that a con-

siderable saving of electrical energy would result from the intelligent use of photometers.

The most outstanding efforts of the Society in relation to production have been an attempt by the Standards Committee to arrive at a standard for wide film.

It is quite generally agreed that placing the sound track on the present 35 mm. film results in a picture having undesirable proportions. When these proportions are corrected by masking the height, the smaller picture area requires greater magnification of the film in order 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, 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. Simultaneously with the general introduction of sound has come a desire on the part of the industry for a large projected picture which will include more action. Although several methods have been suggested for the realization of large screen pictures using the present 35 mm. film, the committee feels that none of these methods offers a permanent solution of the problem. At the present time, the only satisfactory method of obtaining a large screen picture having a width of 30 to 40 feet seems to be through the use of a wider film.

In considering a new standard for wide film 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, the Standards Committee has recommended 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 of Motion Picture Arts and Sciences, with whom the matter will be discussed further.

Having established a maximum height to width ratio for the picture frame, it is necessary to decide on the minimum width of film necessary to insure good sound and picture quality. Anything wider than this minimum would be an economic waste, which must be prevented at all costs.

During the deliberations of the committee, 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. The committee is working on a layout that will permit the use of 1.8 to 1 ratio and provide for a wider sound track with more suitable margins, and is attempting to assign dimensions to this film that will permit the most economic use of existing 35 mm. equipment.

While the specifications of the release print dimensions is the problem of most importance, the Standards Committee has under consideration a negative of such proportions that it may be printed by optical reduction on to 35 mm. film or on the new intermediate film or by contact on a large film for *de luxe* houses.

During our technical sessions consideration was also given to the various advantages and disadvantages of placing the picture and sound record on separate films. From the discussion it was revealed that such a procedure may ultimately be desirable and even imperative. Such a step, however, would not involve scrapping present equipment, but would necessitate additional mechanisms.

But how can better coördination between ourselves and the producers be assured? The Technicians Branch of the Academy, sponsored and subsidized by the production interests, is coördinating technical effort in Hollywood, disseminating technical knowledge by publication, and standardizing practices. The standard release print is a worthy accomplishment. The Academy and our Society must work more closely together to insure a minimum duplication of effort.

Our Board of Governors has approved that a section of our JOURNAL be reserved for a digest of the activities of the Technicians Branch of the Academy, and has authorized me to discuss with the Academy, ways and means of effecting further collaboration.

To date, however, the Academy has been concerned with practical application and not with pure research, which, as I have pointed out, is vitally necessary for the future growth of the industry. We need more research, more laboratories, more man power trained in thinking scientifically. Before the problem of television is solved, so the picture becomes large and clear and rendered in color like the present picture in the theater, some new fundamental scien-

tific discovery will have to be made, and even then the problem will be solved only by the combined efforts of many workers. It is to the interest of all branches of the industry to encourage and to contribute financially, to insure a steady flow of new fundamental discoveries.

You producers can contribute to the welfare of our Society and the industry by intensifying your interest in technical matters, by encouraging your employees to become members of our Society, to subscribe to our JOURNAL, to take an active part in Society affairs, and to permit them to spend a portion of their working hours in the interests of our Society. The slight expense involved in sending representatives to our conventions will be repaid a hundred-fold by virtue of the stimulation of ideas in your personnel. These men will make new friends and get in touch with experts who are ready at all times to aid in solving your individual problems, either by correspondence or by personal contacts, and their value to you will be enhanced accordingly. The usefulness of the Society in this respect, like that of a telephone exchange, increases as it grows in size.

You can also coöperate in a practical way by becoming sustaining members of the Society. To date, all executive work has been carried out voluntarily by Society members employed by certain of the large manufacturing organizations, but each concern should shoulder its fair burden. With the aid of paid executives it will be possible to widen the field of usefulness of our Society to the industry by serving as a clearing house for motion picture engineering data, by expanding the work of standardization, by maintaining closer coördination with allied technical and scientific organizations, and by assisting in the establishment of courses in motion picture engineering in some of the Eastern universities, thereby helping to fill the ranks of the producers with trained employees and potential executives having an adequate grounding in fundamental principles.

We must not lose sight of the fact that the main problem of the producer of motion pictures is one of *dramatics*—he is constantly striving to incorporate in that small film image the intangible something which will tickle the emotions of the theater patron. The public is always looking for something new and different; since the drama has changed very little in the past three hundred years the producer must depend more and more on the engineer to add novelty to his presentation.

We engineers realize that the quality of the sound as reproduced

in the average theater must be improved if the public is to remain interested. The quality of speech is satisfactory, but that of music leaves much to be desired. The public has become educated to the finer points of musical quality as a result of better radio reception. We must keep ahead of this standard of public appreciation if the sound is to provide a sufficient emotional stimulus. However, with existing film and equipment it is possible to record and reproduce sound with a much greater degree of realism than is manifest in many theaters today. The remedy for this is the education of all those responsible for the handling of the film, not forgetting the theater manager.

No effort must be spared to improve sound quality even if this requires wider film or involves placing the sound record on a separate film. As compared with a train load of impedimenta required to stage a traveling dramatic show, what does it matter if an extra projection machine, an extra film, or an extra projectionist be required to insure the utmost in entertainment? The industry must face the fact that it will constantly have to improve the various mechanisms employed, if the interest of the public is to be maintained.

We, the members of the Society of Motion Picture Engineers, pledge ourselves to give increasingly of our services and knowledge, with a view to adding realism to the motion picture, thereby contributing to the education and enjoyment of the theater patrons throughout the world.

I have tried to stress the importance of research. We are now to hear from a member of our Society, the vice-president and general engineer of one of the large organizations which is concerned not only with the production, but with the exhibition, of motion pictures—Dr. Alfred N. Goldsmith, Vice-President of the Radio Corporation of America.

DR. GOLDSMITH: One of the first researches, perhaps the greatest research, carried out by mankind, occurred when some primitive individual stuck his fingers into a yellow flame which had somehow been produced, and withdrew them with a howl. He had a sense of curiosity—which was unpleasantly gratified. Nevertheless, protection against wild animals, and cooked food were the first results. The further results during the millennia which have passed since that memorable day fairly stagger the imagination by their importance.

Presumably it is fair to state that man and his lowly cousins, the apes, are distinguished from the rest of the animal kingdom by an amount of curiosity which is sometimes rather unhealthy. Men and monkeys get into all sorts of difficulties by trying this and that—by "monkeying with it," as we say. Nevertheless, men accomplish a great deal in just this way. Curiosity is perhaps the greatest single force in the advancement of mankind and has done more to contribute toward the evolution of science, engineering, and industry in general than any other single factor.

The great creed of industry today has two sections. The first of these is, "study the possibilities." The second one is, "try them out." Each of these involves research. Research is simply *organized curiosity*. Research may be scientific or it may be industrial, but it is research just the same.

Modern research differs from the earlier random and haphazard experiments in that it is in general more definitely directed and far better organized. If one carries out research on almost anything that happens to pop up in one's head, one may hit a desirable target perhaps once in a million times, but if research is intelligently directed along apparently promising lines, one may hit the target once in a hundred times—and this is about the "batting average" of a succcessful research man.

The careful organization of research and the provision of suitable equipment and favorable surroundings are extremely necessary. Trying to think things out in a garret without any equipment while freezing to death is all very well in its way. It is a romantic and picturesque procedure (at any rate for the people who read the life story of the dead inventor). But providing a large staff of highly skilled men for research, and supplying them with proper quarters and modern apparatus is much more likely to lead to early and worthwhile results.

Industry ever develops from the simple toward the complex. Its scope first extends from a mere locality to a city, then to a state, a nation, and finally to the entire world. It cannot meet the pressing needs of mankind on such a vast scale except through unremitting toil in the finest laboratories. Pure scientists, application engineers, and commercial investigators are clearly a part of the successful business structure of the present and future. Industry will encourage research lest it stagnate and perish. The specter of obsolescence always faces the industry that does not enthusiastically foster research.

Much has been achieved in the motion picture field through research up to the present, but far more astonishing possibilities, in a multitude of new directions, shine brilliantly before us, awaiting only the skill of the research specialist to bring them into the world of actual things. Men will continue their everlasting battle against ignorance. They will gather, as the fruit of their toil, the precious knowledge which is power. Modern machinery will release them from excessive toil, and the future entertainment devices, which will use scientific methods to get artistic and entertaining results, will brighten their hours of leisure. Through research, men arrive at the truth concerning nature and bend natural forces to their will. Through research there will be fulfilled the ancient prophecy: "For ye shall know the truth, and the truth shall set ye free."

PRESIDENT CRABTREE: We all like to know what the other fellow is doing. The Vice-President of our Society recently returned from England and I am sure our producer-guests would like to hear some of his impressions—Dr. K. Hickman.

DR. HICKMAN: Mr. President, Ladies and Gentlemen, and Distinguished Guests: We are here tonight to honor the producer. The other speakers will tell you of the many wonderful things the producer has accomplished in the last thirty years; I will relieve the dull monotony of praise with the mildest of mild criticisms.

What has the producer accomplished in sound, for instance? We can remember going to the movies twenty years ago and hearing the tinkling of a piano, to which tune Bronco Billy lassoed a bucking steer. At the end of each reel the tinkling stopped, the couples in the back row unclasped, the lights went up, a brief pause, and then more picture and more tinkling. Even in those early days, music was recognized as an essential part of the presentation.

From the tinkling piano we graduated to the trio, to the orchestra, to the full symphony orchestra, and now, in the fullness of time, to that magnificent achievement, "sound-on-film," where the musical art of four hundred years is crowded into a strip one-eighth inch wide and the art of thirty years occupies a full inch, and the scientist-producer is proud. But why stop there? You have brought the symphony concert to the movies—why not the movies to the symphony concert? That would be doing a real service to humanity.

The ideal music for a picture has been described as pleasant to the ear but having no definite theme to distract the mind. I suppose

the ideal picture for a classical concert would be pleasing to view but have no story to claim the attention. You will agree with me that research is hardly necessary here—just use any current release.

Just another thought before I sit down—how about giving the poor public the right of choice? When you enter a shop to buy socks you can weigh your money in one hand and size up the socks with the other, and take the variety you want. When we enter a theater you take our money at the door, and if afterward we don't like the show there is nothing we can do about it but stare at the ceiling. With the picture growing larger month by month there is less and less of the theater left to test one's eyes. If you had your patrons' welfare really at heart you would provide a different show at each end of the house, and swivel chairs, and let the social consequences take care of themselves.

PRESIDENT CRABTREE: We shall now hear from the man who directs the operations of the largest research laboratory in the world, Mr. H. B. Charlesworth, Vice-President of the Bell Telephone Laboratories, Inc.

MR. CHARLESWORTH: I simply want to say how pleased I am to be with you tonight and that our organization has been glad to participate in the deliberations of this Society whose work is so far-reaching and important in the industry. We all know what an important part research is playing in industry. The time has long since passed when a cut and dried method is going to carry us through; how true that is of the motion picture industry, which is concerned with so many elements requiring fundamental research for their solution. We are glad to have had a part in the development of the motion picture industry and hope that we shall contribute our full share to its development in the future.

It would be only repetition to outline some of the interesting problems before us. We know that future progress will be bright, and I shall not take further time to deliberate about it. I thank you for the privilege of being with you.

PRESIDENT CRABTREE: Our next speaker is known to all of you. I venture to say his name is known to every man, woman, and child in the country. He wields a guiding hand over the destinies of this industry; he is not unmindful of our activities, as manifested by the stirring speech he made at our last convention. He has kindly

consented to introduce the various producers and guests this evening—Mr. W. H. Hays, President of the Motion Picture Producers and Distributors of America, Inc.

MR. HAYS: In a world where industry literally must keep its eye on the keyhole of the laboratory if it is to endure, and where what happens in a test-tube may very probably entirely obliterate the art and put a new one in its place, I don't have to emphasize the importance of your activities to the motion picture industry. It is a great satisfaction to be able to contact with those whose business, mainly precise discovery, is not affected at all by what may be the psychological condition of a people and an imaginary or so-called depression which appears to be upon us.

I was very interested in the speech by your Vice-President. He spoke of the "tinkling" which has always been with the movies. About twenty-five years ago that started. A merchant from a small town in Wisconsin walked into a theater somewhere in a side street in Chicago, saw a flickering shadow and was enamoured of it. He borrowed money on his little store and came back and bought that little motion picture theater. He then hired a little boy to play the piano and do the "tinkling" before and after the picture. As he sat and sold and took tickets most of the time, he watched the effect of the music on the audience—this is a true incident. After one show, he suggested to the boy at the piano: "At the next show 'tinkle' the piano during the picture and see what happens." The boy did so, and that was the first time that music accompanied a picture. That merchant was Carl Laemmle and the little boy was Sam Katz.

My appreciation of the moment is known to you all; my function is to present these gentlemen who are here to join with me in this appreciation. The first one is not only a ranking officer in a company, but is in charge of all its product; he has the soul and vision of an artist, and his great achievement has been to lead the way in raising the standard of our motion pictures—Mr. J. Lasky, Vice-President of Paramount.

MR. LASKY: Mr. President, Ladies, and Gentlemen: When I was a small boy I had several ambitions: first, to be a fireman; second, to be a soldier; third, to be a sailor; and the other, to be an engineer; but until now I have never attained the ambition of being an engineer. After hearing the remarks of your President, however, I find I am an engineer. Just imagine wishing for something you had all the

time and didn't know it! I want to come into the Society as a member so that I may have that distinction.

It is a great source of comfort to the producers to know that the Society is existing and how vast is the great work you are doing. However, let me confess once more. One of my greatest worries was the coming of sound into the movies. I didn't believe in it and thought it would never arrive. I used to say it couldn't be done, and used a thousand arguments that now seem ridiculous. Every night we were faced with a problem I shall never forget, of turning ourselves inside out to adapt ourselves to this medium. The best thing seemed to be to retire; I am ashamed to say so now, but my first impulse was to quit. Thanks to the engineers and the gentlemen who give their lives to research and to science and all that it means, we poor humble followers did catch on and thank God for the sound and all that it means, and this time I don't care what you see in the future, I am for it and if I am alive I won't quit!

MR. HAYS: I have repeatedly said that no story on the screen is half as interesting as the screen itself; it is particularly true of sound pictures. At the meeting which President Hoover held in Washington last winter, he said that nothing had happened in industry more remarkable than how motion pictures had changed in a year and a half—in almost a step. It is marvelous how industry adapted itself to it.

The next introduction—how we made from an admiral, a great executive—the shot that sounded around the world was a pin drop compared to the development of sound on the screen, and most potent in that was Mr. J. E. Otterson, President of the Electrical Research Products, Inc.

MR. OTTERSON: Mr. Chairman, Ladies, and Gentlemen: In my short connection with the motion picture industry, I have been less concerned with the "tinkling" that went on in motion pictures twenty-five years ago and more concerned with the "tinkering" that is going on now. It is necessary for the artistic effect of motion pictures that the process by which the result has been attained should be concealed. Due to this fact, I would say that the work of the engineer, as well as the motion picture industry of the future, lies in concealing the fact that an engineer has anything to do with motion pictures—to bring about such a natural effect that the public will not associate with it any mechanical or engineering process.

MR. HAYS: The next presentation is the President of the Amkino Corporation of America, Mr. L. I. Monosson.

MR. MONOSSON: It gives me great pleasure to say a few words about the relation of the Soviet cinematography to the American motion picture industry. Of course, our technical achievements at the present time are very small, but the American industry is thirty years old and the Soviet is only ten or twelve years old—even less. We are very young, and this may be the reason why our achievements are so small. For this reason we look to the motion picture engineers in America for help. Technical language is the same all over the world, and this may be the reason why the first contact with the Russian motion picture industry was made through the American Society of Motion Picture Engineers.

MR. HAYS: The next presentation—Mr. George E. Quigley, Vice-President of the Vitaphone Corporation.

MR. QUIGLEY: I am a little fearful that I talk like a Vitaphone. I shall content myself with an expression of the pleasure I have of being with you.

MR. HAYS: The next presentation is Mr. H. G. Knox, Vice-President of the Electrical Research Products, Inc.

MR. KNOX: As an engineer, I suppose I am in order in saying that the technical developments in the next year will be more startling than in the past. The work of Electrical Research Products is coördinated, and we are working in the closest possible way with the producer. We expect, with regard to the part that sound plays in motion pictures, that in the next two years we will have relative perfection. That will be accomplished with no more complicated apparatus, and the producer and the audience will get the benefit of this improvement in sound quality.

The only message I have tonight is to assure the members of the Society of our willing assistance in help to solve the problems of sound pictures.

MR. HAYS: The next introduction is the Vice-President of RKO, Major L. E. Thompson.

MAJOR THOMPSON: I am as much out of place in this gathering as a cat in a strange garret, because I happen to be the only member

of the Theatre Operating Commission. This seems to be a case of the engineer and the producer out to do the theater. I have heard a lot about the "tinkling"—it was fine, it was cheap, and as the tinkling developed we got sound, but we got a bill with it. Out in front of every theater there is a little coop, sometimes with a girl in it; but everybody is doing the same thing—selling tickets—and it is this that keeps the producers and the Society in business.

I just want to leave one thought with you—that in all this research work that you are going to do, I hope you do a lot and that it brings forth benefits for the theater; but when you do it, try and figure some way of keeping the expense down because the box-office is on its last legs.

MR. HAYS: The next presentation is Mr. Paul Gulick, publicity director of Universal.

MR. GULICK: Personally, I am very glad to meet face to face the gentlemen who caused the revolution in the motion picture business. You don't look revolutionary to me; you are able spokesmen and leaders; you have talked rationally and seem to formulate plans which will be helpful.

My business is that of press agent, and it is my business to make people like the pictures and pay at the box-office that Mr. Thompson told you about. I have never had any ability to become an engineer. The only accomplishment I have attained is to get my name mentioned on the program tonight so that I can tell my wife where I have been.

MR. HAYS: The next, my friends, is a very great artist and most distinguished international representative of this great business, Mr. Serge Eisenstein, the director who is here from Russia.

MR. EISENSTEIN: Mr. President, Ladies, and Gentlemen: I don't like to make speeches. Please don't mind if my speech is bad; my feelings are not—I am smiling.

You know, everybody asks the employees if they like the boss, "Hollywood." The joke of that boss is that it will not smile. When you visit Hollywood you are shown the marvelous installations and the results of research, and at the end you are always invited to look at the pictures. The differences between the technical and artistic accomplishments are tremendous. I don't want to say that the pictures are not good, but behind the screen production, from the

artistic point of view you feel the lack of research such as is behind every engineering achievement. When I arrived in Hollywood I wanted to know: "Is there a university or high school of motion pictures?" And I received the answer: "No, there is not; the business developed so quickly—but we can have everybody outstanding on Broadway for our business; we can have the best singers and artists so we don't need a university." Now, I think that is not the way to insure a really great development in art, and when we see such remarkable results on the technical side, it is because there is a scientific basis for them. I will say that you have some scientific organizations which work on this subject, such as Harvard and Yale. I had the honor of speaking in both places and saw what use is made of research there, but it is almost nothing. They are occupied with the theater drama, and I think that these universities, isolated as they are from the real motion picture business, can never provide the producers with the knowledge they must have. The only institution which approaches what I have in mind is the Academy of Motion Picture Arts and Sciences. I want to say in leaving, that the greatest thing to be accomplished for the future of the motion picture business is the foundation of a high school or university for research on the artistic side.

MR. HAYS: The next and last: A recent graduate of the University of Southern California, who has come to New York on a visit, who is incidentally the star in a very great new picture which I have thought enough of to see twice in the projection room, whose shooting is as straight as his love is charming—Mr. John Wayne.

MR. WAYNE: I want you all to know that I consider it a very great honor to be presented here to people who are creating and aiding in the adjustment of our industry. This occasion recalls to mind the words of my partner in the picture, *The Big Trail*. One day we were watching the movements of the wagons, horses, and cattle in the picture and he said, "We actors are like that; we are driven and shoved, we don't know where." It is you people who are giving us something to work with, and I hope everything is going to be "ok" with sound.

MR. HAYS: Mr. President, I have finished the task of introducing these gentlemen as you requested, and I close as I began: I give you these lines in all earnestness: For those who take the helm of leadership there is no stopping on the road of scientific and technical

progress. One makes way for another. A true art form is a living, growing thing. You have learned to trust the courage and willingness of the industry and to go ahead; the industry, in turn, has learned to look to you with confidence for 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.

PRESIDENT CRABTREE: After hearing all these eulogies, we realize more than ever our great responsibilities. Knowing that the eyes of the producers are focused upon us, we shall go back to our laboratories and workshops better prepared for greater accomplishments.

COMMITTEE ACTIVITIES

REPORT OF THE THEATER LIGHTING COMMITTEE*

In a previous report the theoretical aspects of good illumination in theaters were discussed. These included visual acuity and comfortable vision. The former is improved by higher screen brightness and lower auditorium and screen illumination levels, and the latter by low contrasts between the picture and its surroundings and a higher order of room brightness. Since the committee's previous report, brightness and illumination tests have been made in a group of theaters especially selected for poor and good lighting conditions, for the purpose of combining visual observations with measurements, so that such measurements could later be interpreted for the benefit of theater managements, architects, and others. A test procedure was drawn up, covering the essential points reported on previously and other considerations developed later by the committee. Briefly the survey program covered the following points:

1. An estimated quality of the projected picture by a number of observers with especial reference to visual acuity and comfortable viewing over an appreciable period of time.
2. Brightness and illumination measurements of the screen, its surroundings, and various parts of the auditorium, noting the placement of light sources and their effect on visibility of the picture.

About thirty theaters were given a preliminary survey and of these seven were given a thorough study. An analysis of the data obtained shows that with the screen brightness ranging from 2.5 to 10 millilamberts, there is no evidence of discomfort due to too great contrasts, even in houses almost totally dark. Brightness below about 3.0 millilamberts was unsatisfactory due to the reduction of visual acuity. In one theater having a screen brightness of about 9 millilamberts an impression of too high illumination was obtained. This seemed reasonable on account of the smallness of the house—800 seats capacity. In the other 800-seat houses, in which visual acuity was satisfactory, the screen brightness was only about 3 millilamberts.

* Presented at the Fall 1930 Meeting, New York, N. Y.

In none of the theaters was there sufficient stray light to appreciably affect the picture. Measured values were less than 0.01 millilamberts, and in none of the seven were the contrasts in the picture too great. While black velvet was used to surround the screen in some of the theaters where good visual comfort was obtained, these houses were relatively narrow; where gold, yellow, or similar hangings were employed, with higher brightnesses of about 0.05 millilamberts, the conditions were quite comfortable.

In this connection it is interesting to note that it is common practice to "screen" the pictures at the producers' studios with relatively high screen brightness and short observation distances, and to judge the contrasts and densities of the printed film by observations made in this manner. Such conditions do not represent those obtaining in the theater, and more comfortable lighting conditions, comparable with those encountered in the field, should be established in the screening rooms.

When theaters operate on the two-performance-a-day schedule, and people do not enter and leave during the performance, auditoriums almost totally dark have commendable visibility characteristics. For the houses running continuous performances, intensity values of about 0.1 foot-candle were found satisfactory for taking seats easily, provided the eyes had gradually accommodated themselves to that intensity in passing from the high intensities existing at the entrances. One of the most outstanding criticisms of nearly all the houses examined was the relatively high intensities in the lobbies compared with the values inside the auditorium. The intensities encountered, varying from 6 to 20 foot-candles to daylight values, should be somewhat lower to prepare the eyes for intensities of 0.5 to 2 foot-candles at the entrances of the auditorium.

It is probably desirable that patrons find their seats without the aid of ushers' flashlights, so that, bearing in mind the fact that the entrance and foyer intensities may be as high as 20 foot-candles or more, the gradation from 20 millilamberts to the very low values suitable for auditoriums requires carefully graded illumination intensities for the intermediate points.

The Screen Illumination Committee of the Academy of Motion Picture Arts and Sciences requested this committee to submit recommendations for screen illumination tests and a detailed description of the procedure outlined above was furnished to the Academy group for use in their work.

ILLUMINATION DATA OBTAINED IN SELECTED THEATERS[1]

Theater	A	B	C	D	E	F	G
Average foot-candles on screen[2]	8.3	8.2	3.8	2.6	3.4[3]	10.0	6.9
Average millilamberts brightness	6.3	9.3	3.0	2.4	3.1	10.0	5.6
Stray light on screen—ML.	0.0025	0.0027	0.0050	..	Negligible		
Brightness of screen surroundings—ML.	0 (?)	0.054	0.0064	..	..	..	..
Brightness on front wall—ML.	0.003	0.017	0.009	..	..	..	..
Foot-candles, front row center	0.17	0.16	0.33	0.02	..	..	0.02
Foot-candles, middle row center	0.012	0.35	0.51	0.02	..	..	..
Foot-candles, back row center	0.016	0.25	0.37	..	..	..	0.31
Foot candles, center lobby	6.0	..	7.3	..	Daylight intensities		..
Maximum light source brightness in field of vision—ML.	2280[4]	35.3	..	0.04	0	0	0.05
Observed visual comfort	Comfortable	Uncomfortable	Comfortable	..	Comfortable	Comfortable	Very comfortable
Visual acuity	Very good	Fair to good	Fair to very good	Poor	Good	Good	Good

[1] Abridged.
[2] No film in projector.
[3] Wide film.
[4] Bare lamp, visible only from upper balcony.

The committee has found this quite an extensive undertaking. Although progress has been slow we believe it will ultimately furnish a fund of information of great value to non-technical as well as technical workers.

F. M. FALGE
R. E. FARNHAM
EMERY HUSE
L. A. JONES

C. E. EGELER, *Chairman*
J. C. AALBERG
F. A. BENFORD
A. C. DOWNES

DISCUSSION

MR. FRIEBUS: In discussing the illumination necessary to permit patrons to pass into and out of the theater during the performance, the matter of the color to be used for lighting and the minimum amount required was neglected. I suggest that it be considered. I believe that the contraction of the pupil is greater for the same intensity of illumination at the red end of the spectrum than at the blue. Perhaps better illumination could be obtained with blue light, which affects the eye less in viewing the screen than if red light were used.

MR. FARNHAM: In our survey, we found that theater owners are quite prone to use red in winter to suggest warmth, and blue or green in summer to suggest the idea of coolness. This is a feature with which the committee has had to contend.

PRESIDENT CRABTREE: I believe that in many cases the level of illumination in the theater is too high for comfortable vision, so that it is difficult to concentrate on the picture. To me, the picture becomes more real the darker the surrounding parts of the theater. Of course, it is admitted that absolutely dark theaters are out of the question nowadays. There is no doubt, however, that in the future, the dark condition must be approached more and more.

REPORT OF THE MEMBERSHIP AND SUBSCRIPTION COMMITTEE*

The membership of our Society has continued to grow until we now have 756 active, associate, honorary, and sustaining members. There have been very few losses through delinquency or otherwise during the year. Sixty-two members were reported as delinquent, of which number this committee succeeded in holding in the Society all but twelve, while practically all of those who dropped out did so because they left the industry.

Your committee has tried to bring the Society to the attention of all technicians in the motion picture industry. It has been a booster committee, having members in all large cities and foreign countries where motion pictures are produced. Once each year the committee invites all members of the Society to recommend those whom they know to be eligible for membership. Occasionally, applications have been held up for some time by the Board of Governors pending an investigation of the classification of the applicant; this delay is generally caused by the diffidence of the applicant to record his own accomplishments and qualifications on the application form.

The relatively high entrance fee and annual dues charged by the S. M. P. E., as compared with other similar organizations, prevents many of the younger technicians from applying for membership. The committee, after considerable deliberation, unanimously recommends that the entrance fee and dues be reduced at the earliest date consistent with our ability to maintain the high standard of the JOURNAL and semi-annual meetings of the Society.

This committee has made a special effort to secure subscriptions for the JOURNAL. Nearly 200 subscribers have been added to the

* Presented at the Fall 1930 Meeting, New York, N. Y.

circulation this year and we might well expect an equal increase for the coming year with equal effort. With 800 subscribers the JOURNAL could be made self-supporting.

In conclusion, your committee requests continued effort on the part of all members in assisting the committee in its work of increasing the membership of the Society and the list of subscribers to the JOURNAL.

C. BARRELL
J. W. BOYLE
W. H. CARSON
W. CLARK
L. W. DAVEE
J. DEFRENES
E. R. GEIB
D. E. HYNDMAN
H. T. COWLING, *Chairman*
J. KLENKE
M. L. MISTRY
B. E. NORRISH
I. ROSEMAN
E. C. SCHMITZ
J. L. SPENCE
F. ZUCKER

IMPORTANT ANNOUNCEMENT REGARDING PAPERS FOR SPRING CONVENTION

The Papers Committee is planning a papers program of unusual interest for the Spring Convention in Hollywood and is arranging this program with unusual care, so that members attending the convention will secure maximum value from the papers sessions. In working toward this end, several changes in the procedure for handling contributed papers have been made, and members planning to submit papers for presentation are asked to note these changes carefully. The committee earnestly requests the coöperation of all members to enable it to carry out its plans effectively.

(1) The new plan requires that all manuscripts of papers for the Convention be submitted by April 1st. The dates for the Convention are May 25th to 28th, inclusive. This will allow a period of one month for review of papers by members of the committee and by special experts within the Society. The necessity for such careful review is obvious if a uniform standard is to hold for all papers accepted.

(2) It is also planned, during the interval after April 1st, as a special feature of the next Convention, to prepare rather full abstracts of papers and to distribute preprints of the abstracts to members at the Convention. This will permit those attending the Convention to know the general character of papers before they are presented, so

that they may not miss sessions in which papers of particular interest to them are offered. It is also expected that these extended abstracts will stimulate discussion of papers presented and thus make the sessions more interesting and instructive.

(3) Each prospective author is asked to submit, in addition to his manuscript, (*a*) a short abstract of about 100 words summarizing his paper, which can be used for program purposes and for press releases, and (*b*) a short biographical sketch (see page 259, this issue of JOURNAL) for JOURNAL publication. Since the program and the press releases are the usual means by which members and guests obtain a detailed list of papers, authors will help to insure a full audience for their papers by providing the short abstract requested.

(4) All manuscripts should be sent to the Editor of the JOURNAL, Sylvan Harris, 33 West 42nd Street, New York City. Each manuscript should be accompanied by such diagrams and photographs as are proposed to be included in it. Detailed instructions to authors are contained in a pamphlet entitled, "Instructions to Authors" which may be obtained upon application to the Editor.

The committee is anxious to obtain a well-rounded program, and requests that all prospective authors send the titles of their proposed papers to the Editor as early as possible. If titles and authors of prospective papers can be obtained in this manner it will assist the committee in planning.

The committee believes that members will agree that the features of the new plan as outlined are desirable and will do their utmost to coöperate with the committee.

O. M. GLUNT, *Chairman*

PROGRESS COMMITTEE WORK

The principal work of the Progress Committee for many years has been the compilation of data giving the results of scientific experimentation, descriptions of new apparatus, and the discussion of practices in the industry. This information has been obtained from the trade, from technical journals published in various parts of the world, and from personal reports by committee members. A general report, summarizing the collected data, is presented at each of the semi-annual meetings of the Society. Later, this information is published in the Society's JOURNAL, thus making it accessible for all members and others receiving the JOURNAL.

The files of the committee contain much useful information which may be consulted at any time by writing the chairman. It seems as if more use should be made of this information, which has been compiled at considerable personal expense by the members of the committee.

As to the semi-annual report, the present chairman has made a conscientious effort to arrange the report in the most useful way possible for easy reading. There are eight general divisions as follows: (1) Production, (2) Distribution, (3) Exhibition, (4) Applications of Motion Pictures, (5) Color Photography, (6) Amateur Cinematography, (7) Statistics, (8) Publications and New Books. A comprehensive bibliography of references is also included. It is thought that this arrangement is a logical one. Few people ever read all of the material in a progress report but almost everyone is interested in certain sections of the report.

There may be other ways of arranging the material, however, which will make it more accessible. It may be considered by some members that one of the semi-annual reports ought to be shorter, giving only a generalized rather than a specific survey. The chairman has worked on the basis that a progress review should be current, and should contain enough detailed information about most of the items to acquaint the reader with the essential facts about each subject.

It is the aim of your committee to make this report the most accurate and complete review of conditions in the industry published in the world. Any suggestions which you may have toward this end will be appreciated.

GLENN E. MATTHEWS, *Chairman*

STUDIO LIGHTING COMMITTEE

The Committee on Studio Lighting is preparing a questionnaire for submission to studios throughout the world, so as to be able to formulate a comprehensive report as to what is being done throughout the entire industry. The committee would be very glad to receive suggestions from any member on the questionnaire or on any subject related to Studio Lighting. Please address M. W. Palmer, in care of the New York Office of the Society.

M. W. PALMER, *Chairman*

ABSTRACTS

The following abstracts are published by courtesy of the Eastman Kodak Company, publishers of the Monthly Abstract Bulletin of the Kodak Research Laboratories.

Variation of the Brilliance of Distant Objects with Distance. M. HUGON. *Sci. Ind. Phot.*, **1**, May, 1930, p. 161. A mathematical study of the variation of the brilliance of distant objects with the distance has been made, considering atmospheric absorption and light scattering. The wave-length used in viewing the objects must be chosen, considering the relative values of absorption and scattering. The results are employed in connection with some photometric studies using wedge and photography. Using filters, it was found that the ratio of direct sunlight to diffused light from the sky is practically constant when the sun is 30 degrees above the horizon. Contrast is found to increase with the wave-length. The experimental results are closely in agreement with theory. As an application, photographs have been taken of distant objects using panchromatic and infra-red sensitive plates and suitable filters.

Deterioration of Sulfite Hydroquinone Solutions and the Mode of Activity of Old Solutions. J. PINNOW. *Z. Wiss. Phot.*, **27**, No. 11–12, 1930, p. 344. By careful oxidation with permanganate in sulfuric acid solution in the cold, α- and β-hydroquinone disulfonic acid gave compounds which liberate, by boiling, oxalic acid and large amounts of sulfurous acid. A similar oxidation by air could explain the formation of the complex compound observed by Schilow and Fedotoff, which is formed in solutions having no more developing power. The sulfite solution in the developer is better protected against oxidation by a mixture of α- and β- hydroquinone disulfonate than by hydroquinone.

Receiving the Image. D. L. WEST. *Mov. Pict. Rev. Theater Management*, **25**, September, 1930, p. 8. Details of television images as received have improved markedly since 1926. A type of home receiver is briefly described. Synchronization in these sets is accomplished by utilizing one of the main component frequencies in the received television image current to drive a small synchronous motor coupled directly to the shaft of the scanning disk motor. For a showing at the London Coliseum, in July, 1930, a large multi-lamp screen was used consisting of a bank of small electric lamps. Each lamp was connected to a commutator device. A ground glass screen was placed in front of the lamp bank.

F/2.5 Leica Camera. *Amat. Phot.*, **70**, Oct. 15, 1930, p. 375. A new model of the Leitz "Leica" has an $f/2.5$ lens, and takes interchangeable lenses, one an $f/3.5$ lens of 35 mm. focus and the other an $f/4.5$ lens of 135 mm. focus.

Small Film Pictures. J. J. HANSMA. *Focus*, **17**, Aug. 30, 1930, p. 468. Equipment and technic for developing and printing small negatives, such as "stills," made on motion picture film. The following negative developer formula is recommended: (*a*) Oxalic acid, 0.4 gm.; metol, 4.0 gm.; pyrogallol, 12.0 gm.; potassium metabisulfite, 1.0 gm., and water to 200 cc. (*b*) Sodium sulfite

(crys.), 48 gm.; water to 168 cc. (*c*) Acetone, 40 cc.; water to 200 cc. For use, 15 parts of each of the three solutions are diluted with 80 parts of water.

Tanar Corporation Introduces New Sound Truck. *Amer. Cinemat.*, **11**, September, 1930, p. 15. The first Roos portable recorder used the single film system, and the apparatus, weighing 70 pounds, could be packed into two cases. The second portable outfit is fitted into a Dodge speed truck which is insulated to serve as a monitor room. A flashing lamp is used and amplification is sufficient for four microphones and six cameras. Power is obtained from storage batteries which can be charged from the truck motor in the field.

Air Column Speaker. *Amer. Projectionist*, **8**, August, 1930, p. 11. The new unit uses the amplifying system feeding a magnetic or dynamic speaker in the usual way. The speaker has a vibrating reed which is actuated by the amplified signals from a radio set or phonograph and it in turn acts on a sensitive air valve, causing it to open and close in accordance with the frequency of the sound being produced. The opening of the air valve allows a minute jet of air under twenty pounds pressure to escape, the sequence of these jets forming a musical note which is amplified by resonance in the exponential horn. Laboratory tests show that the air valve responds to frequencies quite uniformly from 30 to 14,000 cycles. It is pointed out that the great volume obtained by the speaker is not caused by the blast of air but only by the escape of air through the minute air valve.

Triergon Process for Making Phonograph Records by the Use of Sound Films. H. VOGT. *Kinotechnik*, **12**, July 20, 1930, p. 385. A sound record of the variable density type is made on film. This is reproduced on a wax record by means of a lamp, light-sensitive cell, amplifiers, and electromagnetic stylus. For the best reproduction, it is stated to be necessary to make the reproduction at one-fortieth the speed at which the original record was made. In this way, the effect of the natural frequency of the armature of the electromagnetic stylus is said to be nullified.

Transmitting Images. D. L. WEST. *Mov. Pict. Rev. Theater Management*, **25**, August, 1930, p. 12. Visible light sources commonly used for subject scanning have been replaced by a scanning source composed of invisible radiation, which is claimed to make the physical conditions more pleasant for the subject being "televised." With present scanning equipment it is possible to accommodate several at a time, although, unless the size of the light spot is reduced in proportion to the increase in area scanned, detail is obviously lost. The article includes illustrations of equipment used as well as views of the transmitting studio.

Eberhard Effect and Its Significance for Photographic Photometry. N. VALENKOV. *Z. Wiss. Phot.*, **27**, No. 8–9, 1930 p. 236. The Eberhard effect is in a high degree dependent upon the sharpness of the photographic picture. For the straight line portion of the H. & D. curve the effect is proportional to the difference of the densities between the pictured object and the surrounding field. If the surface of the object is large the Eberhard effect shows an edge effect which is never wider than 1.5 mm. Pictures smaller than 3 mm. in diameter show increased densities through the Eberhard effect. The effect is independent of the form of the picture. Very fine grain photographic emulsions show no Eberhard effect. With increasing average grain size the effect increases. For x-rays there is almost no effect. The increase of density caused by the Eberhard effect is in

all cases very small. Development with metol-hydroquinone and potassium bromide did not show any more effect than development with ferrous oxalate developer. The effect is independent of the intensity of the light source. The effect has little significance for both astrophotometry and spectrophotometry. With x-rays especially, it has no significance at all.

Peko Camera on the Way. *Movie Makers*, **5**, September, 1930, p. 476. This amateur standard spring driven camera is of the vertical type, having one reel located above the other inside a cast metal case. Features are: a self-contained footage meter; a finder adapted for either waist or eye level exposures; and a non-buckling film guide. The spring release button is located on the front of the camera.

Wide Film Cinematography. A. EDESON. *Amer. Cinemat.*, **11**, September, 1930, p. 8. More than half a million feet of film was used in photographing *The Big Trail.* No trouble was encountered from abrasion, but film buckle, leading to the destruction of several camera motor drives, was experienced when the film spools were not carefully smoothed before insertion in the magazines. It was found necessary to use lenses of exactly double the focal length of those employed for 35 mm. shots. The photographic quality in the large film is claimed to be greatly superior.

European Sound Picture Industry. *Electronics*, **1**, September, 1930, p. 282. An outline is given of interrelations of the various sound picture interests dealing with the relationships brought about by capital and patent pools and technical advances.

Walturdaw's Projector Range. *Kinemat. Weekly* (*Design and Equipment Supp.*), **164**, Oct. 9, 1930, p. 41. Notes are given on the Hahn II, the Ernemann II, and the Ernemann III projectors. All are fitted with a fire prevention device. Should the film break above the intermittent sprocket, the top loop naturally enlarges, lifts a flap, actuates a mercury switch, and cuts off the light beam and motor current. The Ernemann III projector has a lens mount capable of carrying lenses of 80 and 100 mm. diameter, thus enabling an aperture of $f/1.9$ to be used on lenses of almost any focal length. By replacement of the standard gate, this model can be rapidly adapted for wide film; the exact width is not specified.

Theory of the Motion Picture Claw Pulldown Mechanism. C. FORCH. *Kinotechnik*, **12**, Aug. 5, 1930, p. 407. A mathematical analysis is made of several claw, pull-down movements. It is concluded that, with the usual claw pull-down mechanisms, conditions can be arranged to obtain a movement that very closely approximates that obtained with a Geneva pull-down. If a radially slotted disk is mounted on the end of the pull-down crank shaft so as to be driven by the pin of a crank with its shaft parallel but eccentric to the pull-down crank shaft, the pull-down can be effected in 90 degrees or less, instead of 180 degrees. With a Geneva pull-down, the steadiness of the picture depends upon the absolute identity of the four members of the Maltese cross. With the claw pull-down, each stroke is made with the same member, and a source of unsteadiness is thus removed.

An Aspheric Mirror of High Efficiency for Motion Picture Projectors. F. HAUSER. *Kinotechnik*, **12**, July 20, 1930, p. 379. A mirror for motion picture projectors is said to combine the advantages of the spherical and the elliptical mirrors. It is built up from several zones in such a manner as to have a small amount of spherical aberration. The mirror is said not to be as sensitive to the

longitudinal adjustment of the arc as the elliptical mirror, but to be highly efficient.

Subjective Density Measurements. P. LOB. *Kinotechnik*, **12,** Aug. 20, 1930, p. 435. In the instruments for measuring densities subjectively, two parts of a photometric field are matched visually. The optical systems of a number of different types of photometers are described, and the advantages and disadvantages pointed out. Some of the precautions necessary for the different types are given. The polarization photometer has the disadvantage of requiring a monochromatic light. With the wedge type of photometer, the wedge should be of the same material as the object whose density is to be measured, and it is advisable to increase the intensity of the light with increase in the density to be measured, so that a beam of moderate brightness will always enter the eye. In diaphragm photometers, the diaphragm must be exactly in the plane of an optical pupil. Sector photometers have the advantage that no lenses are required. The Callier effect must always be avoided. Instruments in which the conditions are identical in the two optical paths automatically eliminate this source of error.

Lagorio's Color Table. L. KUTZLEB. *Kinotechnik*, **12,** July 20, 1930, p. 383. A color chart is made of a number of narrow vertical color strips of different spectral hue and known saturation alternating with neutral strips, each having a number of steps of different reflecting power from top to bottom. The spectral brightness curve, as rendered by any plate or film may, it is claimed, be obtained by photographing the chart and tracing a line through the points where the images of the color strips match the images of the adjacent neutral strips. The ideal visual brightness curve is printed on the chart, so that the rendering of any plate may be compared with it. The chart is intended for testing panchromatic plates and films and for determing proper correcting filters.

Wide Film versus Wide Image on Standard Film. J. J. FINN. *Mot. Pict. Projectionist*, **3,** August, 1930, p. 31. A number of producers and exhibitors oppose the adoption of Grandeur 70 mm. film or any other wide film by the motion picture industry, because it would necessitate the installation and operation of entirely new equipment. They favor a process which will give a satisfactory wide film image with slightly modified standard reproducing equipment. In the Fear process, using a wide image on standard film, the film is run horizontally in the camera and the projector. By this method pictures of proper proportionate height and width are possible. A system has been proposed in which the picture is taken on 70 mm. film and is subsequently reduced in the printing operation on 35 mm. film. A special three-combination lens of extremely short focal length is used in reproduction. High intensity lamps drawing 160 amperes are employed for illumination. Some blank space is left between the film frames, which is dealt with in projection by a masking arrangement. Many printing difficulties and optical problems are encountered in the new system. Loss of definition in printing from 70 mm. to 35 mm. and the great magnification required to secure a screen image of 45 feet are problems confronting the proponents of this process.

ABSTRACTS OF RECENT U. S. PATENTS

1,775,938. I. Kitsee and D. C. Law, assigned to Cinema Laboratories Corp. A method of coloring the uncovered surface of a motion picture film which is provided with a photographically developed emulsion disposed over the surface in transparent colored relief figurations with minute interstices therebetween. The method consists in moving the film through a substantial vacuum and simultaneously applying to said film, while the air in said interstices is substantially exhausted, a liquid coloring material dissolved in a solvent of celluloid in which the emulsion is not soluble, the color of said liquid being complementary to that of the figurations.

1,776,969. E. H. Foley, assigned to Sound Films Corporation. An apparatus for simultaneously photographing scenes on a negative film and recording the sounds on a plurality of films on which positive prints are to be made. This comprises feed devices for moving both positive and negative films in synchronism, the positive films being moved continuously, and the negative film intermittently, and sound recording devices engaging each positive film at a point adjacent to the picture areas thereof.

1,777,257. A. L. V. C. Debrie. A photographic objective mount, permitting focusing without rotating the objective, including a sleeve member carrying the lenses and having a grooved cam on one side thereof, which is engaged by a pin supported by a lever fastened to the apparatus. Upon swinging the lever, the sleeve member is moved in or out of its casing. The cam is designed according to the focal length of the objective.

1,777,418. H. W. Rogers. Motion picture and sound apparatus, having two turntables driven by a motor, are synchronized by a controlling means comprising two pairs of film controlled switches, a stationary and a power driven rotary electromagnet for each turntable, a flexible magnetic disk disposed between the electromagnets and connected to its turntable to control the movement of the same, a circuit including a source of energy and its electromagnet and switch, and means connected in each circuit for the control of the other switch of the pair, whereby the closing of one switch and its electromagnet will de-energize the other electromagnet.

1,778,104. W. J. Conkie, assigned to Alexander Industries, Inc. A method of synchronizing the words and music of a sing film comprising the uniform projection of time indications, bearing a definite relation to the number of frames projected, during the playing of the song.

1,778,139. R. John. A color motion picture film of the dye transfer type, having an image comprising minute color dots grouped to represent a natural photographic record of lights and shades, said dots containing substantially the same quantity of imbibed dye per unit of surface for the various colors used. This film presents an unbroken image at above 50 diameters enlargement.

1,778,351. L. W. Bowen, assigned to Spiro Film Corporation. Motion picture apparatus using a disk film which is rotatably mounted on a carriage having a rectilinear movement in a plane at right angles with the objective. The driving mechanism is operated in one direction only and automatically returns the carriage to its original position after a complete film has been projected, whereby a film may be repeatedly projected.

1,779,947. A. S. NEWMAN. Motion picture printing apparatus having a printing sprocket, the teeth of which are separated by a circumferential distance equal to the spacing of the pictures, the teeth on one side being slightly shiftable with respect to the teeth on the other to accommodate irregularities in the film. Two auxiliary sprockets are resiliently mounted on their shafts to keep the film taut over the printing sprocket, feed and take-up sprockets, and gearing whereby all of the sprockets are driven.

1,780,025. E. MARKENBERG, assigned to Agfa Ansco Corporation. A process of developing films by reversal, comprising subjecting the film to an underdevelopment, dissolving the silver image, developing the remaining silver salt image after a second exposure, and then equalizing the excessive density of the reversed image by means of a solvent for silver having the character of uniform reducing action.

1,780,039. I. PECHAN, assigned to The Czechoslovak Co. A tripod adapted to facilitate the leveling of a camera having eccentrics engaging bearings in the head and shafts therefor supported by the feet.

1,780,123. N. FLORINE. A continuous-feed motion picture projector in which optical compensation is effected by lenses moving in a rectilinear track in front of the projection aperture. These lenses are resiliently mounted in radial grooves provided in a rotary disk.

1,780,225. E. DE MOULIN. A two camera tripod head having an inverted L piece to support one camera in inverted position to facilitate the taking of trick pictures.

1,780,311. A. PAPO AND A. GENTILINI. A continuous-feed motion picture projector, in which the film is pulled through the apparatus by the take-up reel, having a reciprocating optical system with a portion of its axis parallel to the plane of the film, and including a reflector which is moved by a film engaging member.

1,780,384. I. I. GREEN. A filter holder, adapted to be clamped to the lens mount, provided with a hinged top to facilitate the insertion of one or more filters in a frame and resiliently retained in position.

1,780,510. A. G. WISE, assigned to Metro-Goldwyn-Mayer Corp. A film reel comprising a flange, and a hub having means for decreasing its normal diameter to facilitate the removal of the film upon being wound.

1,780,585. A. FRIED, assigned to William Fox Vaudeville Co. A tripod head, mounted for rotation about a vertical axis, having an adapter for rotation about a horizontal axis and a means including a gear train and flywheel to steady the movement about either axis.

BOOK REVIEWS

Photography—Its Principles and Practice. C. B. NEBLETTE. 2nd edition. *D. Van Nostrand Co.*, New York, N. Y., 1930, 615 pp., $6.50. The original 1926 edition has been a useful textbook for the beginner and even more advanced students of photography. New material in the 1930 edition includes information on the modern theories of latent image formation, the theory of sensitivity of emulsions, the constitution of color sensitizing dyes, and the theory of development and fixation. The author appears to be unaware of the existence of the *Transactions* and JOURNAL of the Society of Motion Picture Engineers, and it is unfortunate that the extensive information on the theory and practice of photography which they contain has been overlooked.

The chapter on color photography is inadequate and could have been extended at the expense of some of the chapters dealing with little used processes.

Any book for the student which deals with practice should dwell, if at all, on those applications which are of importance in every-day life. The most important applications of photography are to photomechanical methods and motion pictures, neither of which are mentioned. However, a perusal of the book and especially the chapters on sensitometry and the theory of development is recommended to all motion picture technicians. J. I. CRABTREE

Introduction to Physical Optics. JOHN KELLOCK ROBERTSON. *D. Van Nostrand Co.*, New York, N. Y., 1929, $4.00. Optics is unquestionably the most difficult branch of physics for the reason that there are no simple phenomena with which the student may begin his study of the subject. He must begin to study it all at once, so to speak, whereas in mechanics, for example, he may begin with statics and leave the more difficult concepts of dynamics until later. In this sense, any work on optics must of necessity be more in the style of a treatise than a textbook. It seems fair to say that the "Introduction to Physical Optics" by John K. Robertson is the closest approach to a textbook that the reviewer has examined. The author has managed his material so skillfully that it seems to satisfy well the avowed purpose of the book, namely, to supply "the needs of two classes of students: (1) those who, at the outset of an intensive study of physics, are laying a thorough foundation for subsequent work in the theory of optics; (2) those specializing in other branches of science, for whom a general knowledge of modern views of light is desirable and, indeed, frequently indispensable. It is hoped, too, that the treatment is such that an appeal may be made to the general reader who desires to have some acquaintance with the fascinating problems of modern physics—problems many of which are most directly approached through the study of light."

The early chapters of the book deal with wave motion and the interpretation of the phenomena of reflection and refraction on this basis. This is followed by a short discussion of lenses and optical instruments. There are then six chapters dealing with the classical phenomena such as interference, diffraction, and polari-

zation, which are followed by a discussion of the electromagnetic theory of light, the origin of spectra, the quantum theory, and radiation potentials. The volume ends with a discussion of the more recent attempts to fuse the two conflicting theories concerning the nature of light.

The author has given particular attention to the clarity of presentation, which is assisted by a large number of excellent photographs and line drawings. A set of problems *with answers* is given at the end of each chapter. These are always useful for classroom instruction but perhaps even more for the technical man whose optics are a bit rusty and who desires to work up the subject by himself.

A. C. HARDY

Fabrikation und Prufung der photographischen Materialien (Manufacture and Testing of Photographic Materials). W. NAUCK AND E. LEHMANN. *Union Deutsche Verlagsgesellschaft,* Berlin, Germany, 1928, 274 pp., 68 illustrations. The first section of this book is intended for the beginner and contains little of interest to those engaged in manufacture. It deals with the manufacture of photographic materials and contains the following chapters:

(1) The Preparation of Sensitive Emulsions and Photographic Papers and Plates; (2) Photographic Raw Stock and Baryta Paper; (3) The Manufacture of Film Base; (4) Recovery of Solvents Used in Film Manufacture; (5) Coating Emulsions on Glass Plates; (6) Coating Emulsions on Paper; (7) The Coating of Emulsions on Films.

The second section of the book, which deals with the testing of photographic materials, is of much greater value and is a creditable assemblage of the published information on the testing of gelatin and chemicals used in photographic manufacture, the analysis of film base materials, the testing of their physical properties, the analysis of emulsions, and the sensitometry of photographic materials.

J. I. CRABTREE

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SOCIETY NOTES

Meeting of the Board of Governors.—At a meeting of the Board of Governors on December 19, 1930, at the Hotel Pennsylvania, New York, N. Y., a large amount of business was transacted, including the following:

(1) It was resolved: "That an Open Forum be established in the JOURNAL, in which might be published letters and communications from members relating to material in the JOURNAL or other matters appertaining to the welfare of the Society, subject to the discretion of the Editor and Board of Editors.

(2) Resolved that an acknowledgment of appreciation for the services rendered by Mr. L. A. Jones and his associates in editing the JOURNAL during the year 1930 be published in the pages of the JOURNAL.

(3) Numerous business matters relating to the London Section were discussed and in response to requests from the London Section for a refund of membership fees and special subscription rates to the JOURNAL, the following motions were made and passed:

(*a*) Resolved that any London Section member may, at his request, be regarded as terminating membership in the Society on December 31, 1930, and that his individual liability shall be satisfied by payment of all back dues and first quarter's dues for the term of 1930–31.

(*b*) Resolved that the Board of Governors instruct the London Section to make an immediate accounting and forward to the General Treasurer of the Society all monies due the parent body. This accounting shall be made on the basis that those members who wish to withdraw from the parent body shall be refunded three-fourths of the current dues paid.

(*c*) Resolved that the JOURNAL be supplied to British *members* at the standard price of $12.00 per annum with the concession that the heavy foreign postage be borne by the Society.

The Spring Convention.—At the meeting of the Board of Governors on December 19, 1930, it was resolved that the Spring Convention be held in Hollywood, Calif., May 25th–28th, inclusive. Mr. W. C. Kunzmann, chairman of the Convention Committee, has announced the selection of the Roosevelt Hotel as Society headquarters.

Mr. O. M. Glunt, chairman of the Papers Committee, announces that the Papers Program will include a series of symposiums on (*a*) sound recording, (*b*) color, (*c*) film properties and processing methods, and (*d*) studio practice.

An invitation to collaborate in the Spring Convention has been

extended to the Academy of Motion Picture Arts and Sciences, Hollywood, Calif.

Mr. C. L. Gregory, chairman of the Historical Committee, is arranging an exhibition of historical films and apparatus.

The Wide Film Situation.—The subcommittee of the Standards Committee, under the chairmanship of Mr. M. C. Batsel, has discussed specifications for a wide film standard, and, having finally reached an agreement, the committee has arranged for the manufacture of a quantity of the film. The General Theatres Equipment Corporation has agreed to construct the necessary projectors for testing out this film. If these tests are satisfactory, particulars regarding the new standard will be circulated to the membership for discussion and approval.

The Aims and Accomplishments Booklet.—This booklet, recently issued and circulated to all members, contains abstracts of all papers presented at the Society conventions together with a subject and author index. Members who have not received copies should make application to headquarters.

The Papers Committee.—The Papers Committee is now responsible for the technical quality of all papers which appear in the JOURNAL whether or not they are presented at Society meetings. The chairman has available the various members of his committee and the Associate Editors to serve as readers and censors of papers submitted.

The Papers Committee will be guided by the following regulations:

(1) All papers which are accepted by the Papers Committee for presentation before conventions shall be published in the JOURNAL in their entirety, regardless of whether or not they may have been published in some part previously.

(2) Papers which are offered for publication in the JOURNAL will be considered on their merits and will either be accepted for publication in their entirety or rejected.

(3) Papers which have been published in other journals which are considered to be of interest to our membership may be reprinted in our JOURNAL in full or in abstract form as agreed upon between the Editor and the Papers Committee.

The Chicago Section.—A meeting was held on December 4, 1930, at the offices of the Enterprise Optical Company, 564 W. Randolph Street, at which Mr. Schoenberg delivered a paper on "Light." This was followed by a showing of the picture *Whoopee.*

Mr. O. F. Spahr asked if the members would be interested in seeing and hearing a sound print being shown in one of the small theaters of the rural sections of Indiana. This picture was one of the first shown by the theater owner in question, who thought he was getting something quite good. The photography, and particularly the sound, was so poor that many of the members had to be reassured that the demonstration was not faked.

The London Section.—Although the officers of the London Section have resigned as of December 31, 1930, the section has not been disbanded by the Board of Governors. A questionnaire has been circulated to the members of the London Section to determine if they wish to elect new officers and continue the section.

TESTIMONIAL OF APPRECIATION

LOYD A. JONES

In sincere appreciation of the services rendered the Society by Mr. Loyd A. Jones, the Board of Governors, at a meeting held December 19, 1930, at New York, N. Y., voted unanimously that announcement of this appreciation be made in the pages of the JOURNAL.

As chairman of the Journal Committee and Editor *pro tem* to the JOURNAL, Mr. Jones undertook the burden of establishing and setting in motion the machinery for changing over the Society's form of publication from that of quarterly *Transactions* to a monthly JOURNAL, the first issue of which was published in January, 1930. Mr. Jones continued in capacity of editor until a permanent paid editor was acquired in December, 1930. These services were donated *gratis* and constitute an example of unselfish devotion to science and the motion picture industry.

PRELIMINARY ANNOUNCEMENT OF SPRING MEETING

May 25–28, 1931, at Hollywood, California

Headquarters: Roosevelt Hotel, Hollywood.

The Society has been quoted the following special day rates for the convention:

Single room with bath.....$3.00
Double room with bath.....$5.00

Those desiring a connecting parlor, additional $5.00 day rate.

Your Convention Committee will submit at a later date, complete information in bulletin form, on transportation schedules and rates over three routes to the West Coast.

With the exceedingly low summer rates in effect during the convention dates, you will be afforded an excellent opportunity of attending our Hollywood meeting by arranging your vacation periods accordingly.

An interesting papers and recreational program is assured during our stay in Hollywood.

Preliminary plans of the Papers Committee, in connection with the Hollywood convention, are presented under Committee Activities in this issue of the JOURNAL. (See page 243.)

W. C. KUNZMANN, *Chairman*

OPEN FORUM

One of the chief reasons why our Society changed its form of publication from quarterly *Transactions* to a monthly JOURNAL was to permit the dissemination of information which is not made available at our conventions. The transactions of a society merely record the proceedings at the society's meetings whereas it is proper for a journal to publish any matter pertaining to the welfare of the society.

Our Society will thrive only if each member takes a deep interest in its welfare. Having the interests of our Society at heart, each of you must have suggestions for making our JOURNAL and conventions of greater value to the industry. It is with this object in view, that at a meeting of the Board of Governors at New York City on December 19th, it was resolved: "That an open forum be established as a new department of the JOURNAL, in which might be published letters and communications from members relating to material in the JOURNAL or to other matters appertaining to the welfare of the Society, subject to the discretion of the Editor and Board of Editors."

May I suggest correspondence on subjects such as the following:

(*a*) Better ways of conducting the conventions.

(*b*) Problems for research.

(*c*) Problems for investigation by the various committees.

(*d*) Discussion of technical papers appearing in the JOURNAL, with comments on the success or failure of their application.

(*e*) Description of interesting or new developments which have come to your attention during your travels, thereby giving all the members the benefit of this knowledge.

(*f*) Preliminary announcements of investigations and discoveries which are to be more fully reported at a later date in formal papers.

Remember that the Society of Motion Picture Engineers is *your* Society and although many of us are widely separated geographically, let us meet monthly in the Open Forum.

J. I. CRABTREE, *President*

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A limited number of most of the issues of the *Transactions* is still available. These will be sold at the prices listed below.

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JOURNAL
OF THE SOCIETY OF
MOTION PICTURE ENGINEERS

SYLVAN HARRIS, EDITOR

Volume XVI **MARCH, 1931** **Number 3**

CONTENTS

JOURNAL
OF THE SOCIETY OF
MOTION PICTURE ENGINEERS

SYLVAN HARRIS, EDITOR

Published monthly at Easton, Pa., by the Society of Motion Picture Engineers

Publication Office, 20th & Northampton Sts., Easton, Pa.
General Office, 33 West 42nd St., New York, N. Y.

Subscription to non-members $12.00 per year; to members $9.00 per year; single copies $1.50. Order from the Society of Motion Picture Engineers, Inc., 20th and Northampton Sts., Easton, Pa., or 33 W. 42nd St., New York, N. Y.

Entered as second class matter January 15, 1930, at the Post Office at Easton, Pa., under the Act of March 3, 1879.

RECENT DEVELOPMENTS IN RCA PHOTOPHONE PORTABLE RECORDING EQUIPMENT*

P. M. ROBILLARD AND E. B. LYFORD**

Summary.—*This paper describes improvements made in the RCA Photophone Portable Recorder since the publication of the original paper describing this equipment. The new optical system and galvanometer, which require much less power for its operation, are described and illustrated. The new amplifier, considerably smaller and lighter than the previous one, is also described. Illustrations and electrical characteristics are given. This recorder is mounted upon a standard Mitchell camera and records by the Photophone variable-area method. The complete equipment weighs 450 pounds, including carrying cases and all accessories.*

The RCA Photophone portable equipment for sound-on-film recording was described in 1929.[1] It is the purpose of this paper to describe the improvements which have been made in the equipment since that time.

Before launching into detailed description of specific parts, let us review briefly the general arrangement of this equipment. Fig. 1 shows the entire outfit in schematic form. The condenser microphone picks up the sound, which is then passed through a cable to the amplifier, where it is brought up to a level suitable for recording. The sound energy passes through another cable, *via* the battery box, to the recording head mounted directly upon a standard Mitchell motion picture camera. The amplifier contains all batteries necessary for the microphone and recording exposure lamp, as well as for its own power-supply—the separate battery box supplies only the power necessary for the camera motor and interphone system.

Since the publication of the previous paper describing this equipment, two important links in the chain of apparatus—the amplifier and the optical system of the recording head—have been completely re-designed.

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* Presented at the Fall 1930 Meeting, New York, N. Y.

** RCA Photophone, Inc., New York, N. Y.

THE NEW AMPLIFIER

Since portability is one of the important features of the entire equipment, it was felt that the original amplifier might, with profit, be reduced in size and weight. The new amplifier case measures only

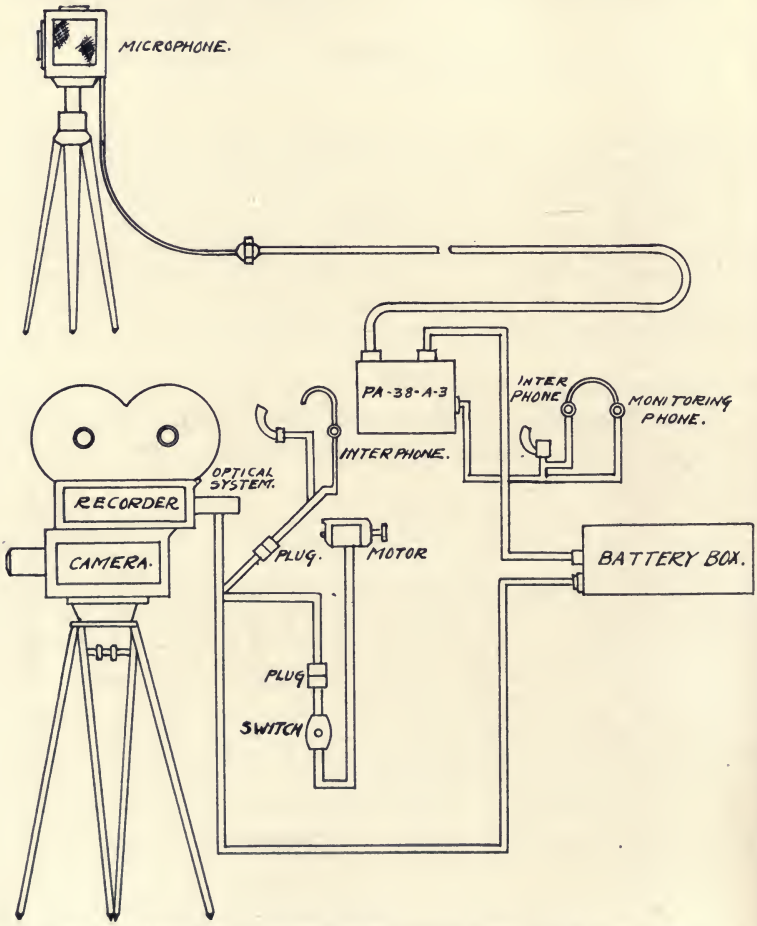

FIG. 1. Schematic arrangement of portable recording equipment.

$8^1/_2$ by 18 by 15 in. over-all and weighs but 53 pounds complete with all batteries.

An interior view of the amplifier is shown in Fig. 2. It comprises three stages of audio-frequency amplification, and employs four

tubes—a UX-864 in each of the first two stages, and two UX-112A tubes in push-pull in the final output stage. As may be seen, the necessary transformers and impedances are mounted on a shelf with the tube sockets, while the accompanying condensers and resistances are mounted beneath. The whole is enclosed within a metal can, which, with the metal panel, combines completely to shield the amplifier from any sort of extraneous disturbances.

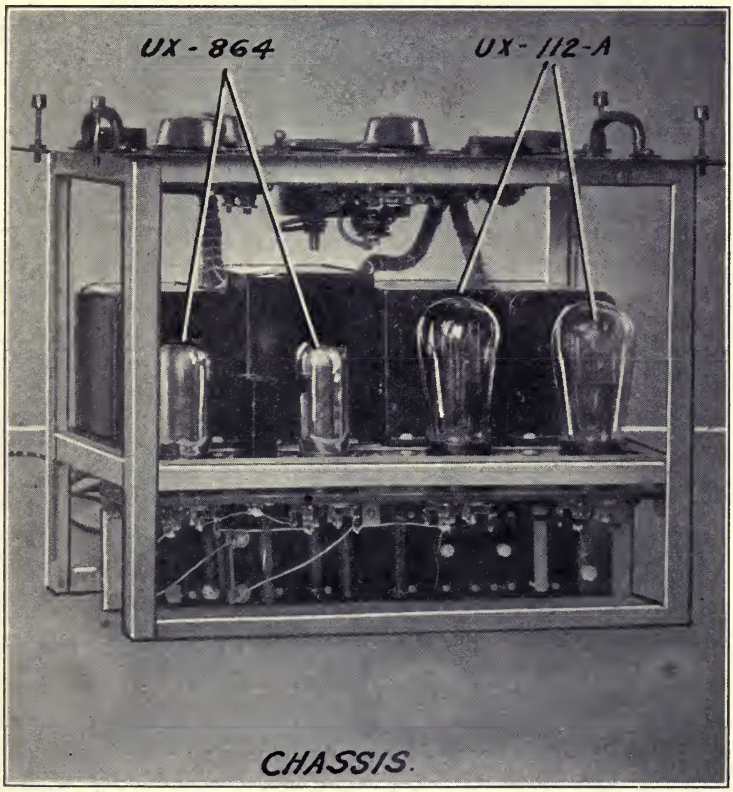

Fig. 2. Interior view of amplifier with shield removed.

Flexible leads are brought out through the bottom of the metal shield to the batteries, which are carried in the case together with the amplifier itself. Fig. 3 shows the amplifier case viewed from above, the amplifier being removed. The "B" battery of 180 volts and a $7^1/_2$ volt "C" battery are in the left-hand compartment. An

8 volt filament battery is carried in the smaller right-hand compartment, a hinged cover enclosing it and allowing the space above to be used for spare tubes, phones, *etc.*

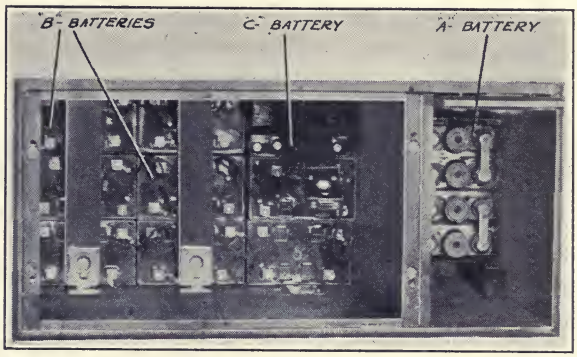

FIG. 3. View of amplifier case with amplifier removed, showing batteries in place.

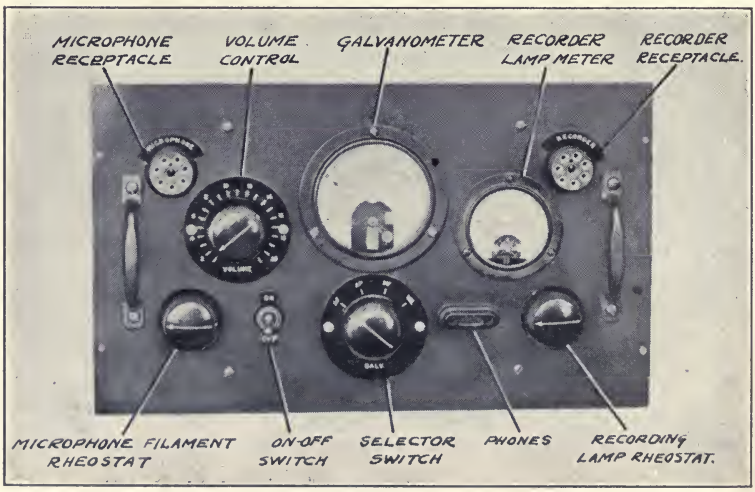

FIG. 4. Panel view of amplifier.

A panel view of the amplifier is shown in Fig. 4. The plug receptacle in the upper left-hand corner is the input, and the one in the upper right-hand corner is the output. A rheostat in the lower left-hand corner controls the filament supply of the microphone

amplifier, and a similar rheostat in the lower right-hand corner controls the current of the recording lamp, indicated by the meter directly above it. The signal volume control may be seen left of the center. The larger meter in the center of the panel measures all the currents, and is controlled by the multiple switch beneath it. The amplifier filament current, amplifier plate current, and microphone amplifier filament current may be read on this meter, and in the fourth switch position the meter may be used as a volume indicator. Phones may also be used for monitoring by plugging the cord tips into the receptacle shown on the panel.

The circuit of the amplifier is of conventional design. Control of volume is effected by a potentiometer across the secondary winding

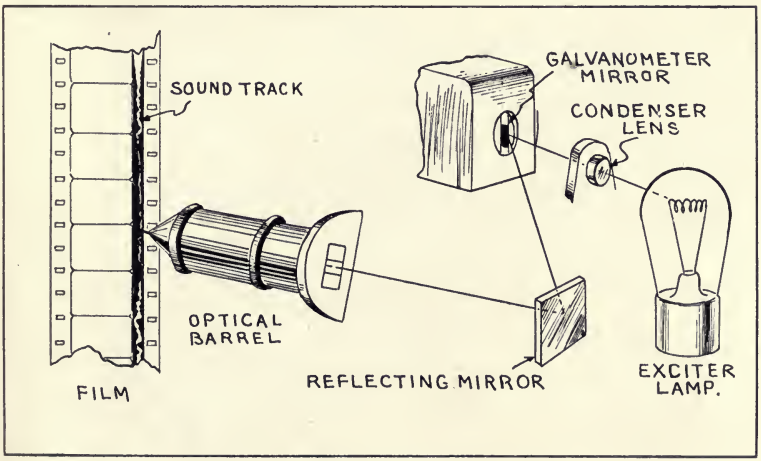

Fig. 5. Schematic of optical train.

of the input transformer. The filament supply of the tubes is controlled by fixed resistances, and the proper grid biases are all obtained from taps on the common "C" battery. The volume indicator is operated through a dry rectifier across part of the secondary winding of the output transformer and the monitoring phones are supplied from the same source.

Some of the electrical characteristics of this amplifier may be of interest. Its input impedance is 250 ohms, designed to work directly from a standard RCA Photophone condenser microphone amplifier. The output impedance of the amplifier is approximately 1.8 ohms, designed to feed directly into the recording galvanometer. The

over-all voltage amplification of these amplifiers averages from 310 to 320, corresponding to a gain of approximately 50 db. The frequency characteristics compare favorably with those of other amplifiers used for similar purposes, and are considerably better at extremely high frequencies, averaging 70 per cent of maximum at 9000 cycles. The total available undistorted power output is about 80 milliwatts.

THE NEW OPTICAL SYSTEM

The optical system of the recording head has also been completely re-designed. Fig. 5 shows a schematic representation of the optical

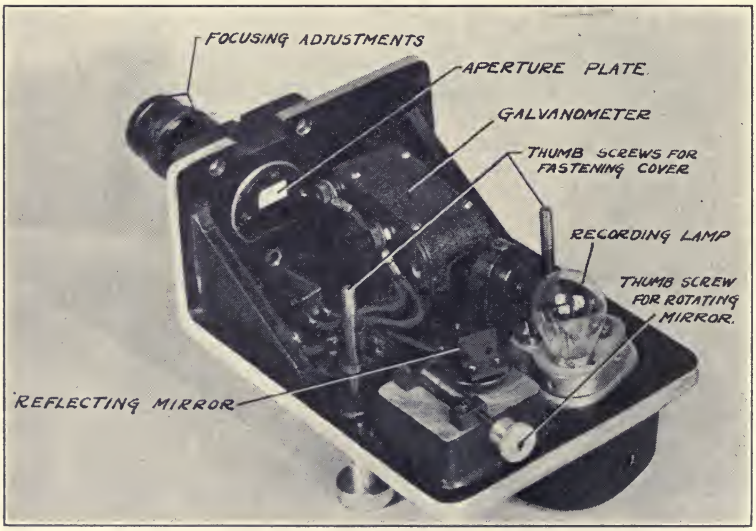

FIG. 6. Recorder optical system; cover removed.

train which is employed. The light from the exposure lamp is focused by means of the condensing lens onto the mirror of the recording galvanometer, which rotates slightly around a vertical axis in accordance with the fluctuations of the incoming signal. This modulated beam of light now travels to the reflecting mirror, and is directed back to the aperture plate of the focusing barrel.

First passing through cylindrical, and then through condensing lenses, the latter being similar to the objective lens of a microscope, the beam of light is brought to bear upon the film. The important new feature of this optical system is that there has been effected a

great economy in the use of the light emitted by the exposure lamp—so much so that this lamp need now be only of the 4 volt, 0.75 ampere type, in contrast to the previously used 5 volt, 4 ampere type. The reduction in power is in the ratio of three to twenty watts. The new exposure lamps, furthermore, need not be of the pre-focused type, as was required in the previous design. They are adjusted by the operator of the equipment in his spare time, and may be dropped into the correct position in a moment's time, if necessary.

Fig. 6 illustrates the appearance of the optical system with the

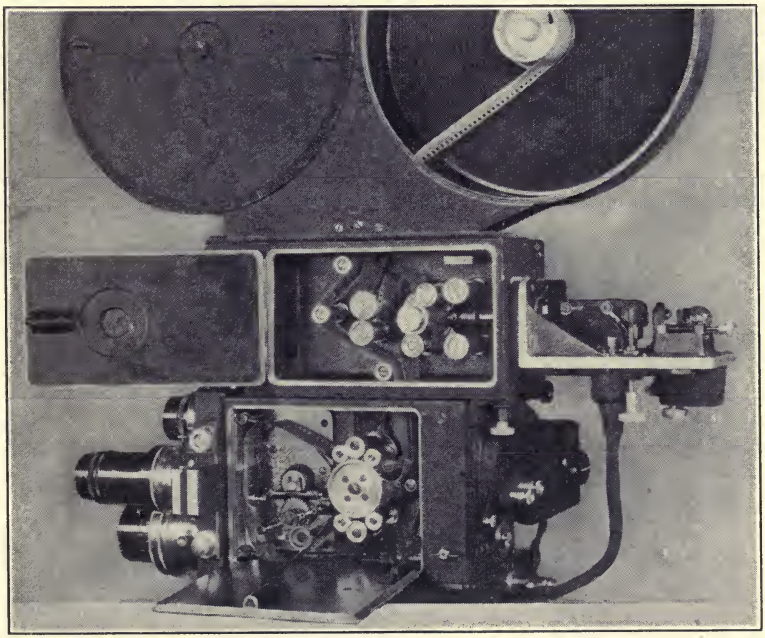

Fig. 7. Optical system and recorder head mounted on camera.

protecting cover removed. All the component parts which have been described may be plainly seen; especial attention is called to the galvanometer, which is of entirely new construction. It is of the fully-enclosed, mechanically-damped type, designed by G. L. Dimmick, of the RCA Victor Company. Space cannot be given for a complete description of this instrument more than to say that it is more rugged and stable than its predecessor, and in addition, requires only about one-third as much power for its operation.

The cover of the optical system is clamped in place by two thumbscrews, and the whole is attached to the recording head by three other screws, all easily removable. The appearance of the optical system and recorder head, mounted on the camera, is shown in Fig. 7, from which it may be seen that the external appearance of the completed unit has been but little changed. In this photograph the optical system is shown with the protecting cover removed, but with the connections made to it by the separable plug beneath.

REFERENCE

[1] HANNA, C. R.: "The Mitchell Recording Camera Equipped Interchangeably for Variable-Area and Variable-Density Sound Recording," *Trans. Soc. Mot. Pict. Eng.*, **XIII** (May, 1929), No. 37, p. 312.

DISCUSSION

MR. KELLOGG: This optical system, designed by Mr. John B. Taylor, of Schenectady, has a very significant feature not possessed by other optical systems. It does not use a mechanical slit, which means a saving in weight of 25 pounds. The optical system with a slit requires a lamp of at least 25 watts, whereas the slitless optical system just described calls for a lamp consuming only 3 watts, which can be operated on dry cells or very small storage-battery, instead of requiring the heavy storage-battery which would be needed with a 25 watt lamp.

MR. E. D. COOK: I would like to ask about the actual illumination obtained at the film with this type of optical system.

MR. OFFENHAUSER: With a three-quarter-ampere lamp, in the present optical system we can obtain sufficient density at the film to fog it under certain conditions. Ordinarily we work at a density of 0.9 to 1.0. The light available from the optical system is more than sufficient to secure that density with normal laboratory treatment.

A MODERN LABORATORY FOR THE STUDY OF SOUND PICTURE PROBLEMS*

T. E. SHEA**

Summary.—*Recently there has been provided among the research facilities of Bell Telephone Laboratories, Inc., a separate building which is intended solely for sound picture research and development work. The prime objects of the laboratory are to find out the best methods and technic for employing sound picture recording and reproducing apparatus now in use, and of making improvements in recording and reproduction. The building contains a recording studio, film processing plant, and review room, together with testing laboratories.*

There has been completed by the Bell Telephone Laboratories during the past year an additional laboratory unit to be used exclusively for developments relating to sound pictures. It is the object of this paper to describe the new laboratory unit and to indicate some of its aims.

Motion picture engineers generally believe that the sound picture will continue to develop in many ways and for a long time, before it may be considered to have exhausted its possibilities. During the past several years the attention of the motion picture industry has perforce been chiefly devoted to the providing of satisfactory recording and reproducing systems in studios and theaters, and to the creation of a satisfactory technic for the use of such systems. As sound apparatus has become better understood by the industry, better results have been obtained with it through the fuller realization of the qualities it inherently possesses.

The introductory period of sound pictures having largely passed, we may expect a period of exploration, in which recording and reproducing systems will be asked to meet more difficult requirements so that the art they serve may grow in its scope. As new conditions arise, it will be necessary to subject apparatus to exhaustive tests to determine its limitations and capabilities in any given circumstances, to give experimental trial to improvements in recording and reproduction intended to overcome limitations, and to work out

* Presented at the Fall 1930 Meeting, New York, N. Y.

** Bell Telephone Laboratories, Inc., New York, N. Y.

revised technics for employing apparatus for recording and reproducing sound.

The central thought in the planning of the laboratory unit described herein has been to provide for experimental control of every factor influencing sound quality, from set and microphone to loud speaker and auditorium. With such an arrangement, the influence of any change in recording, processing, or reproducing can be examined alone, without the confusion wrought by other changes. When one considers the numerous types of problems involved in sound picture developments—acoustical, electrical, mechanical,

FIG. 1. General view of sound stage.

optical, and chemical—and the succession of processes involved in recording and reproducing, the importance of this principle is evident. It is evident, as well, why experimentation under the handicap of production conditions is necessarily difficult.

Accordingly, the building contains the physical essentials of studio, processing laboratory, and theater. The recording facilities comprise a sound stage, monitoring room, dressing rooms, scoring-projection room, and wax and film recording rooms, with asssociated amplifying, testing, and power supply equipment. The photographic facilities include processing equipment, printing machines,

editing equipment, and special optical and photographic testing laboratories. A review room or small theater with associated projection equipment provides for the reproduction of sound and picture. Offices for the staff and a film-storage vault complete the laboratory unit. Entire experimental sound pictures can therefore be produced in this building, or any step in the production and exhibition of sound pictures separately studied.

A description of the principal features of the laboratory unit follows.

General.—The building is located at 151 Bank Street, New York, N. Y., adjacent to the principal buildings of the Bell Telephone

FIG. 2. The monitoring room.

Laboratories. It is a three-story, brick building, of fire-proof construction throughout. It occupies a frontage of 49 feet, a depth of 118 feet, and has a height equivalent to five normal stories. In the construction of the building, the necessity for excluding noise and dirt has been recognized, especially in view of the city location adopted. The building contains an air-conditioning plant supplying all rooms with conditioned air, and especially caring for the ventilation and cooling of the sound stage, the cleanliness of recording rooms, and the control of temperature and humidity in film processing rooms.

Sound Stage.—The sound stage (Fig. 1) occupies the major portion of the third floor, and is 47 feet wide, 70 feet long, and 25 feet in height. It is therefore of sufficient size to permit the erection of ample motion picture sets for experimental purposes. Acoustic treatment of the stage consists of rock-wool covering on the walls and ceiling, together with adjustable monk's-cloth drapes on the

FIG. 3. The monitoring position on the balcony for control of recording volume.

end walls. On the side walls are located power outlets for set lighting, microphones, camera motors, and a signaling and inter-communicating system. A track system on the ceiling expedites the moving of equipment and set materials.

Monitoring Room.—The remainder of the third floor is given over chiefly to a monitoring room and balcony. (Figs. 2 and 3.) At the monitoring position on the balcony (Fig. 3), the action on the

set may be watched while the sound being recorded is projected into the monitoring room through loud speakers. (Fig. 2.) Control of recording volume takes place at the monitoring position, and by means of the intercommunicating and signaling system the monitor keeps in touch with all parts of the recording organization. The monitoring room is treated acoustically with rock-wool, but is considerably more "live" than the sound stage. Monitoring may also be done in a monitoring booth located on the sound stage, when desired. Interconnecting doors between stage and monitoring room

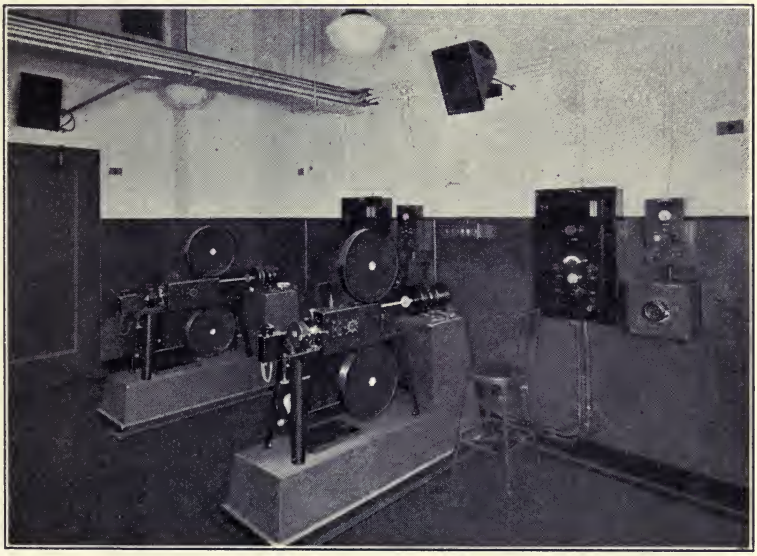

FIG. 4. The film recording room.

may be thrown open in such a way as to permit "long shots" to be taken the entire length of the building.

Scoring-Projection Room.—Under the monitoring balcony and between the sound stage and monitoring room is a scoring-projection room from which picture or sound, or both, may be projected into either sound stage or monitoring room, when these rooms are used for scoring or re-recording.

Dressing Rooms.—For the use of artists employed in experimental work, six dressing rooms have been provided on the second floor, including group and individual dressing rooms.

Recording and Power Rooms.—Film and wax recording rooms are installed on the second floor (Figs. 4 and 5) and include, in each case, two recording machines, together with control and announcing equipment. Amplifying and testing equipment occupies a room adjacent to the recording rooms. Two distributor systems for interlocking and controlling recording machine and camera motors are also available, as well as storage-battery power-supply for the recording system.

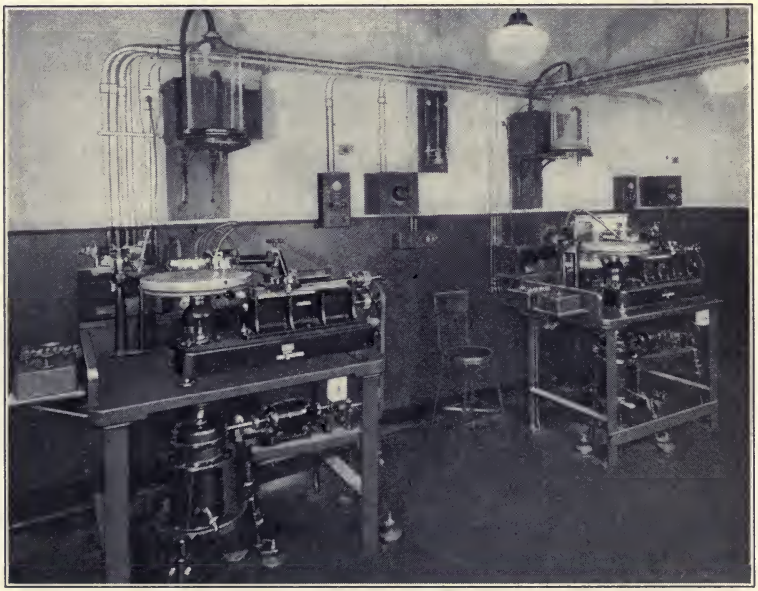

FIG. 5. The wax recording room.

Film Processing Plant.—To insure adequate experimental control of the processing of film recordings, complete printing and processing facilities have been included on the first floor of the new building. Two automatic and continuous processing machines are provided for negative and positive development. (Figs. 6 and 7.) Rack and tank equipment also exists. The output capacity of this plant is larger than is normally required by the experimental work, but a primary requirement is that the processing equipment employed shall be consistent with practice in the industry. Automatic control of the humidity and temperature of the air in the processing

rooms is available, and automatic recording equipment checks this control. Two printing machines of standard make are installed. Film-editing facilities are located adjacent to the processing rooms.

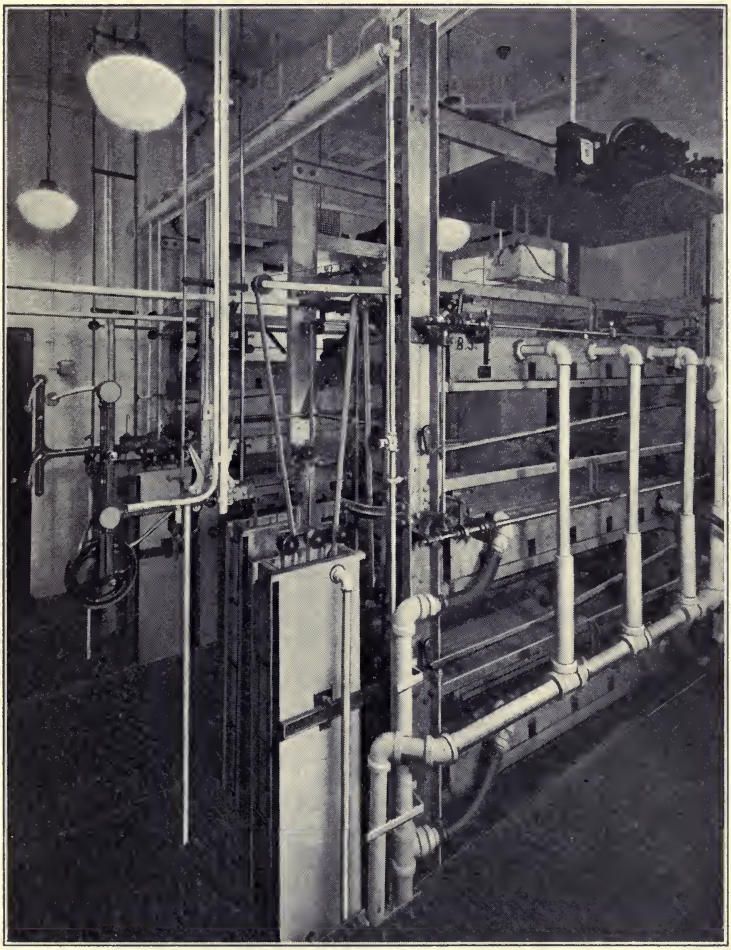

FIG. 6. Processing machine (development end).

In operating this plant, the utmost care is taken in supervision and maintenance to insure consistent and scientific results.

Optical and Photographic Laboratories.—As an aid to optical and photographic investigations associated with processing, and

with recording and reproducing, laboratories equipped with optical and photographic testing apparatus are provided on the second floor.

Review Room.—A small theater or review room is located on the first floor, and offers means for testing, by the reproduction of sound

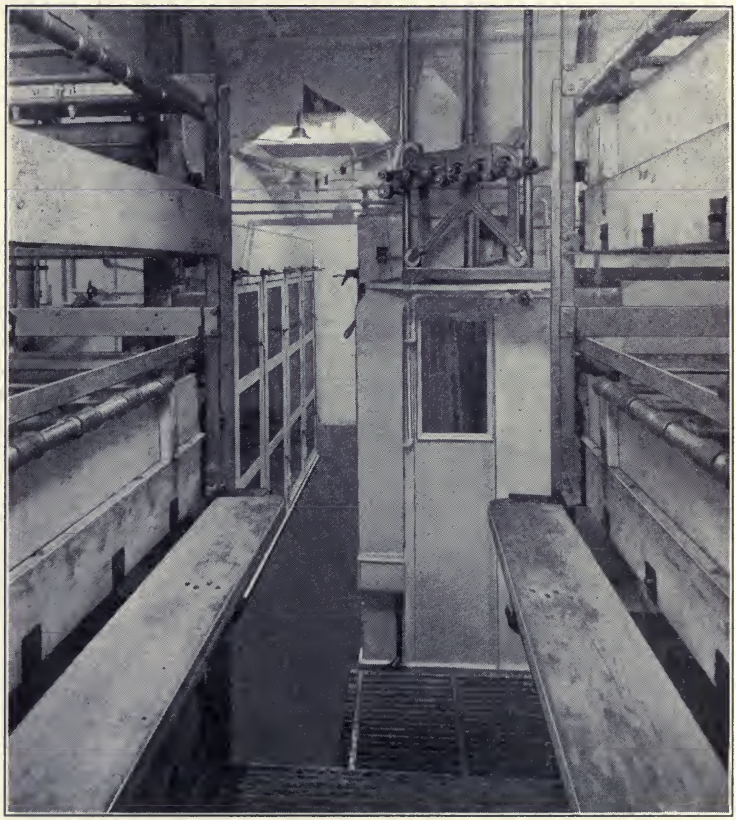

FIG. 7. Processing machines (spray tanks and drying cabinets).

or picture or both, the results of recording and processing. The projection equipment is of the standard theater type, and is maintained at a high level of performance.

Film Vault.—On the roof of the building is a film vault designed to accommodate about 1,500,000 feet of film. Both nitrate and safety type films are employed and stored.

Film Handling.—In general, care has been taken in the construction of the building and the arrangement of operating practices to do whatever is reasonably possible to minimize hazards due to the handling of inflammable film.

Supplementing the facilities of the laboratory building described above, a portable recording laboratory of the newsreel truck variety permits the prosecution of outdoor experimental work. The truck is so arranged that when not used to house recording equipment, measuring apparatus of various kinds can be operated in it.

Finally, contributing to the work of the laboratory unit are many individual design and testing laboratories within Bell Telephone Laboratories, which are concerned either entirely or in part with sound picture developments.

THE DEPTH OF FIELD OF CAMERA LENSES WITH SPECIAL REFERENCE TO WIDE FILM*

ARTHUR C. HARDY**

Summary.—*An analysis is made of the factors governing the apparent depth of field in a picture as judged by a person seated in the audience. The greatest depth of field results, for the same final magnification on the screen, when the focal length of both the camera and projector lenses are kept as short as possible. This procedure results in a greater magnification in projection, and the graininess of the film begins to be apparent if the process is carried too far. Actually the limit of magnification with 35 mm. film has been nearly reached with existing materials.*

It is shown in this paper that the use of a wider film for both negative and positive does not alter the depth of field, provided the same over-all magnification is used. Similarly, making a large negative and a smaller print has no effect on the depth of field under comparable conditions.

By the very nature of optical imagery, a lens is capable of forming a sharp image of only a single plane of the object space. In practice, however, such factors as the aberrations of the lens or the graininess of the film establish a limit for the useful sharpness, so there is a certain *depth of field* that may be said to be in sharp focus. The depth of field is sometimes called the depth of focus, but the latter term has a different significance in optical terminology.

The lack of depth of field of a lens is familiar to anyone who has ever attempted to make photographs with lenses of high relative aperture, but there is nevertheless a great deal of misinformation on this subject. This seems to be a consequence of the custom of judging the depth of field from the results of photographic tests, which are seldom conducted in such a manner as to yield results that are really significant. Even if they are, a lens of poor quality has apparently a greater depth of field than a well-corrected one, and the experimental method of determining the depth of field may therefore be very misleading. It is possible to treat this subject theoretically and, as it happens, the rigorous treatment is less complicated than the approximation that is sometimes made.

* Received by the Editor November 22, 1930.

** Massachusetts Institute of Technology.

This subject is particularly timely because of the current discussion concerning wide film. The effect on the depth of field, when photographing a subject on a wider film, is not immediately apparent. Nor is it apparent that the depth of field may be altered by making a large negative and printing by optical reduction on standard film. The purpose of this paper is to consider these questions in some detail, but before this can be done, a certain amount of optical theory must be developed.

THEORY

The depth of field of any lens or optical system is given rigorously by the two expressions

$$d_1 = \frac{rp}{m\rho - r} \tag{1}$$

and

$$d_2 = \frac{rp}{m\rho + r}, \tag{2}$$

where d_1 represents the depth of field on the far side of the object-plane in sharp focus and d_2 represents the depth of field on the near side. The total depth of field then is

$$d = d_1 + d_2 .$$

In the above equations, r represents the radius of the permissible circle of confusion, p is the distance from the entrance-pupil of the lens to the object-plane on which the camera is focused, m is the magnification of an object in this plane on the film, and ρ is the radius of the entrance-pupil of the lens.

An erroneous estimate of the depth of field of a lens is sometimes made on the basis of the so-called *hyperfocal distance*. This is the minimum distance of an object-plane on which the lens can be focused and still have objects at infinity appear sharp. In other words, for this condition, the far depth d_1 is infinite. From equation (1), it follows that this condition will obtain when

$$m\rho - r = 0 . \tag{3}$$

Now, in the Newtonian form of the lens equation,

$$m = \frac{f}{x},$$

where x is the distance of the object-plane in sharp focus from the

first focal point of the lens. On substituting for m in equation (3), we have

$$x = \frac{f\rho}{r}, \tag{4}$$

where x is the hyperfocal distance measured from the first focal point of the lens. Equation (4) can be written in terms of the $f/$ number of the lens, since this quantity is the ratio of the focal length to the diameter of the entrance-pupil. On substituting, we have

$$x = \frac{f^2 . f/\text{number}}{2r}. \tag{5}$$

When equation (3) is satisfied, equation (2) shows that the near depth

$$d_2 = \frac{p}{2}. \tag{6}$$

Hence, when a lens is focused on the hyperfocal distance given by equation (5), all objects are in sharp focus from infinity to a point half-way between the object-plane in sharp focus and the entrance-pupil of the lens.

Now, a short hyperfocal distance indicates a great depth of field when the camera is focused on the hyperfocal distance. It is sometimes concluded from equation (5), therefore, that the depth of field of a lens varies inversely as the $f/$ number and inversely as the square of the focal length. This argument takes no account of the fact that the size of the image varies with the focal length, and that a smaller circle of confusion is required for comparable quality in a small picture than in a large one. Furthermore, the lack of depth of field is seldom troublesome when the camera is focused on an object at the hyperfocal distance, but rather when it is focused on a nearby object. Under the latter conditions, the quantity r in the denominator of equations (1) and (2) becomes negligible compared with the quantity $m\rho$. Hence equations (1) and (2) become simply

$$d_1 = \frac{rp}{m\rho} \tag{7}$$

and

$$d_2 = \frac{rp}{m\rho}; \tag{8}$$

and the total depth of field is

$$d = d_1 + d_2 = \frac{2rp}{m\rho}. \tag{9}$$

The ratio p/ρ in the above equation can be transferred to corresponding quantities in the image-space by means of the well-known relationship in optical theory that

$$m = -\frac{\rho p'}{\rho' p},$$

where p' is the distance of the film from the exit-pupil of the lens and ρ' is the radius of the exit-pupil. Equation (9) may then be rewritten as follows:

$$d = d_1 + d_2 = \frac{2rp'}{m^2\rho'}. \tag{10}$$

Now, any comparison of the depth of field of two lenses must be made on a basis that insures the same exposure in both cases, since manifestly any desired depth can be obtained by reducing the lens aperture. It is a well-known fact that the amount of illumination on the film in the image of an extended object is determined by the ratio p'/ρ'.[1] Assuming a constant value for this ratio, the depth of field is seen from equation (10) to vary directly with the permissible size of the circle of confusion r and inversely as the square of the magnification. This result is independent of the particular form of the lens. In other words, any claim that one lens has a greater depth of field than another is absurd. If experimental tests seem to indicate a difference between lenses, either the two lenses were not used at the same effective aperture and magnification, or the image quality of one is inferior to that of the other and its depth only appears to be greater.

The lack of depth of field is apparent to the motion picture audience when the size of the circle of confusion on the screen exceeds a certain limiting value. Let us designate by R the radius of the largest permissible circle of confusion on the screen. Then

$$R = rm_pm_s,$$

where m_p is the magnification between the negative and positive in printing (in contact printing this quantity is 1) and m_s is the magnification of the film on the screen in projection. Substituting for r in equation (10), we have

$$d = \frac{2R}{m^2m_pm_s} \cdot \frac{p'}{\rho'}. \tag{11}$$

Let us assume now an object or actor of height h in the plane on which the camera is focused. The corresponding height of the image on the screen is

$$H = hmm_pm_s. \tag{12}$$

Let us designate the over-all magnification between the object and its screen image by M, where

$$M = \frac{H}{h} = mm_p m_s. \tag{13}$$

With this substitution, equation (11) becomes

$$d = \frac{2R}{mM} \cdot \frac{p'}{\rho'}. \tag{14}$$

We see, therefore, that for a fixed value of R and p'/ρ', the depth of field, as seen by the audience, varies inversely as the original magnification in the camera and the over-all magnification M. In other words, it is just twice as hard to obtain sufficient depth when the actor's head is to be ten feet high on the screen as when it is only five feet high. The advantage of making m small will be dealt with presently.

APPLICATION TO PRACTICE

Let us consider the case of standard 35 mm. practice where both the negative and positive film are of this width and the printing is done by contact. Equation (14) shows that, for a fixed over-all magnification M, there is a definite gain in making the magnification m, in taking, as small as possible. This implies either using camera lenses of short focal length or placing the camera at a great distance from the actors. For the same over-all magnification M, equation (13) shows that m_s must be increased in proportion to the decrease in m. In other words, the greatest depth of field is seen to result by making the original negative with as low a magnification as possible and re ying on subsequent enlargement to provide the required over-all magnification. The limit to the subsequent enlargement is set by the graininess of the negative material. Unfortunately, this limit has been reached with 35 mm. negative film, as the magnification in the projector is already so high that any further increase makes the graininess decidedly objectionable. We must conclude, therefore, that the depth of field for a given effective lens aperture p'/ρ' is about as great as it can ever be made with 35 mm. film unless the graininess of the film can be reduced enough to permit greater magnification in projection.

Let us now consider the effect of making the original negative and release prints on a wider film. For the sake of convenience, let us

assume the film to be 70 mm. in width, or twice as wide as the 35 mm. standard. There are several possible ways of utilizing this increased width, but most producers seem to regard the wider film as an opportunity to include more action on a larger screen, the size of images on the screen remaining approximately as at present. If this plan is followed, it is obvious from equation (14) that the depth of field with wide film, at the same over-all magnification M and the same magnification in projection, is identical with that obtained in 35 mm. practice. This implies the use of camera and projector lenses of the same focal length as at present. If, on the other hand, larger images are projected on the larger screen, the increased over-all magnification M can be obtained only by increasing either m or m_s. It is impossible to increase m_s without increasing the appearance of graininess. Hence, any increase in M must be the result of increasing m, and equation (14) shows that this procedure will decrease the depth of field. This is not exactly true, because a somewhat larger circle of confusion can be tolerated with a larger screen. Nevertheless, the fact remains that larger images on the screen are obtainable only by sacrificing depth of field.

Consider now the case where the negative is 70 mm. in width and the release prints are 35 mm. in width, the printing being done by optical reduction. Since the quantity m_p in equations (12) and (13) does not appear in equation (14), it follows that this reduction process neither increases nor decreases the depth of field when the other conditions are met—that is, when the same magnification m is used in the camera and a final image of the same size is projected on the screen. Equation (13) shows that when m_p is one-half, as it is approximately under these conditions, the magnification in projection m_s must be twice as great to keep the over-all magnification M the same. It is claimed, with some justice, that this reduction process reduces the graininess and that the magnification in projection m_s can therefore be increased over what is possible when the print is made by contact. If the reduction in graininess is one-half, so that the magnification in projection can be doubled, the depth of field of pictures produced in this way is the same as with the two methods that have been discussed previously. It may be remarked in passing that it is no more difficult to design a projection lens to cover the 35 mm. film than one to cover the 70 mm. film if they are of the same relative aperture, but, with the same relative aperture, the illumination on the screen with the 35 mm. film will be approximately one-fourth as great. In addition, pro-

jection from the smaller film at a higher magnification imposes more severe requirements on the steadiness of the film in the gate.

REFERENCE

[1] See, for example, "The Distribution of Light in Optical Systems," A. C. Hardy, *Journal of the Franklin Institute*, Vol. 208, No. 6, December, 1929. It may be remarked in passing that the f/number is a measure of the illumination on the film only when the lens is focused on an object at infinity.

TWO-WAY TELEVISION*

HERBERT E. IVES**

Summary.—*An experimental two-way television system in combination with a telephone service has been installed between two buildings in New York. With this system, two people can both see and talk to each other. It consists in principle of two complete television systems of the sort previously used for one-way transmission. Scanning is accomplished by the beam-scanning method using disks containing 72 holes. Purple light, to which the photo-electric cells used are quite sensitive, is employed for scanning, and a yellow-green light is used for illuminating the television booth. High-intensity neon lamps are used with a condenser lens disk at the receiving end to give an image brilliant enough to be seen without interference from the scanning beam. A frequency band 40,000 cycles wide is required for each of the two television circuits. Synchronization is effected by a 1275 cycle alternating current, controlling synchronous motors rotated 18 times per second. Speech is transmitted by microphones and loud speakers concealed in the television booths so that no telephone instrument interferes with the view of the face.*

Ever since the initial demonstration of television both by wire and by radio at the Bell Telephone Laboratories in 1927, experimental work has been steadily pursued in order to learn the problems and possibilities of this newest branch of electrical communication. The latest development to be demonstrated is that of two-way television as an adjunct to the telephone. As a result of this development work, there is now set up an experimental and demonstration system operating between the headquarters building of the American Telephone and Telegraph Company at 195 Broadway, and the building of the Bell Telephone Laboratories at 463 West Street, New York City, two miles away. This system makes it possible to experiment with a method of communication in which the parties engaged not only speak with each other, but at the same time see each other. Study of this system will serve to give information on the importance of the addition of sight to sound in communication and will give valuable experience in handling the technical problems involved.

In principle the two-way television system consists of two complete

* Presented at the Fall 1930 Meeting at New York, N. Y., at a session held at the Bell Telephone Laboratories

** Bell Telephone Laboratories.

systems of the same sort as those used for one-way transmission in the demonstration from Washington to New York City in 1927. In place of a scanning disk and set of photo-electric cells at one end for generating the television signals, and a single disk and neon lamp at the receiving end for viewing the image, there are in the two-way system, two disks at each end and a bank of photo-electric cells and a neon lamp at each end. One of the disks, which, in the system as constructed, is 21 inches in diameter, serves to direct the scanning beam from a high intensity incandescent lamp onto the face of one of the

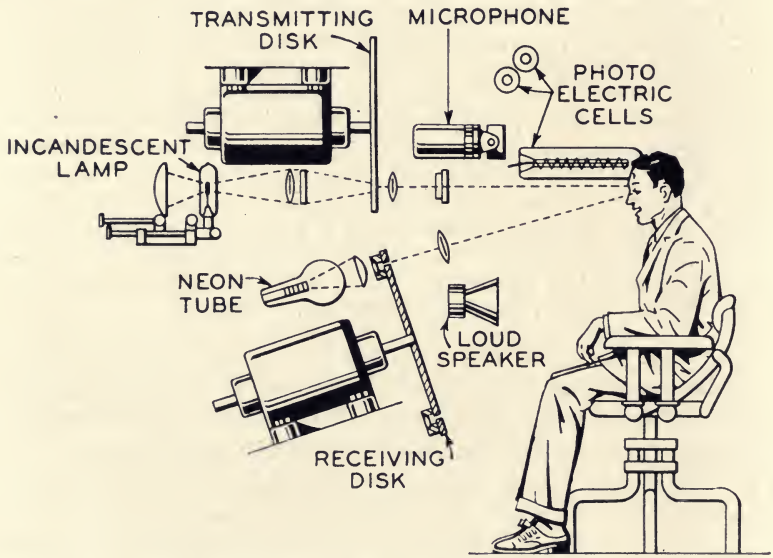

FIG. 1. Schematic diagram of one terminal of the two-way television apparatus.

parties to the conversation. (Fig. 1.) Fourteen photo-electric cells, arranged in banks on either side, before and above the person's face, pick up the reflected light and generate the television signals. The second disk, which is 30 inches in diameter, is placed below the sending disk and exposes through its holes the neon lamp, which the observer sees through a magnifying lens in a position slightly below that of the scanning beam. This neon lamp is, of course, actuated by the signals coming from the distant end of the system, where there is a similar arrangement of two disks, photo-electric cells, and neon lamp.

The two parties to the conversation take their places in sound-

proof and light-proof booths, where, sitting in front of the photo-electric cells, they look at the image of the person at the other end at the same time that the scanning beams play over their faces. (Fig. 2.) A problem of illumination is immediately encountered in that the scan-

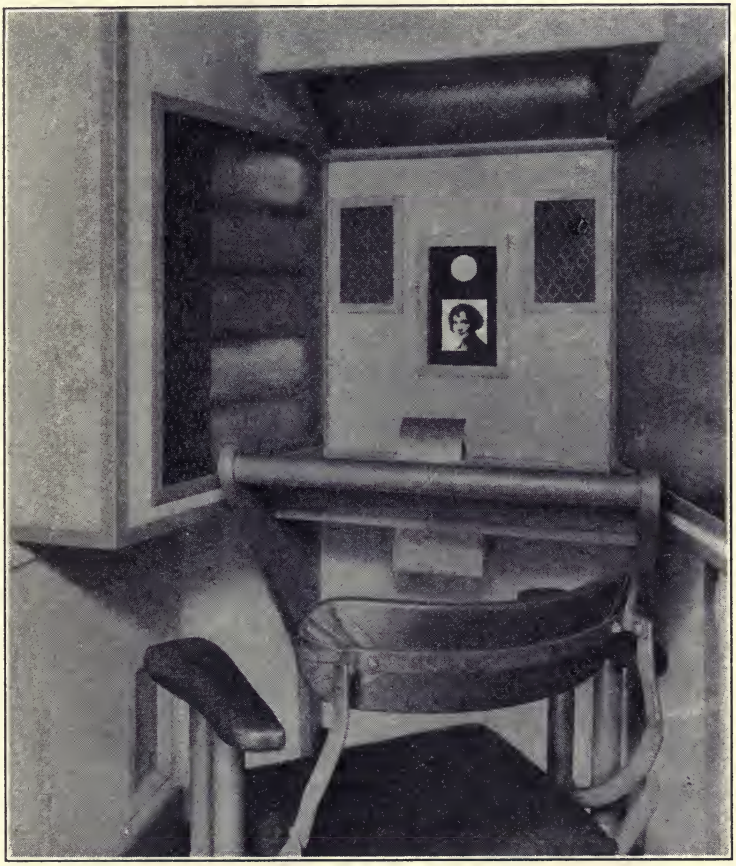

FIG. 2. Interior of television booth showing position of incoming image, and just above it, the hole through which the scanning beam is projected. The photo-electric cells are behind the glass panels.

ning beam is of necessity intensely bright and tends to dazzle the eyes to the extent that the somewhat faint neon lamp image is hard to see. This difficulty is met by using light for scanning to which the human eye is relatively insensitive, and by selecting types of photo-electric

cells which are highly sensitive to this special light. Part of the cells are of potassium, highly sensitive to blue light; the others are of caesium, highly sensitive to red light. The scanning light is a mixture of red and blue from the ends of the spectrum. The scanning beam

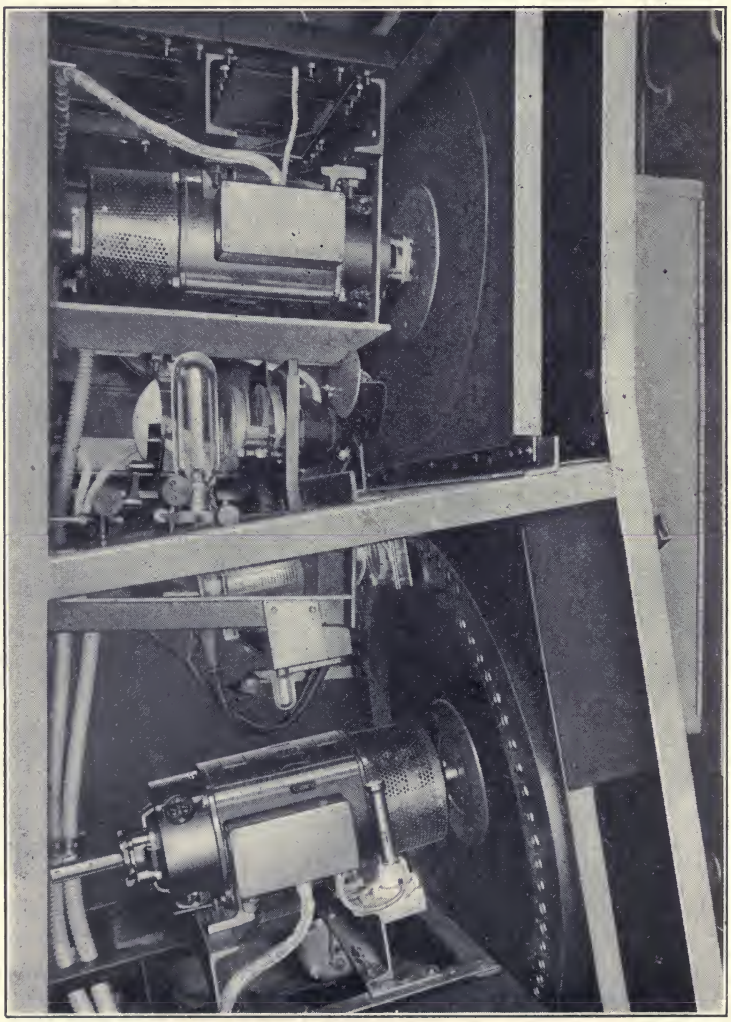

FIG. 3. Side view of synchronous motors and scanning disks. The incandescent lamp furnishing the scanning light is shown behind the upper disk; the neon lamp which translates the incoming signals into light is shown behind the lower disk.

is perceived only as a spot of purple light in the lens which projects it, not bright enough to interfere with clear vision of the neon lamp which provides the image of the person located at the distant end. Adequate general illumination of the booth is provided by lamps furnished with yellow-green filters, transmitting light to which neither type of photo-electric cell is sensitive.

In the original demonstrations of one-way television, scanning disks were used which had fifty holes arranged in a spiral. With this number of holes, it is possible to secure a definitely recognizable representation of the human face. It was decided, however, that for the two-way system a degree of definition should be provided such that faces were rendered in an entirely recognizable and satisfactory manner. Accordingly, the number of scanning holes has been increased to seventy-two, which provides just twice the number of image elements. The transmission band is, of course, doubled by this change, requiring wire connections of considerably higher quality than heretofore. When a seventy-two hole scanning disk is used the component frequencies of the image signal encompass a range of from 10 to 40,000 cycles per second, whereas intelligible speech may be reproduced by a signal wave whose component frequencies cover a range of 2500 cycles per second. This comparison roughly indicates how much more difficult it is to transmit high quality television images than it is to transmit ordinary speech. In general, the electrical features of the apparatus are similar to those previously used, although in the interval improvements and refinements have been made in many directions. (Fig. 3.)

Light reflected into the photo-electric cells gives rise to an alternating electric current whose effective value is of the order of a ten-thousand-billionth ampere. The neon glow lamp on which the image is received at the distant station reproduces the image satisfactorily when the effective value of the alternating current is of the order of one-tenth ampere. This thousand-millionfold increase in current variation, considerably greater than was required for the earlier one-way system, is effected by amplifiers in which the vacuum tubes are coupled by condensers and resistances. The tubes, which operate at low energy levels, are shielded against electrical, mechanical, and acoustical interference.

For the transmission of images between 463 West Street and 195 Broadway, the appropriate stages of the amplifier system are coupled by special transformers to telephone cable circuits equipped with spe-

cial distortion correcting networks which are capable of transmitting the extremely complex current variations without distortion. The amounts of distortion inherent in other parts of the system are either kept small by design or annulled by means of correcting networks.

An indispensable part of a television system is the means for holding

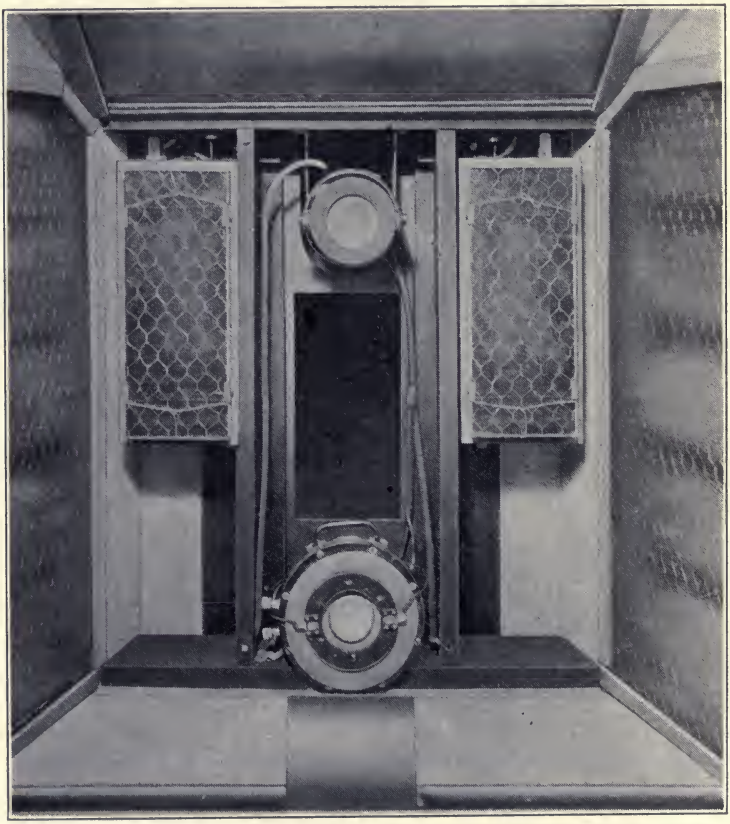

FIG. 4. Microphone and loud speaker used for two-way conversation, in conjunction with the two-way television system. These are ordinarily concealed by the front wall of the booth.

several scanning disks accurately at the same speed. For the two-way television system, a simplified and improved synchronizing arrangement is used. The disks at the receiving and transmitting ends, which rotate at a speed of 18 revolutions per second, are synchronized by means of a vacuum tube oscillator located at one end of the line

and delivering a frequency of 1275 cycles per second at a low power level. This frequency is transmitted over a separate pair of wires, and controls, at the receiving end, by means of vacuum tubes, the field strength of the motor thereby holding its speed exactly proportional to the frequency. In the same way, the speed of the motor at the transmitting end is controlled by a similar vacuum tube circuit so that its speed is also proportional to the frequency of the same oscillator, and thus the motors driving the scanning disks at both ends of the line are held in synchronism. By using a frequency of 1275 cycles per second, the degree of synchronization is held within sufficiently close limits to keep the picture at the receiving end central within its frame to within a small fraction of the picture width. Novel features of this synchronizing system are the use of mechanically damped couplings between the disks and motor shafts, for improving the steadiness of the image, and of an electrical phase shifter for framing the images.

The acoustic portion of the two-way television system is unusual in that it permits simultaneous two-way conversation without requiring either person to make any apparent use of telephone instruments. It is obviously desirable to arrange the acoustic system in this way because the ordinary telephone instrument conceals part of the face and would thus prevent the system from approximating the conditions of ordinary face-to-face conversation. The elimination of telephone instruments is accomplished by using a microphone sensitive to remote sounds and a loud speaker concealed near the television image at each station. (Fig. 4.) The microphone at one station is connected through suitable vacuum tube amplifiers and a telephone circuit to the loud speaker at the other station. This permits conversation in one direction while a similar connection between the other microphone and loud speaker permits conversation in the other direction. The persons using the system then communicate as if face to face, with no telephone system apparently involved.

In order that the transmitted sounds be familiar and natural, distortion in the sound transmission system has been reduced to a minimum. The microphones are of the condenser type used extensively in radio broadcasting and sound picture recording. Being of small size, they are readily concealed near the television image in the most advantageous position for picking up the voice. The loud speaker, also of small size but capable of reproducing a broad frequency range, is likewise concealed near the television image, so that the sounds

produced appear to emanate from the image itself. This loud speaker is of the moving coil type with a small piston diaphragm.

In any system such as that described, the microphone is not capable of distinguishing between the sounds from the local speaker or from

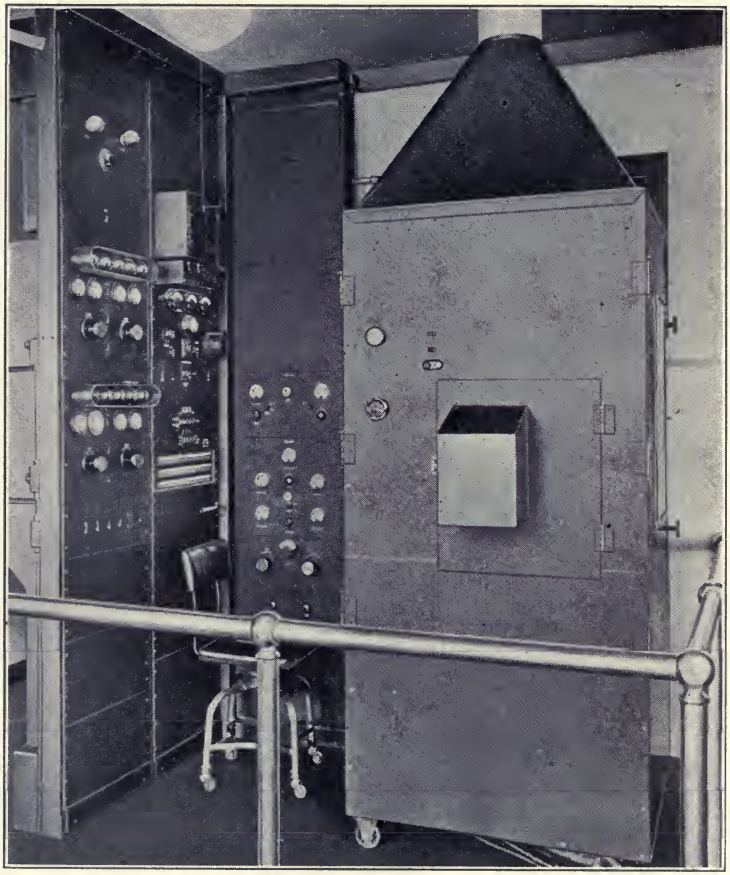

FIG. 5. Scanning disk cabinet and control panels for two-way television at 195 Broadway.

a speaker at the remote end of the circuit reproduced locally by the local loud speaker. If the sounds from the local loud speaker should be impressed upon the local microphone in sufficient magnitude, "singing" would result, and the system would be no longer operable. To prevent this the microphone and loud speaker are installed in care-

fully chosen positions, and the inner surfaces of the sound-proof booths are specially treated to prevent as much as possible the reflection of sounds from the walls into the microphone. Under these conditions, the attenuation of transmitted sounds is of about the same magnitude as would be experienced if the listener were, say, 10 or 12 feet away, but in the same room. This acoustic illusion of distance is in harmony with the visual appearance of the television image.

In addition to the television synchronizing and acoustic circuits, others are provided for signaling and monitoring purposes. Matters are so arranged that an operator can see both the outgoing and incoming image. (Fig. 5.) By means of movable lens and prism systems he can be assured that the scanning beam is properly directed to correspond to the height of the observer and that the received image is properly placed for observation.

Operating arrangements are made so that the two parties to the conversation, after taking their positions in the booths, do not see or hear each other until adjustments are made, whereupon the operators expose the images and connect the talking circuits simultaneously. The experimental service is arranged on an appointment basis. The two parties to the conversation, having arranged with attendants at the two stations for their time, proceed to the respective booths, where they are ushered into chairs in position before the photo-electric cells and instructed as to the operation of the system. Immediately after the attendant closes the booth door the operators make the necessary adjustments, and the simultaneous sight and sound communication is carried on until, upon the parties leaving their chairs, the connections are interrupted.

A TRUCK MOUNTED LABORATORY FOR THE DIAGNOSIS OF THEATER ACOUSTIC DEFECTS*

VESPER A. SCHLENKER**

Summary.—*Experience in acoustic diagnosis by application of Sabine's formula indicates the need of more comparative data for the solution of acoustical problems in theaters. For this purpose, the acoustical truck described in this paper was developed. The various uses of the truck and apparatus housed by it in studying reverberation, distortion, and transients, frequency characteristics, etc., of theaters are described. Oscillograms obtained in a number of such tests are presented.*

A year and a half ago the Vitaphone Corporation decided to accept some responsibility for the correct transmission of sound in the theaters from the loud speakers to the audience. The officials and engineers had learned through disheartening experience that sound which is properly recorded in the studios may become almost unintelligible when reproduced under certain conditions.

Previous experience in acoustic diagnosis by means of Sabine's formula only proved that much more quantitative data are needed for the solution of acoustical problems in theaters. A knowledge of the reverberation period alone is not sufficient. It became evident that the required specific data on a particular theater could be obtained only by means of the very best electro-acoustic apparatus. The effects of domes, barrel ceilings, curved walls, balcony cavities, as well as the characteristics of the loud speakers, had to be known with some degree of accuracy for each theater. The demands for low expense in acoustic correction made it very necessary that a complete survey be made.

THE ACOUSTIC TRUCK

With these conditions in mind an "acoustic truck" was developed and designed for making more complete surveys than those which have been possible heretofore.

An interior view of the acoustic truck is shown in Fig. 1. The frame

* Presented at the Fall 1930 Meeting at New York, N. Y.

** Vitaphone Corporation, Brooklyn, N. Y.

at the right carries an oscillator, an oscillograph and its motor, various transformers, thermocouples, meters, and frequency modulators. The upper cabinet at the left contains spare parts and other accessories. The lower cabinet is a desiccator for four condenser microphones and their associated amplifiers. The rack immediately behind carries the transmitting amplifiers, frequency-calibrating panel,

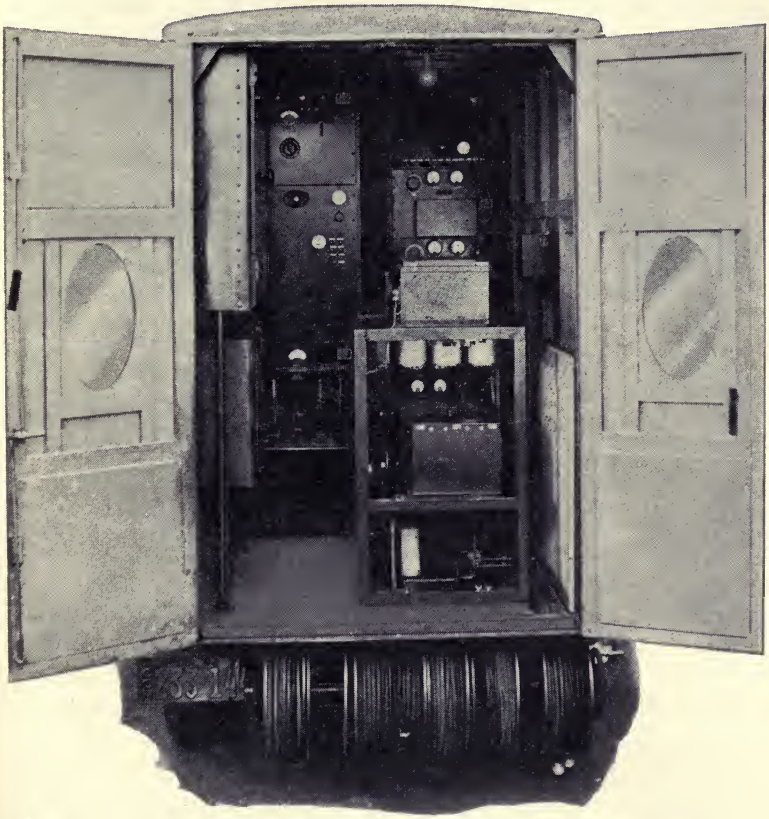

FIG. 1. Interior view of the acoustic truck taken from the rear.

switching panel, and relay. A small light-proof booth between the driver's seat and the transmitting amplifier rack is equipped with film, fixing tanks, and dark-room lamp. The reels for the cables to the microphones, speakers, volume indicator, telephones, and power-supply outlets are mounted outside under the rear doors.

When an acoustic survey of a theater is to be made the truck is parked at the curb near the rear door. The loud speakers are mounted on the stage near the picture screen and their cables are run in from the reels. The microphones and cables are likewise taken into the theater and placed in position. A telephone line is unreeled and drawn in for the necessary communication between the auditorium and the truck. The 110 volt, a-c, power-supply cable is also connected to an outlet in the theater in order to supply the truck with power for the transmitting amplifiers.

REVERBERATION TESTS

In the reverberation test a single-frequency tone is modulated over a half octave by means of a frequency modulator connected to the oscillator. This warbling tone is projected into the theater by means of the transmitting amplifiers and the loud speakers on the stage. When a steady-state condition has been reached the tone is interrupted electrically by means of a relay. Simultaneously, the shutter of the oscillograph is opened and the decay of the sound is photographed as shown in Fig. 2. Two oscillograph traces are employed. Fig. 3 is a block diagram of the apparatus used for measuring reverberation. The upper portion represents the transmitting equipment and the lower portion the receiving equipment with its associated microphones, panels, amplifiers, and oscillograph vibrators.

The output of the loud speakers is picked up by the microphones, passed through the panel P_2 and amplifier A_2, and thence to the oscillograph V_2. The amplifier A_3 is used to monitor the output of amplifier A_2 and is adjustable in 3 db. steps of gain above A_2, the attenuator x being provided for this adjustment.

The trace obtained from V_1 is exactly like that obtained from V_2, except for the amplitude, which in general is greater. The two traces so obtained are shown in Fig. 2.

If the level of V_1 is adjusted to, say, 24 db. above that of V_2, it is clear that the time required for V_1 to be attenuated to the original value of V_2 is a measure of the reverberation period of the theater being studied. That is, referring to Fig. 2, if the amplitude of the trace V_1 at the instant A is the same as that of trace V_2 at the instant B, it is clear that during the time interval t, the drop must have been equal to 24 db., which is the difference in level of the two amplifier-oscillograph channels. It is a simple matter to calculate the time for a 60 db. drop, which is generally used as the period of reverberation.

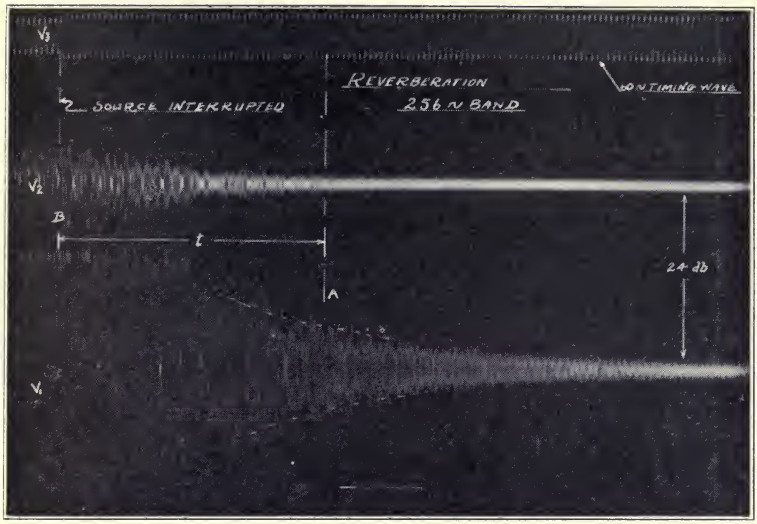

FIG. 2. Oscillograph traces obtained in the reverberation test.

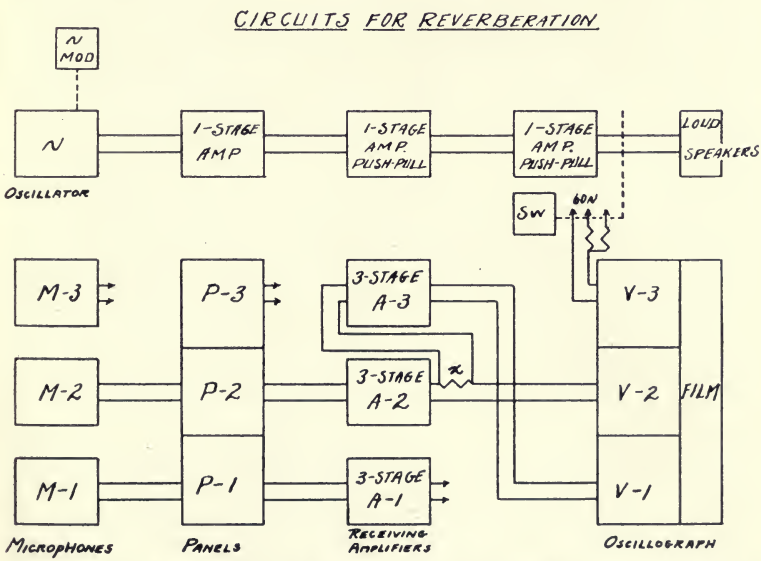

FIG. 3. Block diagram of apparatus used for making reverberation measurements. Various switching arrangements are provided for but are not shown in the diagram.

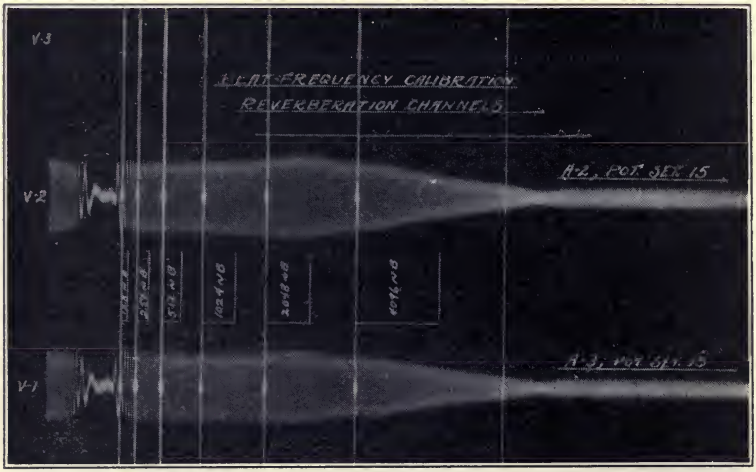

FIG. 4. Traces obtained in test of frequency characteristics.

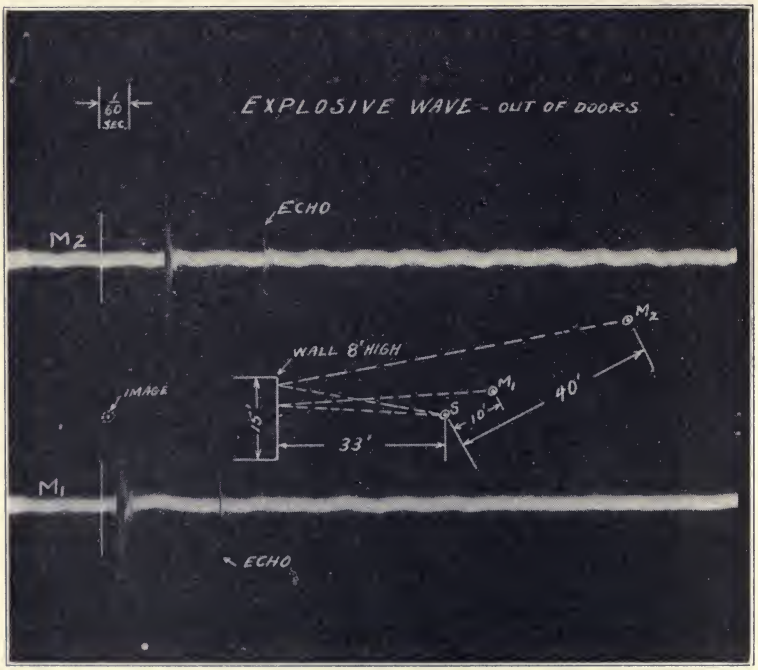

FIG. 5. Traces obtained in simple study of echoes, using the explosive signal.

FREQUENCY CHARACTERISTICS

Frequency characteristics can be taken by causing the beat-frequency oscillator to sweep through the entire audible range. Fig. 4 shows the traces obtained when the output of the transmitting amplifiers is connected through a resistance pad to the input of the receiving amplifier. The half-octave bands are indicated. A comparison of the two traces will serve to show that satisfactory characteristics covering oscillator, transmitting amplifiers, receiving amplifiers, and oscillograph vibrators are obtained.

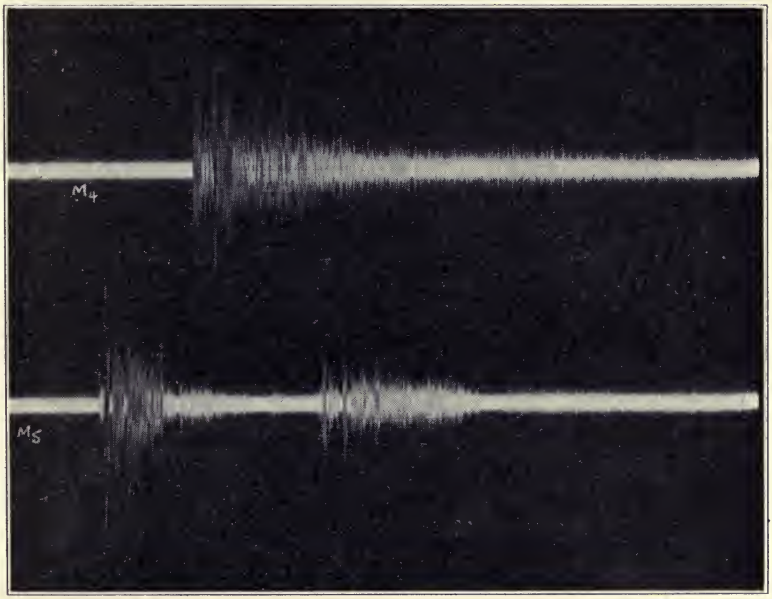

FIG. 6. Traces showing the occurrence of echoes in a theater.

It follows that the characteristic of any part of the theater equipment may be determined by inserting it in place of the resistance pad. Furthermore, the characteristic of the theater equipment as a whole may be determined by substituting for the oscillator a sound disk or film as was done in obtaining the traces of Fig. 4. The disk or film can be played in the ordinary manner when the microphone is placed in the auditorium. The resulting oscillogram will give the over-all frequency characteristic.

THE EXPLOSIVE SIGNAL

In theater acoustics the location of the source of sound is fixed so that an opportunity for locating material to the best advantage presents itself. In this respect the acoustics of theaters differs from that of other auditoriums where the source is not confined to a fixed location. In order to properly locate the acoustic treatment it is obvious that more knowledge of the acoustic contributions of the various surfaces of the interior should be known. Important information of this kind is acquired from an explosive signal which is set off on the

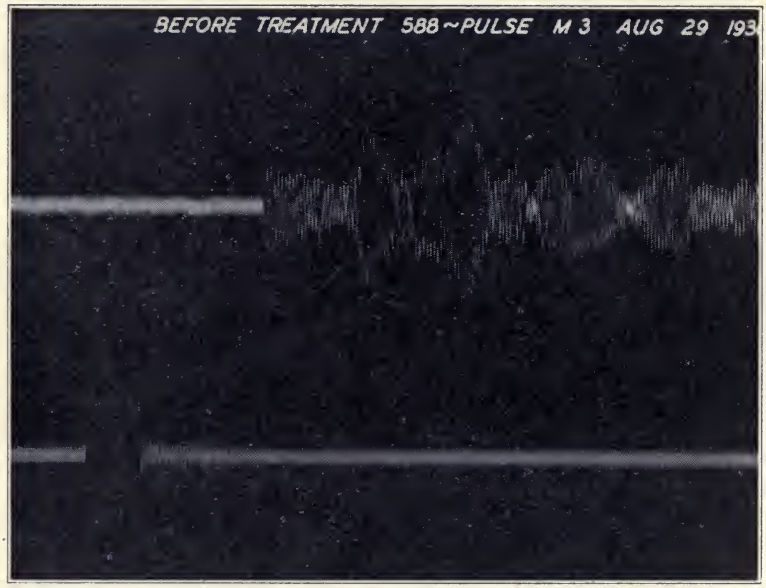

FIG. 7. Traces obtained by using the "synthetic syllable" in an untreated theater.

stage in front of the loud speakers. With two vibrators connected to the outputs of two independent channels it is possible to record on the same oscillogram the direct and multiple reflections picked up by two microphones.

Referring to Fig. 5, which gives traces obtained out-of-doors with this arrangement, the two microphones, M_1 and M_2, were set up on a flat roof with only one small reflecting wall in the immediate vicinity. This represents a very simple case of echo-sounding, in which the image is first located and then the reflecting surface. It should be

observed that the signal itself covers a very short period of time compared with the time-interval between the direct sound and its echo.

When this test is applied to a theater the resulting oscillograms are much more complicated, as indicated in Fig. 6. The upper trace M_4 represents the sound in the balcony at the rear of this particular theater while the lower trace M_5 is the sound picked up in the orchestra near the front. It will be noted that a very definite echo exists in the front of the house.

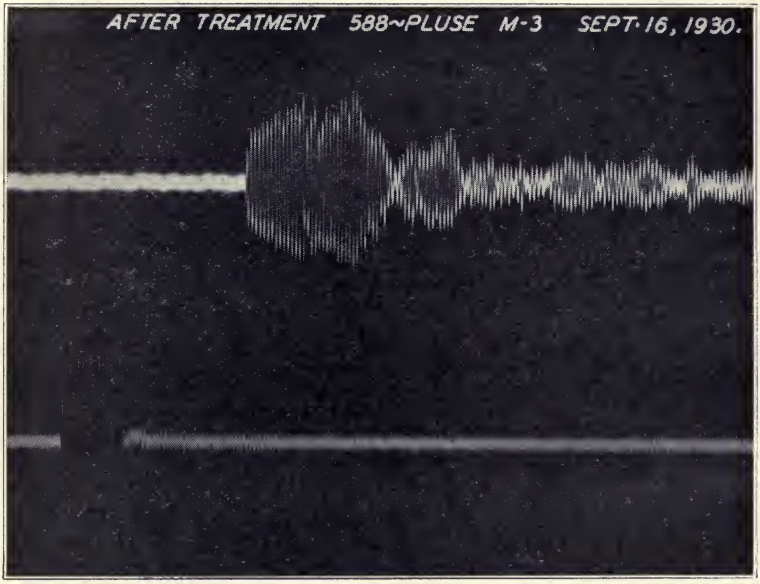

FIG. 8. Traces obtained using the "synthetic syllable" in a theater after acoustic treatment.

USING THE SYNTHETIC SYLLABLE

Further information can be obtained by employing a single syllable of speech. For analytical purposes a syllable can be simulated by a single-frequency pulse. The length of the pulse can be varied if necessary, but three-hundredths of a second is as short as any speech sound used by the average speaker. The frequency can be varied over the audible range to include the various frequency components. Reflections and echoes of this signal when projected from the loud speakers can be recorded on oscillograms. The results of such a test in a theater before treatment are shown in Fig. 7. The lower

trace represents the sound picked up by a microphone placed four feet in front of the speakers. The upper trace is due to another microphone at the rear-center of the theater. After acoustic improvement the same test was repeated giving the condition indicated in Fig. 8. It is evident that the pronounced series of echoes has been effectively reduced.

Intensity distribution in the various seats of a house may be de-

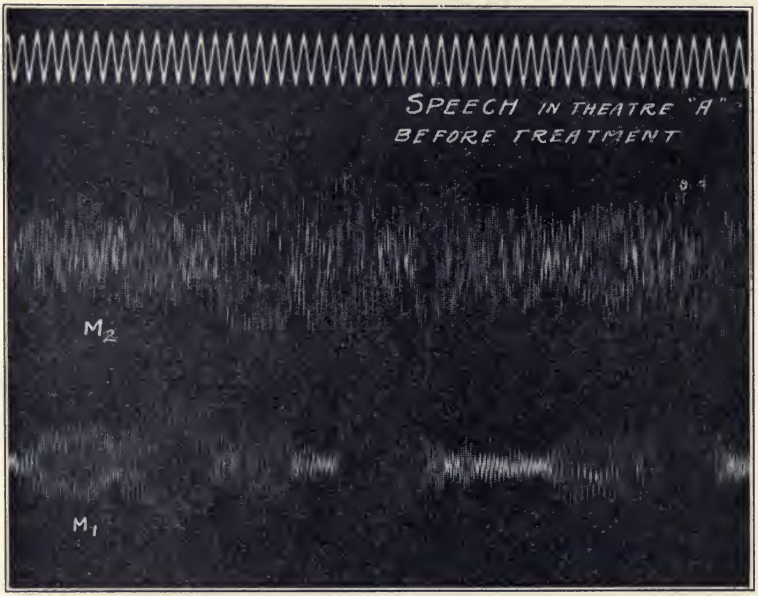

FIG. 9. Traces of speech from microphones at two different positions in the theater before acoustical treatment.

termined by the use of the "synthetic syllable" just described. Because of the multiplicity of the observations it is sufficient to record the deflections of the volume indicator on the output of the receiving amplifier when the syllable is projected by the theater loud speakers. In this way the making of many oscillograms is avoided, thereby increasing the speed of this test.

The room noise level in most theaters has been found to be so high that it offers a serious handicap in making reverberation measurements. Before making such measurements the noise level is determined so that the signal can be made sufficiently loud. The receiving amplifier gain is then adjusted accordingly.

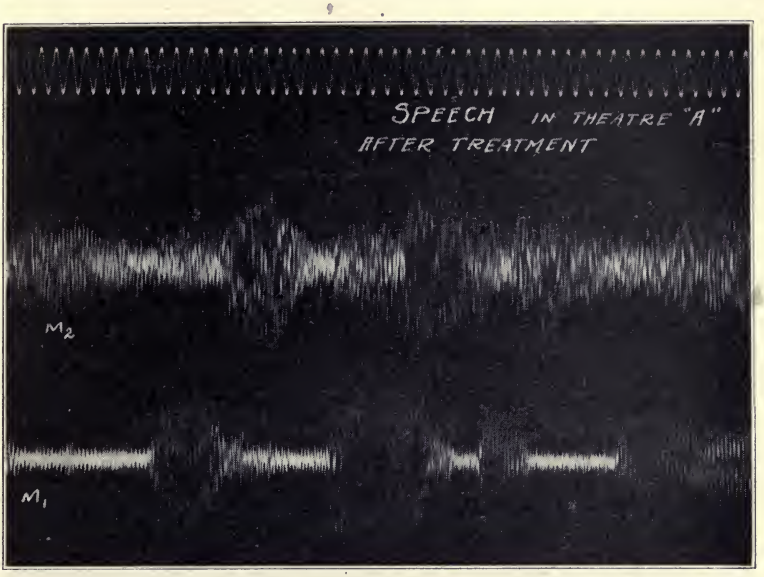

FIG. 10. Traces of speech obtained from microphones at two different positions in the theater after acoustical treatment.

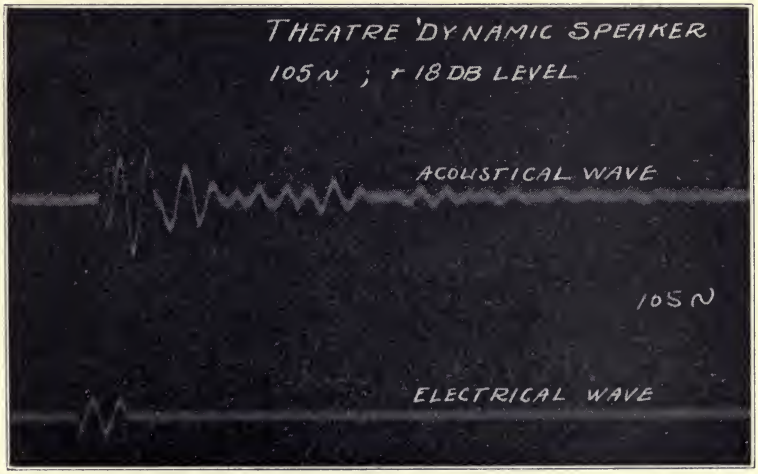

FIG. 11. Traces obtained for a dynamic speaker in a theater showing phase distortion and transients.

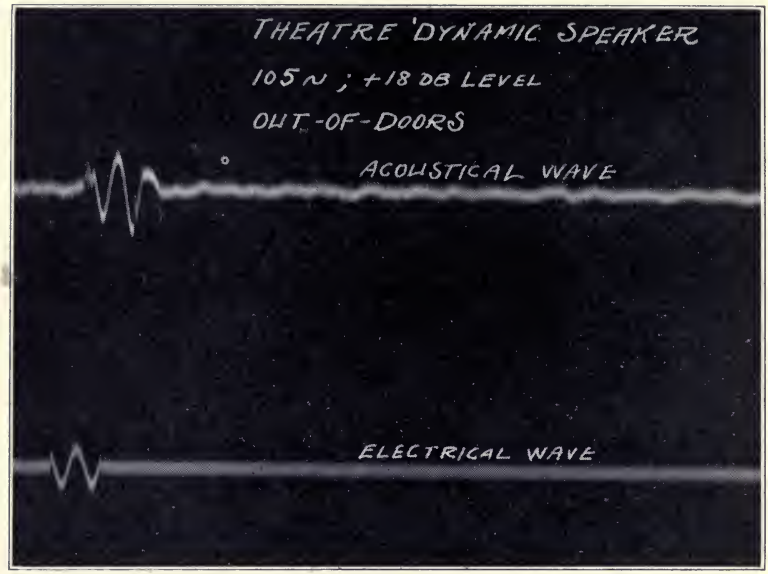

FIG. 12. Traces obtained for same conditions as those in Fig. 11 but out-of-doors instead of indoors.

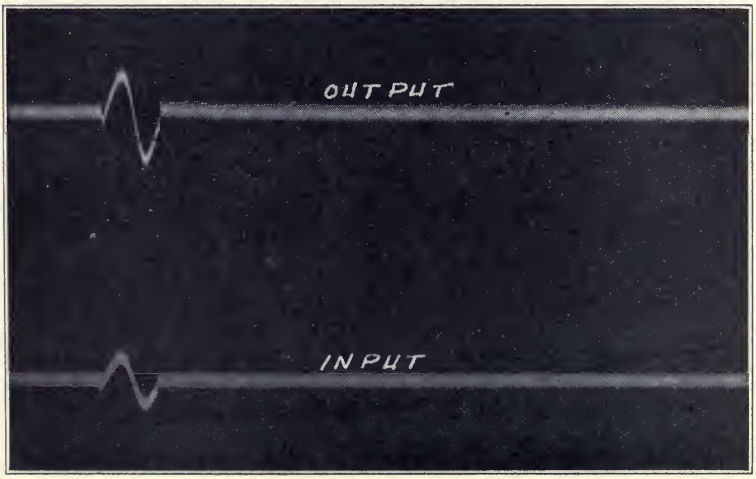

FIG. 13. Traces showing freedom from distortion of theater power amplifier.

SPEECH DISTORTION

An excellent indication of the over-all distortion of speech which comes from the loud speakers of the permanent theater equipment can be obtained by making an oscillogram with two traces as shown in Fig. 9. The lower trace represents the speech which is picked up by a microphone M_1 placed about four feet in front of the speakers. The upper trace represents the same speech as picked up by the microphone M_2 at the center of the orchestra. M_1, then, is the sound as it is projected from the speakers while M_2 is the sound received by the listeners. The distortion at M_2 is so great that the syllables are barely discernible. After acoustically treating the theater the experiment was duplicated in every detail with the results shown in Fig. 10. The improvement is evident. The individual syllables are easily identified in the upper trace. It should be observed that all these tests were made without the presence of an audience. Proper allowance must be made for the acoustic absorption which would be due to the audience.

PHASE DISTORTION AND TRANSIENTS

During the routine testing of every part of the apparatus it was discovered that loud speakers used as a part of theater equipment are responsible for a large amount of distortion. When a known electrical wave is put into the speakers the acoustical wave projected should be a faithful copy. In Fig. 11 are shown the results of such a test on theater electro-dynamic cone speakers in a room with walls and ceiling covered with rock-wool one inch thick. The same experiment repeated out-of-doors gave the results shown in Fig. 12. Phase distortion as well as transients are in evidence. The results of the tests of the electro-acoustical units are in sharp contrast to the result obtained from a similar test of a theater power amplifier. In Fig. 13 are shown traces of the electrical wave put into the amplifier and the electrical wave delivered. No distortion is evident on this oscillogram.

Although the acoustic truck has been designed for theater work, any auditorium can be tested which can provide the a-c power-supply. Extensive experimental data on various acoustic materials have already been obtained by means of this apparatus in connection with a sound chamber. After a material has proved its merits in the test chamber it can then be installed in the theater where it is again tested under actual operating conditions.

DISCUSSION

MR. WEINBERGER: Has a means been found for determining the effect of the audience on the acoustical performance and of the scattering of the sound by the audience? Also, has any study been made of the effect of radiating sound from the horns in various directions on the reverberation produced in the theater? To what extent would this influence the oscillograms? By what means do you locate or identify the various surfaces which cause the reflections shown on the oscillograms and what is the correlation between these surfaces and the oscillographic traces?

MR. SCHLENKER: I have not studied the effect of the audience on the acoustical performance because of the difficulty of performing experiments with audiences. Perhaps later on we can go into these problems. However, there is no doubt that selective reflection occurs when an audience is present.

MR. WEINBERGER: The reverberation certainly will be influenced by the direction in which the sound is projected; have you studied this? The acoustical performance is greatly affected by audience reflections and I believe that these reflections contribute to a great extent toward the final result.

MR. SCHLENKER: All our work has been done in empty houses. The presence of the audience affects the local reverberation period not so much over the 60 db. range as it does over the first 10 or 15 db. Over the latter range, the presence of the audience or of an absorbing surface has a marked effect on the decay of sound. We have not gone into the study in detail, and I am not able to answer your question fully.

MR. EYRING: In how many theaters have you made measurements of this kind? How do the measured values agree with the values calculated by the reverberation formula using accepted absorption coefficients.

MR. SCHLENKER: Measurements were conducted in ten theaters. The work is just commencing, and it has been difficult to obtain adequate equipment. There is no close correlation between the calculated and the measured values because my measurements of reverberation are taken over a 20 db. range. This is necessary because of the high noise level which exists in most theaters. The loud speakers available will not permit more than a 30 db. increase above the noise level. However, the decay over the first 20 db. is the more important. Further decay is masked by the noise in the room.

MR. ROSS: Was any attempt made to determine the particular surfaces of the auditorium which caused the reverberation? Since the speed of the moving film in the oscillograph is known, as well as the speed of propagation of sound, this should be possible. If, during a certain time-interval the sound wave travels a distance of 36 feet, it is clear that the disturbing surface must be 18 feet from the loud speaker. Upon locating the surface in this manner, it could be treated without going to the expense of treating the whole auditorium.

MR. SCHLENKER: Knowing the time-interval and the floor plan of the theater, I have been able to calculate the most probable location of offending surfaces as close to the speaker as 6 inches.

SOME NEW RCA PHOTOPHONE STUDIO RECORDING EQUIPMENT*

W. P. DUTTON AND S. READ, JR.**

Summary.—*An illustrated description is given of some new input equipment for sound recording. This equipment provides for mixing the audio outputs of four or eight microphones into the recording amplifier, which has two output channels. Some of the interesting features of this equipment are: (a) Constant impedance mixing, providing constant load on each microphone amplifier for all combinations of volume control settings, thus giving unchanging fidelity and a constant output level from each microphone channel for all combinations of volume control settings in the other channels: (b) Filter for eliminating low rumbles, caused by room vibrations, wind disturbances, etc., can be switched "on" or "off" at the mixer. This filter does not affect the fidelity above 100 cycles. (c) Recording amplifier, having two output channels, supplying two loads with no interaction between them. Each channel has a convenient switching arrangement for changing the output transformer ratio, making possible the operation of one, two, or three 500 ohm loads in parallel. (d) Each unit of the equipment is designed to mount on a standard relay rack or in an individual box equipped with handles for carrying.*

From the experience gained in the design of the two previous types of photophone recording equipment and from new operating and design requirements obtained through contact with the West Coast Studios, general requirements for this new recording equipment have been formulated. The usual set-up for recording requires from one to four microphones. In special cases where large symphony orchestras or other organizations of similar magnitude are to be recorded, more than four microphones may be required. The equipment as a whole must be easily portable, so that the studios which use it do not require a permanent set-up of amplifiers with radiating lines to the several pick-up points. This portability is a distinct advantage, since it allows the maximum efficient use of the equipment. The procedure for operating this equipment must be as simple as possible, so that the operators can focus all of their attention upon the scene, which is being recorded.

The complete control of the equipment must be in the hands of

* Presented at the Fall 1930 Meeting at New York, N. Y.
** RCA Victor Company, Inc., Camden, N. J.

one man, usually the chief recordist, who presides at the mixer. The controls on the equipment must be so adjusted with respect to each other, that, once the level is established, the chief recordist can conveniently control the over-all output. In the particular arrangement which is now being used by some of the RCA Photophone licensees, a mixer booth, which includes space for the chief recordist, mixer panels, microphone control panels, power supply to the microphone and monitoring speaker, is usualy located directly on the stage. The amplifier and film recorder are usually housed in a separate booth somewhat off the stage. Each unit of the equipment must be capable

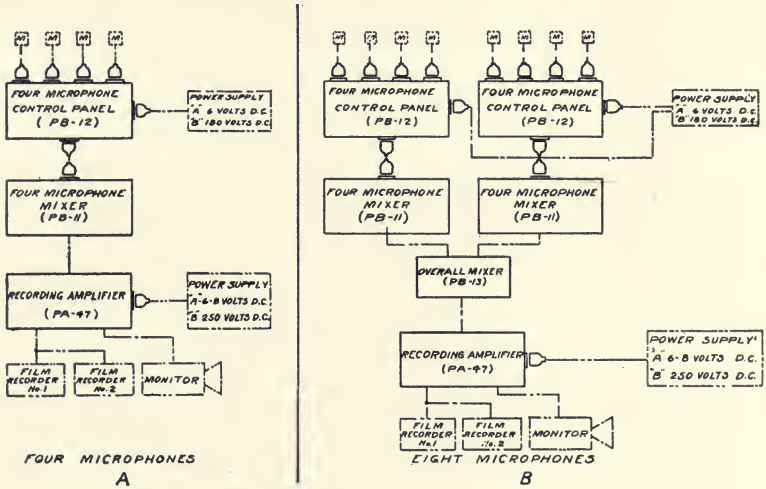

FIG. 1. Block diagram—recording equipment for four and eight microphones.

of operating by itself or in any arrangement of similar equipment. In addition to its use in the portable form, this equipment must also be suitable for mounting on a standard relay rack where this is desired.

DESCRIPTION OF EQUIPMENT

Using the above requirements as a foundation, this new equipment provides for the following features:

For the set-up where one to four microphones are required, a four-microphone mixer has been designed. This is used in conjunction with a control panel for supplying power to the four microphones and connecting the audio output of the microphones to the mixer panel. From the mixer panel, the audio signal is connected to the input of

the recording amplifier, which has two similar output stages. For the set-up where more than four microphones are required, two of the four-microphone mixers and two of the four-microphone control panels are supplied. An additional unit is furnished for combining the audio outputs of the two four-microphone mixers. This unit is known as the over-all mixer. The recording amplifier remains the same. A block diagram shown in Fig. 1 gives a graphic picture of these two set-ups.

Each unit of this equipment is mounted in a carrying case which is provided with the necessary handles for carrying. These units are of such size and weight that they can be easily carried by one man, with the exception of the amplifier, which weighs approximately 65

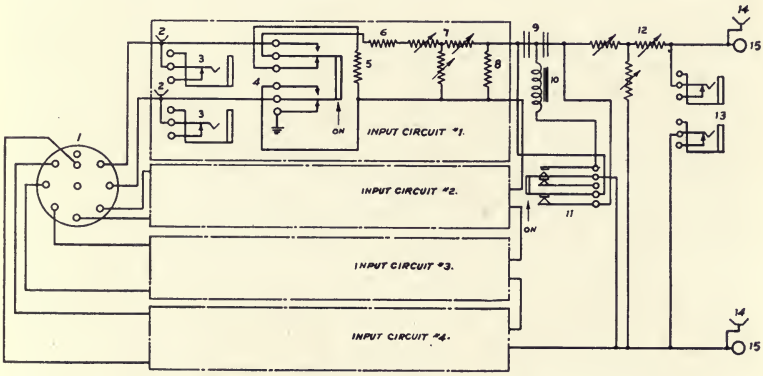

FIG. 2. Schematic diagram—four-microphone mixer (PB-11).

lbs. Each unit of this equipment has the minimum number of controls without sacrificing any of the desirable technical and operational features. Each unit can be operated by itself, with the remaining parts of the equipment or with equipment of a similar type. Those units which require power for the "A" and "B" circuits have a switch, fuse, and a signal light, built in as part of the unit. For the case where it is desired to mount these units on a relay rack, shields and terminals for wiring connections are provided. A more detailed description of the several units is given below.

FOUR-MICROPHONE MIXER (PB-11)

The four-microphone mixer provides for the following:

(1) Control of the individual audio outputs of four-condenser

microphone amplifiers, each having an output transformer designed to work into a 250 ohm line.

(2) Control of the combined output of the four-microphone amplifiers.

(3) Switching means for connecting or disconnecting any one of the four-microphone circuits at will.

(4) An attenuating network to cut off frequencies below 100 cycles.

Referring to Fig. 2, the audio inputs to this panel are connected through an eight-conductor cable, plug, and receptacle from the four-microphone control panel, or directly to the respective input ter-

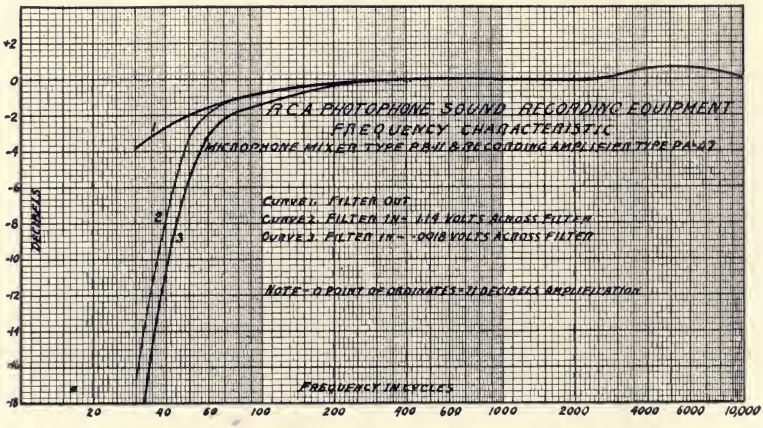

FIG. 3. Frequency characteristic—four-microphone mixer (PB-11).

minals. The audio output of the panel is connected to terminals and binding posts. Listening jacks are provided for each of the four input circuits and also the output circuit, for headphone monitoring or trouble shooting. The double-pole, double-throw "on"-"off" switches for each microphone circuit operate as follows:

In the "on" position they connect the input from the receptacle, input terminals and listening jacks direct to the corresponding "T"-pad circuit. In the "off" position they disconnect the input receptacle, input terminals and listening jacks from the "T"-pad circuit, ground one side of the input line, and connect another resistor to the "T"-pad circuit to simulate the load of the microphone amplifier. The "T"-pads used in this mixer are of the constant impedance, con-

tinuously variable type. Two arms of the pads have straight resistance variation and the third arm is tapered for proper loading. The over-all attenuation of the mixer is twenty decibels, the lower range having straight line variation.

The connections and loading are so arranged that the load on each microphone amplifier is constant for all settings of the volume control. This connection insures unchanging fidelity from each microphone amplifier and that the output level from each microphone channel is not affected by the volume control settings in the other channels. The calculations of the mixing circuits, particularly the proper loading

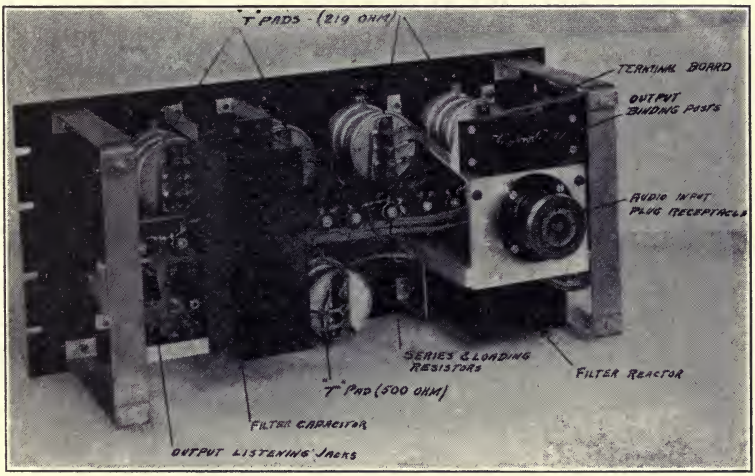

FIG. 4. Four-microphone mixer—rear view showing unit removed from box (PB-11).

for constant impedance mixing, presented an interesting problem. The equations used in these calculations are covered in the "Appendix."

The filter for attenuation of frequencies below 100 cycles can be switched "on" or "off" at will. It consists of two sections and gives a curve as shown in Fig. 3.

Curve 1 is the normal frequency characteristic of the recording amplifier. Curve 2 is the frequency characteristic of the mixer and recording amplifier, as connected for normal operation, with 1.14 volts across the filter. Curve 3 is the same with 0.0018 volt across the filter. These two voltages are probably the maximum and mini-

mum voltages which will be encountered and therefore represent the limits of the filter cut-off under actual operating conditions. Such a characteristic tends to reduce low frequency disturbances caused by room vibrations, wind currents, *etc.*

The filter switch operates as follows: In the "on" position, it connects the two capacitors in series with the line, and the reactor across the line, to the over-all volume control. In the "off" position, it short-circuits the capacitors and disconnects the reactor. A rear

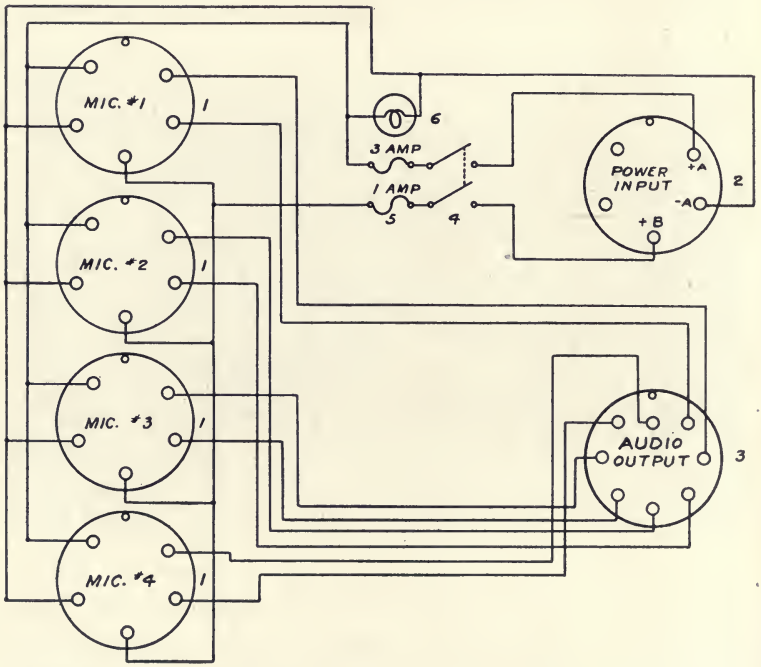

FIG. 5. Schematic diagram—four-microphone control panel (PB-12).

view of the four-microphone mixer, removed from the box, is shown in Fig. 4. The identities of the several parts are as indicated.

FOUR-MICROPHONE CONTROL PANEL (PB-12)

The four-microphone control panel provides for the following:

(1) Control of the power-supply to four-condenser microphone amplifiers with suitable protection for "A" and "B" supply.

(2) Separation of the audio outputs of the four-condenser microphone amplifiers and transfer to the four-microphone mixer.

Referring to Fig. 5, the power input to the panel is connected through a five-conductor male plug, a power-control switch and two fuses for protection of the "A" and "B" supply. The signal light indicates when the filament voltage is "on." The audio and power inputs to the microphone amplifiers are connected through four five-

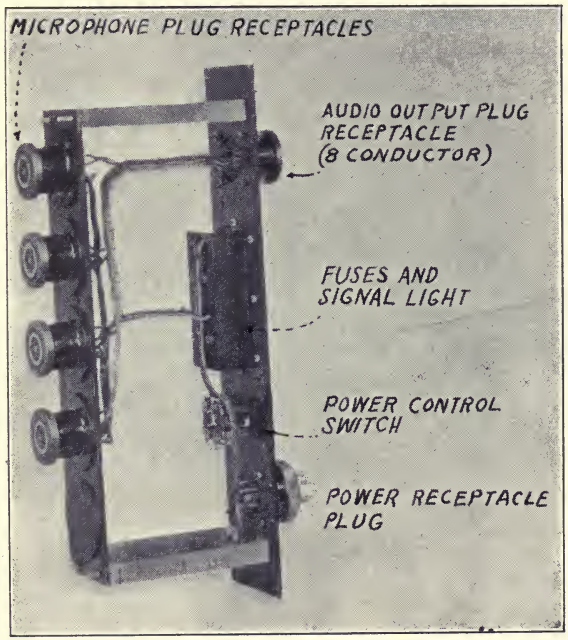

FIG. 6. Four-microphone control panel—bottom view showing unit removed from box (PB-12).

conductor, female receptacles. The audio output of each microphone amplifier is connected to a pair of contacts in the eight-conductor receptacle, and then by cable to the four-microphone mixer. A bottom view of the four-microphone control panel removed from the box is shown in Fig. 6. The identities of the several parts are as indicated.

OVER-ALL MIXER (PB-13)

The over-all mixer provides for the following:

(1) Connection of the audio outputs of two of the four-microphone mixers into one over-all control.

(2) Connection of the combined output to the recording amplifier.

Referring to Fig. 7 the audio inputs to this panel are connected through binding posts or terminals from the two four-microphone mixers. The audio output is also connected to binding posts and terminals. Listening jacks are provided in each input circuit and in the output circuit for head-phone monitoring or trouble shooting. The double-pole, double-throw "on"-"off" switches for each input circuit operate as follows:

In the "on" position, they connect the input from the binding posts, input terminals and the listening jacks, direct to the "T"-pad circuit. In the "off" position they disconnect the binding posts, input ter-

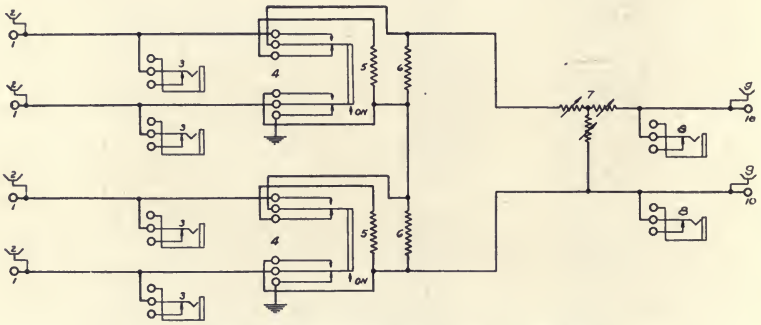

FIG. 7. Schematic diagram—over-all mixer (PB-13).

minals and listening jacks from the "T"-pad circuit, ground one side of the input line, and connect another resistor to the "T"-pad circuit to simulate the load of the four-microphone mixer. The same general equations as derived for the mixing circuit of the four-microphone mixer are used for this panel. These equations are covered in the "appendix." A rear view of the over-all mixer removed from the box is shown in Fig. 8. The identities of the several parts are as indicated.

RECORDING AMPLIFIER (PA-47)

The recording amplifier provides for the following:

(1) Sufficient amplification to supply the recorder with the proper audio level under the most adverse conditions to be encountered in the usual stage set-up.

(2) Sufficient undistorted audio power for the operation of two recorders similar to the type PR-4 Recorder described by Kellogg.[1]

(3) A frequency response of plus or minus one decibel, from the 1000 cycle value, over a range from 100 to 10,000 cycles.

(4) Sufficient controls, so designed that the audio output can be controlled from the mixers for ordinary operating conditions, without touching the amplifier.

The recording amplifier contains a four-stage voltage amplifier, utilizing UX-864 Radiotrons, connected to the paralleled input of two similar push-pull power stages, utilizing UX-171-A Radiotrons. It has an over-all amplification of approximately 85 db. and the maximum undistorted power output from each of its output stages is 800

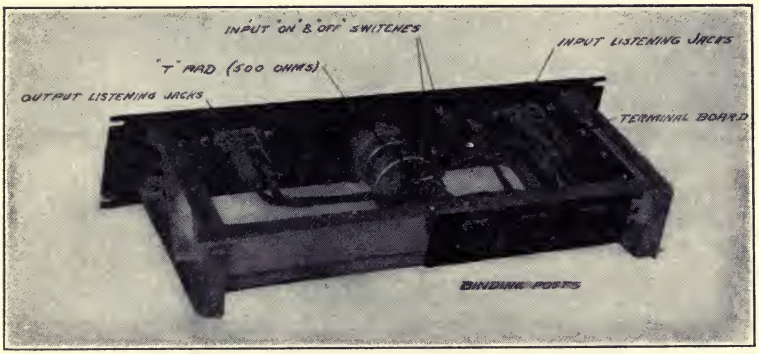

FIG. 8. Over-all mixer—rear view showing unit removed from box (PB-13).

milliwatts. Two volume controls are provided; the main one is connected across the secondary of the input transformer and has twenty steps with 2-db. variation between steps; the auxiliary volume control is connected in the grid circuit of the second voltage amplifier and has three steps with 20-db. variation between steps. The only other controls on the face of the panel are the power control switch and the rotary switch for transfer of the meter from one circuit to the other.

Referring to Fig. 9, the audio input to this panel is connected through binding posts or terminals from either the four-microphone mixer or the over-all mixer, depending upon the particular set-up. The audio output of each power stage is also connected to binding posts and terminals. Listening jacks are provided in the input cir-

cuit and also in each output circuit, for head-phone monitoring or trouble shooting. The power input to the panel is connected through a five-conductor female receptacle or terminals, to a power control switch and fuses for protection of the "A" and "B" supply. The

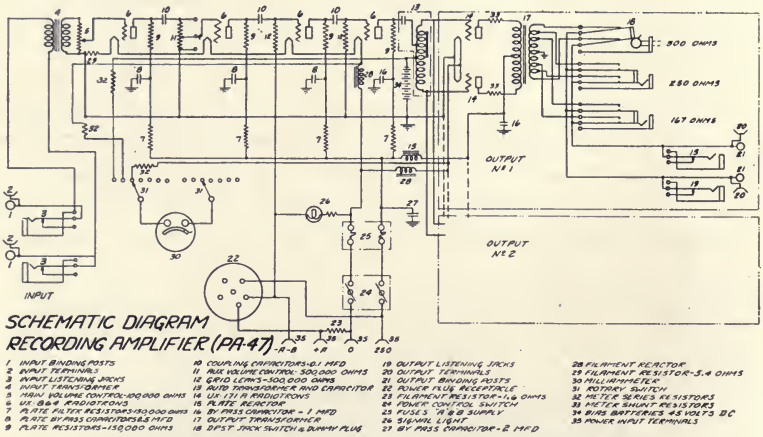

FIG. 9. Schematic diagram—recording amplifier (PA-47).

signal light indicates when the filament voltage is "on." Metering of the bias voltage on the UX-171-A stages, filament voltage on the UX-864 and the UX-171-A power stages, and plate currents of the power stages are observed by means of a d-c milliammeter in connection with suitable series resistors, shunts, and a rotary switch.

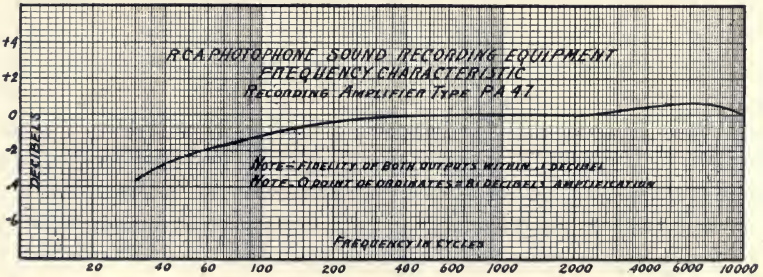

FIG. 10. Frequency characteristic—recording amplifier (PA-47).

The input transformer is designed to work from a 500 ohm line, has a balanced primary with mid-tap, and a static shield between the primary and secondary windings. The main volume control has a maximum resistance of 100,000 ohms. There is a variation of 2 db.

between steps with an "off" position. The filaments of the four UX-864 Radiotrons are connected in series with a filament reactor in the positive side and a series resistor in the negative side. This connection provides a bias potential which is successively more negative for each stage. The filaments of the UX-171-A power stages are connected in parallel with a filament reactor in the positive side. The UX-864 plate circuits consist of a plate reactor which is common to the four tubes, individual series resistors with by-pass capacitors

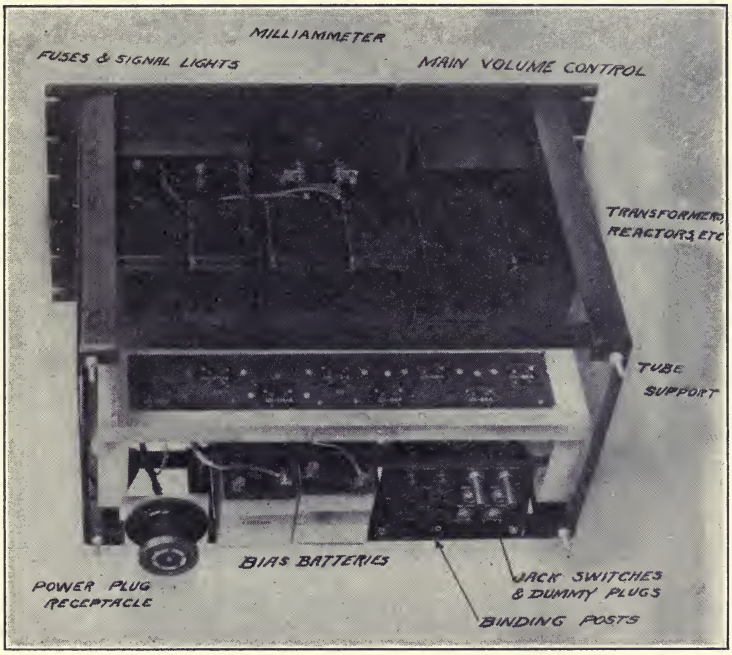

FIG. 11. Recording amplifier—rear view showing unit removed from box (PA-47).

for filtering, and the plate resistor. Coupling condensers between stages are of such value that the required fidelity curve can be obtained.

Each UX-171-A plate circuit consists of a plate choke, primary of the push-pull output transformer, and plate current metering shunt. The grids of each push-pull output stage are supplied from the plate circuit of the last voltage amplifier stage through a coupling capacitor and auto-transformer. The four grids of the two stages are connected

in push-pull, parallel across the auto-transformer. The output transformer of each stage has a balanced secondary with mid-tap. Three taps either side of this mid-tap are provided for working into a 500 ohm, 250 ohm, or 167 ohm line. The power required for operation of this amplifier is 1.25 amperes at 6 to 8 volts d-c for filament supply and 0.065 ampere at 250 volts d-c for plate supply.

Some of the design features which lessen external disturbances and contribute to the stable and convenient operation of this amplifier are:

(1) Use of the UX-864 non-microphonic Radiotron. This tube was originally developed for use in the RCA condenser microphone where a non-microphonic tube is absolutely required for quiet operation.

(2) The two filament circuits each have a filter reactor.

(3) Plate battery supply to the amplifier is by-passed by condensers.

(4) Each stage of the voltage amplifier has a resistance-capacity filter in its plate circuit.

(5) Each output stage has a convenient switching arrangement for changing the output transformer ratio so as to work into a 500 ohm, 250 ohm, or 167 ohm line.

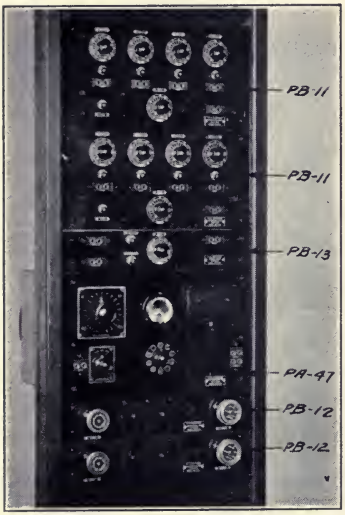

FIG. 12. Recording equipment for microphones.

A fidelity curve of this amplifier is shown in Fig. 10. A rear view of the recording amplifier removed from the box is shown in Fig. 11. The identities of the several parts are as indicated.

Referring again to Fig. 1, a view of the equipment for eight microphones mounted in a standard relay rack, is shown in Fig. 12. The several units in each of these photographs may be identified by their type numbers.

APPENDIX

DERIVATIONS OF FORMULAS AND CALCULATIONS FOR CONSTANT-IMPEDANCE MIXING SYSTEM

The output of a microphone amplifier can be controlled (decreased or attenuated) keeping the load on the amplifier and the resistance

looking from the other side of the controlling device toward the amplifier *constant* if a "T" resistance section is used. Referring to Fig. 13 (Part 1), the resistance R of such a section is the resistance looking into either end when the other end is loaded with a resistance R. If the desired ratio of input to output voltage is represented by K and the input and load resistances by R the value of R_1, R_2, and R_3 are

$$R_1 = R_2 = R\left[\frac{K-1}{K+1}\right] \tag{1}$$

$$R_3 = R\left[\frac{2K}{K^2-1}\right]. \tag{2}$$

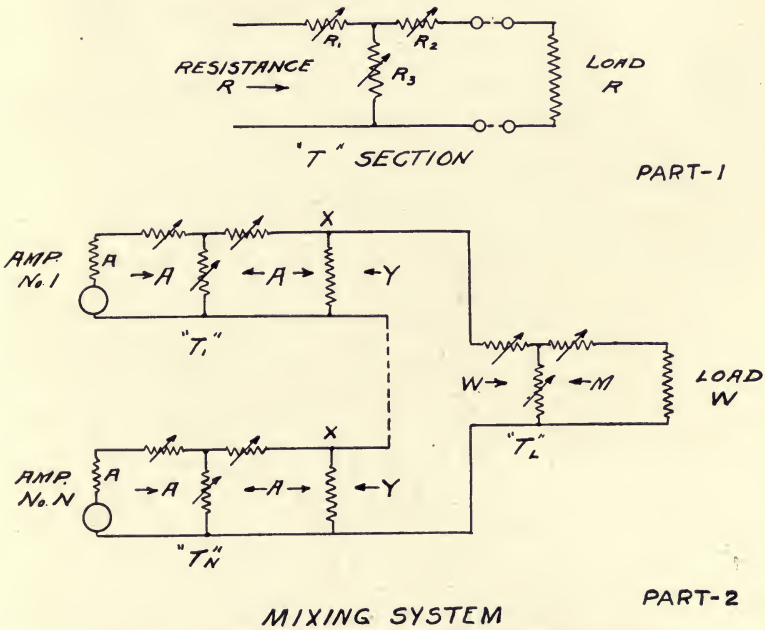

FIG. 13. Formulas for constant impedance mixing system.

Referring to Fig. 13 (Part 2), which represents a general mixing system:

Let N = No. of amplifiers, whose outputs are to be combined.
A = Resistance of "T" section in the microphone amplifier circuit.
W = Resistance of "T" section used for overall control.
X = Shunting resistance across the output of the "T" section used in the microphone amplifier circuit.
Y = Resistance of A and X in parallel.

The resistance Y will remain constant for all attenuations of microphone amplifier outputs (as explained under "T"-pad discussion

above). Therefore, varying the attenuation of one of the inputs will not affect the attenuation of any of the other outputs. The load on each input circuit will not change if its "T" pad is properly loaded by the resistance X in parallel with $(N - 1)Y + W$

$$A = \frac{X[(N-1)Y + W]}{X + [(N-1)Y + W]} \tag{3}$$

$$Y = \frac{AX}{A + X}. \tag{4}$$

Combining (3) and (4)

$$X = \frac{A}{2[W + A(N-2)]}\left[NA + \sqrt{(NA + 2W)^2 - 8AW}\right]. \tag{5}$$

If the resistance M looking from the combined output circuit does *not* have to remain constant, values of N, A, and W can be substituted into equation (5) and the value of the loading resistor X determined. If several of the combined outputs are to be combined into one channel it is obvious that M must equal W and remain constant. This imposes the condition that:

$$W = NY \tag{6}$$

Solving, 3, 4, and 5

$$A = W\left[\frac{2N-1}{N^2}\right] \tag{7}$$

W and N known

$$X = W\left[\frac{2N-1}{N(N-1)}\right] \tag{8}$$

$$W = A\left[\frac{N^2}{2N-1}\right] \tag{9}$$

A and N known

$$X = A\left[\frac{N}{N-1}\right]. \tag{10}$$

It should be noted that the last-imposed condition makes it possible to choose only two of the variables in the system.

As was previously mentioned, it was decided to design a four-microphone mixer and another over-all mixer for combining the outputs of two four-microphone mixers.

FOUR-MICROPHONE MIXER (PB-11)

It was desirable to have the input to the recording amplifier equal to 500 ohms so for four microphones $W = 500$ ohms and $N = 4$.

From equation 7 and 8, $A = 219$ ohms, and $X = 292$ ohms.

The plate impedance (referred to transformer secondary) of the output tube in the microphone amplifier is 125 ohms; therefore a series resistance of 219 − 125 or 94 ohms must be added, so as to make the input resistance to the pad equal to A. This means the microphone amplifier has a constant load of 313 ohms. (See Fig. 2.)

OVER-ALL MIXER (PB-13)

Since M does not have to equal W, equation 5 can be used to solve for X. Thus, $N = 2$ and $A = W = 500$ ohms; then $X = 1212$ ohms. (See Fig. 7.)

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[1] KELLOGG, E. W.: "A New Recorder for Variable Area Recording," JOUR. SOC. MOT. PICT. ENG., **XV** (November, 1930), No. 5, p. 653.

MATERIALS FOR THE CONSTRUCTION OF MOTION PICTURE PROCESSING APPARATUS*

J. I. CRABTREE, G. E. MATTHEWS, AND J. F. ROSS**

Summary.—*An analysis is made of the factors which affect the choice of materials to be used for the construction of various types of processing apparatus. Three general classes of material are considered, namely: (1) metals, (2) coated metals, and (3) non-metallic materials. In addition to the direct action of solutions on metals, the possibility of electrolytic corrosion effects must be recognized. The results of an exhaustive series of tests on the effect of photographic solutions on single metals and metallic couples are summarized, including the effect of the materials on the solutions.*

Practical recommendations are given regarding materials suitable for the construction of apparatus such as processing machines.

When selecting a material for the construction of processing apparatus, several factors should be considered, namely:

(1) The resistivity of the material to the most corrosive liquid with which it will come in contact. For example, a galvanized tank, while fairly satisfactory for washing purposes, is very rapidly corroded by fixing baths.

(2) The effect of the material on the photographic properties of the solution. For instance, a developer solution in a brass tank may appear visibly unchanged, but on testing, it may fog emulsions badly, due to the presence of copper salts dissolved from the brass.

(3) The time during which the solution will be in contact with the material. If a developer is stored in a japanned tank, the japan will ultimately soften and peel off.

(4) The cost of the material.

(5) The adaptability of the material for construction purposes. Glass, for example, is entirely unsuitable for large tanks because of its fragility, and the difficulty of annealing such tanks.

There are three general classes of materials suitable for the construction of processing apparatus: metallic materials, coated metals,

* Received by the Editor, February 2, 1931.

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and non-metallic materials. These may be sub-classified as follows:

A. Metallic materials: Unplated and plated metals; alloys.

B. Coated metals: Enameled steel, asphalt-coated metals, and lacquered metals.

C. Non-metallic materials: Enameled steel, glass, impregnated fibrous materials, wood, paraffined wood, porcelain and glazed earthenware, rubber, rubber composition, nitro-cellulose materials, slate and Alberene stone.

METALLIC MATERIALS

No metal or alloy has yet been found which will resist corrosion in all photographic solutions, and it is therefore necessary to restrict their use to specific purposes. Metallic materials possess certain very desirable properties, however, such as ductility, non-fragility, and general workability.

In considering the suitability of a particular metal for construction purposes, it is very important to know whether the article will be built of a single metal or of two or more metals. In the former case, only the corrosive effect of the solution itself need be considered, whereas in the latter case, an electrical current flows between the two different metals and its effect must be considered in addition to the chemical action.

In testing the resistivity of various metallic materials to chemical action, it is necessary to observe the effects obtained under two sets of conditions: (1) those in which only a single metal or alloy is involved, and (2) those in which two or more metals or alloys are in contact with each other and also with the photographic solutions.

The Resistivity of Single Metals in Photographic Solutions.—An extended series of tests was carried out to determine the resistivity of a large number of metals and alloys to common photographic solutions. The experimental details of the tests made on most of the materials given in the following list, are recorded in papers by two of the present authors.

Metals—Aluminum, Iron, Lead, Nickel, Tin, Zinc.

Plated Metals—Galvanized Iron; Tinned Iron, Lead-coated Iron; Aluminum-coated Iron; Chromium, Silver, and Cadmium-plated Brass.

Alloys—Allegheny Metal (chromium-nickel-steel), Aterite No. 136 (copper-zinc-nickel), Brass, Duriron, Monel, Niaco (nickel alloy), Nickel Silver (copper, zinc, nickel, iron), Nicolene (nickel-copper),

Phosphor Bronze (copper-tin-phosphorus), Solder (both high and low tin content), Rezistal Steel (chromium steel), Type Metal (lead-tin-antimony), Duralumin (aluminum-magnesium-copper), Corronil (nickel alloy), Nichrome (nickel-chromium), and various Stainless Steels.

The Resistivity of Two or More Metals in Metallic Contact toward Photographic Solutions.—When two different metals are placed in contact and immersed in a solution, an electrolytic battery is formed which causes more or less rapid disintegration of one of the metals. This electrical action may occur in several ways: with plated metals, when some of the plating wears off; with soldered metals, between the solder and the metal; and with alloys, between the tiny crystals of the various metals which compose the alloy.

In making metal containers for photographic solutions, it is often necessary to use a second metal or alloy in the form of solder, to render joints or seams free from leaks. Also, in the construction of pipe lines for transporting solutions, it is frequently not possible to use faucets or fittings of the same material as the pipe line. A concrete example of the trouble which may arise from the metallic contact in a solution is as follows:

In the course of a series of tests on metal tanks of a copper-nickel alloy, soldered on the inside with a lead-tin solder, it was observed that if a developing solution remained in the tank for a short time the developer gave very bad fog. The solder with which the seams of the tank were soldered appeared to be slightly etched, and the original luster of the metal had disappeared, being replaced by a dark, grainy deposit. The alloy itself was unaffected as far as could be detected from its physical appearance. A series of tests definitely proved that the excessive fog was a result of the tin constituent of the solder passing into solution, due to the flow of an electric current through the solder, the solution, and the alloy.

Corrosion was also observed due to the same cause when a tank made from this alloy and soldered on the inside was used as a container for an acid fixing bath, except that the alloy was corroded instead of the solder. When the joints were soldered on the outside, no developer fog was produced and corrosion was considerably less.

An extended study of this aspect of corrosion was made and the results are given in the two papers to which reference was made previously.

Only the practical application of the results of tests on the various

metals will be considered in this article; the orginal papers should be consulted for more detailed information.[1,2,3]

Practical Value of Metal Materials.—Lead and nickel were the only metals tested which appeared to be of any special importance for use with processing solutions although iron is of value for particular purposes. Lead, nickel, and iron (black or ungalvanized) tanks or piping can be satisfactorily used for most developing solutions although lead is attacked by strongly alkaline developers. Tanks lined with lead or nickel can be used for fixing solutions but they are slowly attacked, become coated with silver, and must eventually be replaced.

Practical Value of Plated Metals.—Galvanized iron has long been used for the manufacture of washing tanks although it is not entirely suitable for this purpose. Vessels made of this material must not be used for mixing developers which contain sodium bisulfite, because the bisulfite attacks the zinc coating, forming sodium hydrosulfite which causes fog.[4]

Nickel-plated brass is satisfactory for small developing tanks which are used intermittently. Metals plated with silver, either by deposition from an exhausted fixing bath, or by electroplating, are more resistant to developing solutions according to the homogeneity of the silver coating, but their resistance toward fixing baths is only slightly greater than that of the unplated metals. Aluminum- and cadmium-coated metals do not satisfactorily resist photographic solutions. Chromium-plated metals would probably be satisfactory if it were possible to secure a continuous non-porous coating over the base metal, but no such coatings are available to date. Lead-coated iron can be used for developing and washing tanks if the iron base-metal is not exposed, but is not very satisfactory.

Plated metals and alloys are always open to the objection that as soon as some of the plating wears off, exposing the base-metal underneath, electrolytic corrosion sets in, and disintegration takes place rapidly.

Practical Value of Alloys.—Of the numerous known alloys, Monel metal has been most extensively used although it is less satisfactory than certain types of stainless steel such as Allegheny metal. Monel metal as well as plain nickel and Corronil metals gives similar results to Monel metal. Monel metal is attacked and coated with silver when stored in used fixing solutions.

Allegheny metal is resistant to both developing and fixing solutions,

and has the least tendency of the commercial alloys to accumulate a deposit of silver in a used fixing bath. Also, very little corrosion occurs in a fixing bath if the alloy is completely immersed but if partially exposed to the air, corrosion pits form somewhat readily around the air line. However, it is the most satisfactory commercially available alloy.

Alloys often are more resistant to the action of certain acids and alkalis than the metals of which they are composed, as, for example, Duralumin, whose tensile strength and resistance to acids are far above that of aluminum. Some samples of this alloy looked rather promising for use with photographic solutions while others were not satisfactory and for this reason the material cannot be unqualifiedly recommended.

COATED METALS

Enameled Steel.—Enameled steel is extensively used for small tanks and has proved fairly satisfactory. When the undercoating of steel is laid bare by the chipping away of the relatively brittle vitreous enamel, it corrodes very rapidly, and the vessel is rendered useless. Smooth, hard enamel coatings are resistant to weak acids but with developers and alkaline solutions the surface becomes etched, making it difficult to clean. Dye solutions permanently discolor such roughened surfaces of enamel.

Lacquered Metals.—A satisfactory photographic lacquer consists of asphalt paint or a mixture of asphalt paint with rubber cement, the latter serving to overcome the slight brittleness of the asphalt coating. Baked japan is very satisfactory, but none of these materials will resist developing solutions containing a high percentage of alkali. Freshly applied asphalt paint will often produce a scum on the developer surface.

NON-METALLIC MATERIALS

Several satisfactory materials for use in handling photographic solutions on a large scale are to be found in the non-metallic group.

Glass.—Glass apparatus, well annealed, free from ribs, and with the corners of tanks rounded off, is quite satisfactory and is one of the most resistant materials available. For the storage of strong alkalis, special resistant glass should be used. Owing to its fragility, however, glass is not suitable for large tanks.

Impregnated Fibrous Materials.—Tanks prepared with fibrous materials impregnated with varnish or lacquer develop cracks with use,

thus permitting access of the solutions to the under layers. Such tanks are entirely unsatisfactory for use with solutions containing strong alkalis, or with fixing baths, because these solutions disintegrate the fibrous materials through crystallization as explained later under "Porcelain and Glazed Earthenware."

Containers made from most laminated phenolic condensation products can be used with photographic solutions, with the exception of strong oxidizing solutions. Some samples of these materials have been found to swell and warp out of shape when used with strongly alkaline solutions.

Wood.—Wood is fairly satisfactory for developing, fixing, and washing purposes and is cheaper than any other available material. It has the disadvantage that, unless strongly braced, it has a tendency to warp out of shape. In many localities fungus growths accumulate on the outside of the washing tanks which must be removed frequently, while the inside of wash tanks often becomes coated with a layer of slime which necessitates frequent cleaning. Wooden containers also become permanently discolored if they are used for dye solutions. The most satisfactory varieties of wood for the construction of tanks are cypress, spruce, redwood, maple, and teak.

Paraffined Wood.—Although certain woods such as cypress and teak are frequently used for the construction of containers for photographic solutions, paraffin-impregnated wood is much more satisfactory. It also possesses the additional advantage that it does not tend to accumulate slimy layers as rapidly as unwaxed wood. The chief disadvantage of paraffined wood is that it is too heavy for the construction of large equipment which is to be handled manually. Methods of impregnating wood with paraffin have been investigated by Eberlin and Burgess,[5] who found that the best results were obtained with cypress and spruce by soaking in water for twelve hours, and then immersing in molten paraffin was for two hours at about 257°F. (125°C.). If the wood becomes overloaded with paraffin, it loses its resiliency and breaks easily. A shorter time of treatment or a lower temperature should then be used so that less paraffin becomes absorbed by the wood.

The soaking serves to swell the wood and in the hot paraffin bath the water in the pores is replaced by paraffin. The wood should be wiped thoroughly with a cloth on removing from the paraffin bath so as to remove the excess wax. Water-tight joints with paraffined wood are best made by grooving the pieces of wood to be joined

together, as for a T-joint, and inserting tightly a small piece of unparaffined wood in the groove. When placed in water the untreated strip swells and completely caulks the seam.

Porcelain and Glazed Earthenware.—Porcelain, glazed biscuit-ware, and tile material are usually unsatisfactory because the glaze invariably cracks, causing minute fissures into which the solution penetrates and crystallizes. The crystals then grow and cause the biscuit-ware to disintegrate, incidentally causing the glaze to chip. Tanks of high-grade, dark-brown earthenware, glazed on both sides are especially recommended for storing ordinary developing and hypo solutions, but should not be used with strong alkalis.

Rubber, Rubber Composition, Nitrocellulose, and Asphaltum Materials.—Pure hard rubber will withstand practically all photographic solutions at normal temperatures. Some so-called hard rubber tanks are made from a mixture of asphalt or rubber composition with an excess of mineral filler. Such tanks are somewhat brittle, warp under heat, and when used as containers for solutions disintegrate in the same manner as porous earthenware. Smooth surfaces reduce the tendency to etching since less strain is exerted on the walls during the crystallization process.

Rubber sheeting and rubberized cloth are often used for coating the inside of wooden trays and troughs, and are very satisfactory. Cheap rubber sheeting or tubing often contains an excess of free sulfur which reacts with photographic developers and causes chemical fog.[6] Pure gum-rubber materials are quite satisfactory.

A tarry material called "Oxygenated Asphalt" used for sealing storage batteries and supplied by the Standard Oil Company, has been found to be a satisfactory protective coating for use with all kinds of photographic solutions. This material is applied while hot as a thick coating over the metal or wood, and if a smooth surface is desired the coating can be smoothed out by the use of a blow-torch. Nitrocellulose lacquer (E. K. Lacquer No. 5119) is useful for coating wooden articles such as racks for handling motion-picture film, although several coatings are usually necessary, either by brushing, spraying, or dipping. Small apparatus constructed of nitrocellulose sheeting is satisfactory for use with almost every type of aqueous solution.[7] Wooden tanks lined with this material have also proved satisfactory.

Slate and Alberene Stone.—These materials are very suitable for constructing large tanks for containing developing solutions. For

fixing solutions, Alberene Stone (a gray, finely crystalline variety of soapstone) is entirely satisfactory, but slate is not recommended as it often splits along planes of cleavage as a result of crystallization. Some varieties of soapstone are not resistant to fixing baths, and tend to disintegrate where the sodium thiosulfate crystallizes out.

A satisfactory cement for joining large pieces of soapstone, as in constructing a tank, can be prepared from 1 part whiting and 2 parts litharge, thoroughly mixed and made into a putty with boiled linseed oil. A mixture of litharge and glycerine is recommended for cementing small fittings into the tanks.

PRACTICAL SUGGESTIONS

Materials suitable for constructing various types of photographic apparatus are as follows:

Small Apparatus.—Allegheny metal is one of the most satisfactory materials known. Nickel, Monel metal, Mond, and Corronil metal are suitable for use in developing solutions.

Small Tanks.—Since these containers are generally used for a variety of purposes, they should be resistant to most photographic solutions. Suitable materials are glass, enameled steel, hard rubber, teak wood, or spruce impregnated with paraffin wax, wood, or metal coated with "Oxygenated Asphalt," and well-glazed porcelain or stoneware. Allegheny metal, Monel, Mond, or Corronil metals and nickel with pressed seams or joints soldered on the outside are satisfactory for washing or developing and for fixing purposes when the tanks are to be used intermittently.

Deep Tanks.—Alberene stone, well-glazed stoneware, and wood (cypress) are suitable for developing and fixing baths. Lead-lined wooden tanks are fairly satisfactory for developing solutions provided the joints are lead-burned and not soldered. Plain wooden tanks are satisfactory but they tend to accumulate slime. Tanks of paraffined wood can be used if the wood is properly joined together with strips of untreated wood as explained above. Tanks of Portland cement have been found satisfactory for developers of low alkali content. Metal or wooden tanks coated with "Oxygenated Asphalt" are excellent providing the base-material is not exposed.

Tubes, Sprockets, and Idlers for Motion-Picture Developing Machines.—Hard rubber, lead, Allegheny metal, and Pyrex glass have been found satisfactory for developing tubes. Lead gathers a deposit

of silver from the fixing bath, and in time this tends to obstruct the tube. However this deposit can be removed by scraping. Brass or copper tubing should not be used since both materials affect developers and are corroded by fixing baths. Idlers and sprockets should preferably be made of hard rubber or Allegheny metal according to the purpose for which they are intended. Metal tubing should not be soldered with solders containing tin.

Troughs for Reel Development.—Glazed stoneware and wooden troughs lined with sheet rubber or rubberized cloth are satisfactory for practically all ordinary processing solutions. Lead, Mond, Nickel, Allegheny metal, Monel, and Corronil metals are satisfactory for use with developing solutions but are slowly attacked by fixing solutions. For acid oxidizing solutions or strong alkalis, glazed stoneware troughs are recommended, but the troughs should be emptied after use. Metal troughs may be used in an emergency if the interior of the trough is lined with pure gum rubber sheeting or paraffined cloth. This latter lining is applied by coating the interior of the trough with cloth and sticking it to the metal with Cumar resin (medium hard grade). The cloth is then brushed over with molten hard paraffin wax and the surface finally smoothed off with a hot iron. Metal troughs may also be coated with "Oxygenated Asphalt" but great care should be taken to insure that the metal is covered completely and that the coating is free from bubbles. Japanned metal-ware is satisfactory only for intermittent use.

Piping, Pumps, Faucets, Etc.—For transporting developing solutions, hard rubber, iron (not galvanized), Duriron and Allegheny metal piping and pumps are satisfactory and should be used in connection with faucets of similar materials. For transporting fixing solutions, hard-rubber piping, valves, and pumps are recommended. Tinned or tin-lined copper or brass faucets or piping should be avoided for use with developers or fixing solutions. For conveying distilled water, however, pipe lines and fittings of block tin soldered with pure tin solder are satisfactory. Lead piping joints should be "wiped" or lead-burned, and not soldered. If silver-plated apparatus is used, the plating should be free from pinholes or scratches.

A suitable packing for pumps consists of asbestos rope twisted with the aid of a little hard grease.

Lead and hard-rubber piping needs supporting while hard rubber must be protected from blows or excessive pressure.

The following table summarizes the above recommendations.

Construction Materials for Processing Apparatus

Solution	Storage Tanks	Pipe Lines	Racks	Sprockets and Idlers	Coils
Developer	Wood Iron Asphalt-coated wood Lead-lined wood Glazed earthenware	Black iron (not galvanized) Soft rubber	Allegheny metal Nickel Monel metal	Allegheny metal Monel metal	Nickel Monel metal Lead
Hypo not containing silver	Wood Lead Asphalt-coated wood Glazed earthenware crocks	Hard rubber Soft rubber Lead	Allegheny metal Monel metal	Allegheny metal Monel metal	Allegheny metal Lead
Hypo containing silver	Wood Asphalt-coated wood	Hard rubber Soft rubber	Allegheny metal Monel metal	Allegheny metal Monel metal	Allegheny metal
Water	Wood Iron	Galvanized iron Soft rubber	Allegheny metal Monel metal	Allegheny metal Monel metal	

PRECAUTIONS TO BE TAKEN WHEN SELECTING CONSTRUCTION MATERIALS

(1) Do not permit tin, copper, or alloys containing these metals to come in contact with developing solutions, especially concentrated developers, because more or less of the tin or copper will dissolve and cause either serious chemical fog or rapid oxidation of the developer. Do not use galvanized-iron vessels to mix developing solutions containing sodium bisulfite because sodium hydrosulfite which is a bad fogging agent, will be formed. Likewise, the zinc in the inner coating of galvanized piping will cause developer fog.

Contact between two or more different metals or alloys exposed to a developer will hasten the rate of corrosion of the metals and thus increase the amount of fog obtained. Soldered joints are particularly to be avoided with developers, but if such joints are unavoidable, a low-tin solder or one free from tin should be used, and the joints so made that a minimum of solder is exposed to the solution.

(2) For fixing, toning, and acid-oxidizing solutions, avoid metals whenever possible.

(3) When choosing metal for the construction of apparatus a single metal should be used whenever possible, and it should be either electro-welded or soldered from the outside to avoid electrolytic corrosion. Lead containers should be joined together by lead burning.

(4) Apparatus constructed of aluminum, zinc, or galvanized iron

should not be used with either developers or fixing baths since these metals react with such solutions with the formation of precipitates which leave a deposit on the film and often stain the gelatin.

(5) Plated metals should be avoided whenever possible and only single metals or alloys used in preference, since electrolytic corrosion sets in as soon as a little of the plating wears off.

(6) For fixing baths or strong saline solutions, avoid porous materials such as incompletely-glazed earthenware, impregnated fibrous materials, or rubber compositions, because crystallization of the salts within the pores of the materials causes disintegration.

(7) Tanks coated with lacquer or baked japan are not resistant to strongly alkaline developers or fixing baths of high acid concentration.

(8) Avoid the use of cheap rubber tubing or other materials containing free sulfur or metallic sulfides in connection with developing solutions, because the alkali in the developer attacks these, forming alkaline sulfides which cause chemical fog.

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AIDING THE THEATER PATRON WHO IS HARD OF HEARING*

F. H. GRAHAM**

Summary.—*From available data on the acuity of hearing of various groups of people, a chart is constructed showing the estimated distribution of any large group according to their hearing ability. Articulation vs. loudness curves are used to determine the amount of aid possible for any particular degree of deafness. From these sources it is estimated that approximately 10 per cent of the population who now cannot hear sound pictures satisfactorily can, with benefit, use a theater-hearing-aid system which reproduces without distortion; this number is reduced correspondingly with the amount of distortion introduced. The requirements of such a system are outlined and the Western Electric theater-hearing-aid attachment is described in detail.*

During the early days of sound pictures when new converts were being added to the list of enthusiastic theater patrons, a small discordant note made its appearance. This arose from a minority, who, knowingly or unknowingly, had defects in hearing which were sufficiently serious to prevent proper reception of this new form of entertainment. The various societies for the hard-of-hearing, by circularizing the producing companies and by means of publicity, sought to stem the tide which was eliminating the silent pictures, their only form of theater entertainment. In this, however, they have been doomed to disappointment, for economic and other considerations have pushed the development of sound pictures to the almost total exclusion of the silent variety.

The fact that the hard-of-hearing belong to a minority group compared with those with normal hearing should not obscure the importance of adding them to the list of theater patrons. By so doing the theater will have increased its potential patronage by approximately 10 per cent. In addition to the possible financial gain created by drawing its patronage from a more populous community the theater secures general goodwill in its performance of a humanitarian work.

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* Presented at the Fall 1930 Meeting at New York, N. Y.

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NUMBER OF HARD-OF-HEARING IN THE U. S. A.

Trustees of the Coolidge Fund for the Deaf estimated the number of hard-of-hearing persons in the United States to be 10,000,000.[1] Other estimates as high as 15,000,000 have been made. Obviously, these people do not all have the same degree of deafness. The hearing of any ear for a particular sound is commonly expressed in terms of the intensity level of the sound just audible to that ear compared with the threshold intensity required for a normal ear. If we represent these threshold intensities by I and I_6, respectively, the hearing loss, or gain, of the ear under test is given in sensation units (SU)* by 10 log (I/I_0).

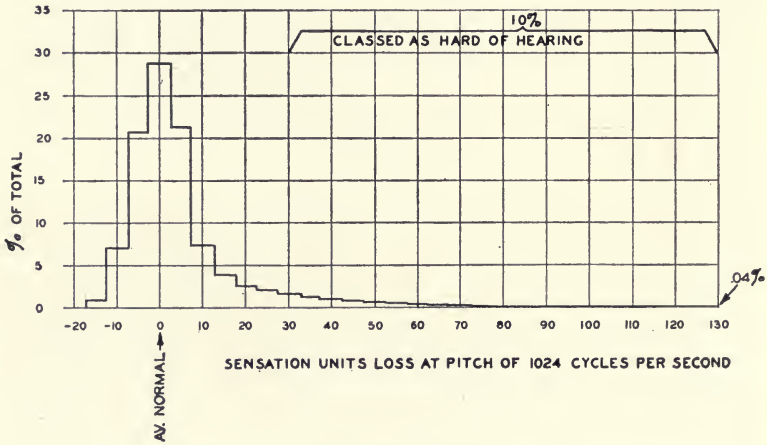

FIG. 1. Estimated hearing ability of representative group of people relative to an average normal.

There has been recorded by various investigators a certain amount of quantitative data showing the results of hearing measurements on a number of persons. In making measurements of threshold intensity on a group of persons having normal hearing, H. Fletcher and R. L. Wegel[2] found it to vary over a range of about 30 SU. Twenty-two per cent of the supposedly normal group tested were, on later

* The decibel is the logarithmic unit commonly used to express the ratio of two amounts of power. When it is used in describing the magnitude of sounds heard by the ear this unit is generally termed sensation unit, and it represents approximately the smallest change in the power level of a sound which the ear can detect.

otological examination, found to class as subnormal.[3] Tests on school children[4,5,6] have fixed the proportion having subnormal hearing at from 4 to 8 per cent, with some estimates exceeding these figures. C. C. Bunch,[7] on testing groups arranged according to age, found that acuity of hearing decreased with age. The 1920 U. S. Census classes only 0.04 per cent as deaf mutes.

Using the statistical data contained in the references cited, we have constructed the chart in Fig. 1 showing the probable distribution of the hearing ability at a pitch of 1024 cycles per second of the people of the United States. The total population is divided into groups expressed as a percentage of the total, the hearing loss of each group differing in steps of five sensation units from the average normal. Since the form of this chart will depend upon the pitch at which the hearing is measured, 1024 cycles per second was chosen as being fairly representative of the speech frequency range.

Admitting the obvious approximation of this chart, it will serve in the absence of more accurate data to show us the nature of the problems involved in supplying sound satisfactory to everyone. Fortunately the majority, comprising about 85 per cent of the population, fall in the normal-hearing range. In ordinary life surrounded by every-day noises a hearing loss of 30 SU or more handicaps us in conversation and in receiving programs at a conversational level. In quiet places a smaller, and in noisy locations a larger, amount of hearing loss can be tolerated. This can be explained by the fact that the effect of noise upon a normal ear is very similar to the effect of partial deafness, and by the natural tendency in the presence of noise to raise the level of the voice or to step up the volume of reproduced programs in order to over-ride the noise level so that a normal ear can hear. On the chart possibly 5 per cent of the population fall in the doubtful class where good reception under average conditions is problematical. The remaining 10 per cent are classed definitely as hard of hearing. This group cannot with *any* degree of satisfaction hear programs designed for normal-hearing audiences. Referring to the chart, at least 98 per cent of the population can be expected to have 50 per cent or more of their hearing or a hearing-loss of no more than 65 SU.

THE AMOUNT OF AID WE CAN EXTEND TO THE HARD-OF-HEARING

Fig. 2, a chart published by H. Fletcher[8] shows the relation between articulation and volume of received speech. The volume is

given in terms of initial speech intensity defined as that received by a normal ear with the speaker talking directly into the ear. The articulation is the percentage of sounds received correctly. Seventy per cent articulation is considered as a fair minimum value which will provide good intelligibility. Twenty-five per cent is sufficient to allow us to carry on a conversation.

The normal ear can accommodate itself over a wide range of volume, as can be seen by referring to the curve in Fig. 2 designated as 100 per cent hearing. To illustrate the limitations imposed by deafness, let us take, for example, an ear having a 65 SU hearing-loss at a pitch of 1024 cycles per second. The articulation *vs.* volume relationship

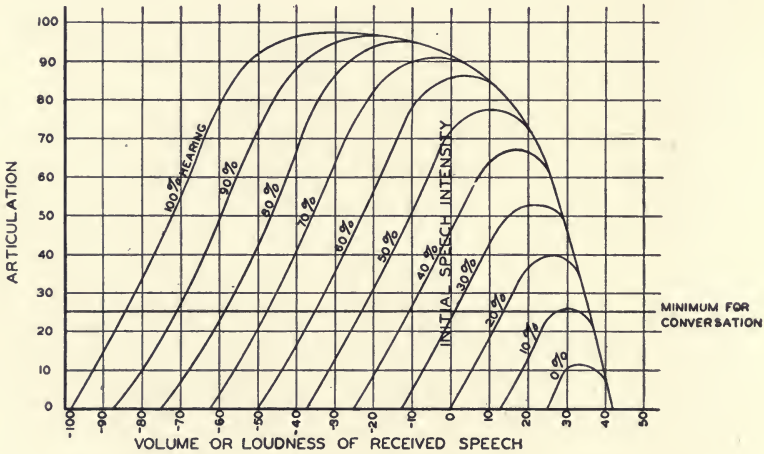

FIG. 2. Volume *vs.* articulation of undistorted speech for various degrees of hearing.

for this ear, which is given by the curve designated 50 per cent hearing, shows that initial speech intensity is required to allow a maximum possible articulation of 70 per cent. To obtain this amount requires high-quality transmission without distortion. Very little can be gained by increasing the volume much above this point due to its producing painful sensations in the ear. A transmission system which distorts the speech received by the ear having 50 per cent hearing will lower the maximum possible articulation below 70 per cent and make good reception impossible. From this we can see why the hard-of-hearing are critical as to the volume and quality of the sounds supplied them.

REQUIREMENTS OF A SYSTEM FOR AIDING THE HARD-OF-HEARING IN THEATERS

To meet the requirements of the hard-of-hearing, a system designed to aid them in receiving theater programs should transmit with a minimum amount of distortion a volume of sound somewhat greater than initial speech intensity. For Western Electric high-efficiency type head receivers an energy level of one-hundredth of a watt in each receiver is ample to furnish all possible needs. Sufficient range of volume control must be provided to allow a selection of the proper volume to suit each hard-of-hearing patron. In addition, the apparatus should be comfortable to use. It should allow maximum freedom of movement to the user and to his neighbors as well. Taking into account the sensibilities of the hard-of-hearing it should be unobtrusive in appearance.

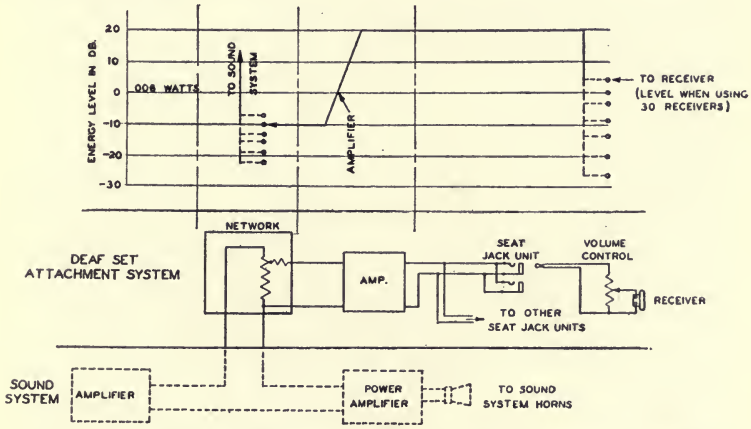

FIG. 3. Circuit for deaf-set attachment system. Capacity, 30 seats.

The theater management obviously cannot tolerate any detractions from the normal performance, such as clicks or loss of volume in the sound system. In particular, sounds escaping from the receivers are objectionable to normal-hearing patrons, due to the phase difference existing between these sounds and those received from the screen horn.

DEAF-SET ATTACHMENTS FOR WESTERN ELECTRIC SOUND SYSTEMS

In Fig. 3 is shown the schematic circuit of a deaf-set attachment for Western Electric Sound Systems. The attachment consists of a

FIG. 4. Showing individual equipment for hard-of-hearing in operation.

network which diverts a small amount of power from the sound-system amplifier, an amplifier which raises this power to a level high enough to supply the number of receivers required, a seat-jack unit containing two jacks for every two seats to be equipped, and a telephone set for each hard-of-hearing patron. The telephone set consists of a receiver, a small volume control inserted in the receiver cord and a plug to connect the telephone set to the seat-jack.

The energy levels shown in Fig. 3 are those for a system capable of supplying from one to thirty seats. Other amplifiers having higher output capacities are available where more than thirty seats are to be equipped. The head-set system operates as a unit with the sound system and does not require the attention of the sound system operator.

Fig. 4 shows the individual equipment for the hard-of-hearing in operation. The seat-jack unit is mounted on the front seat standard just under the arm of the seat. The volume control is contained in a small cylindrical case, which for convenience and ready access is held in the hand. The receiver is held to the ear by a headband which permits the user freedom of movement. The headband obligates the observer to keep the receiver on his ear while it is in use, thus minimizing the sound escaping into the air.

We have shown the attachment linked with the regular sound picture system. When public address facilities for stage reënforcement are available, the hard-of-hearing can hear the stage presentations as well as the sound pictures. For amplifying stage programs where a sound system is not installed, an acoustic pick-up equivalent to that of the public-address system must be used.

A word of caution should be inserted in dealing with the problem of the hard-of-hearing in theaters. For reasons pointed out, those who have only a small percentage of hearing remaining cannot be guaranteed to be made to hear, irrespective of the type of hearing-aid installed. In fact, little good would result in encouraging them to try since their reactions must be unfavorable and will probably tend to discourage others from making use of the system. Similarly, the use of a system which alters the character of the sound by reason of poor transmission characteristics or by superimposed noises, or of a system which does not contain essential fundamentals of design, will increase the number of people who cannot use it satisfactorily. By such methods the movement to bring the hard-of-hearing into the theaters will be retarded.

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TEST SET FOR SERVICING SOUND PROJECTION EQUIPMENT*

A. H. WOLFERZ**

Summary.—*In connection with the installation, operation, and repair of amplifier equipment as used in the motion picture industry, various electrical measurements are necessary. In order to carry out these measurements, a portable test set was designed. This test set was arranged to measure the various voltages and currents encountered in amplifying equipment and in addition, means were provided for testing circuits, amplifier and rectifier tubes, and for measuring resistance and capacitance.*

Since the motion picture theater is the main outlet for the products of the motion picture industries, it seems that anything reasonable which will keep the show running, and, which is quite as important, keep it producing satisfactory results, is worth considering. Equipment of all kinds requires periodic attention, adjustments, and occasional replacement of parts.

In order to facilitate this work, a portable test set for assisting in the servicing of sound-picture equipment is hereby suggested. As with practically all kinds of apparatus a compromise must be made between the desired and the attainable. So, with this test set, if we were to design it for all the tests possible, portability would be sacrificed and it would become useless for field work. It has been designed, therefore, to perform only the essential and necessary tests.

Since the heart of the reproducing system is the amplifier tube, suitable testing facilities are provided so that in the event of trouble these tubes may be tested both in conjunction with the amplifier equipment and independently of it. The use of apparatus for measuring the characteristics of amplifier tubes, because of its bulk and weight, is restricted to laboratories and service stations. However, a simple, rapid test is quite essential at the time of installation and at regular intervals thereafter, as routine inspection. The amplifier tubes most commonly used in amplifier installations are the types 112-A, 245, 210, 250, 171-A, 227, 226, 845, 239, 205, 211, 280, and 281, the last two being rectifier tubes.

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* Presented at the Fall 1930 Meeting at New York, N. Y.
** Weston Electrical Instrument Corp., Newark, N. J.

The commercial 60 cycle alternating current supplied by the lighting mains is used. The filament or heater of the tube being tested is connected to the secondary of a transformer having a variable primary, so that its turn-ratio may be altered to compensate for variations in the line voltage. An a-c voltmeter is connected across the filament or heater so as to indicate when the correct value is obtained. The plate circuit voltage is approximately 120 volts and the grid is connected to one side of the filament or heater, providing a bias such that approximately the rated plate current is obtained. The grid potential is made less negative, causing the plate current to increase when a good tube is being tested. When the tubes are old or defective the change of plate current becomes very small or is not noticed at all. When making this test the rated values of plate and grid potentials are not applied to the tube. It is, however, a useful test when trouble exists which causes the equipment to be incapable of producing proper operating voltages.

When the amplifier equipment is capable of supplying to the tubes the normal filament, grid, and plate voltages, the tubes may be tested under operating conditions. The tube to be tested is removed from the socket on the amplifier panel and inserted into a socket provided on the test set. The test set is provided with a cable terminated by a plug which is inserted into the socket on the amplifier panel. When this connection is made, the value of the plate current is indicated by the plate milliammeter of the test set. On pressing a switch the grid is made less negative, causing an increase of plate current.

After testing a number of good tubes under these conditions, an average value of increase can be determined. As with the previous test, a slight increase or no increase of plate current indicates that the tube is below normal or is unfit for further use.

A third method of testing tubes may be provided which also employs the filament, grid, and plate potentials as they exist at the amplifier panel, but, instead of obtaining two values of plate current for a change of grid potential, the circuit is so arranged that the plate current remains constant.

The tube is inserted into the socket provided on the test set, the latter being connected by cable and plug to the socket on the amplifier panel. The plate current corresponding to normal plate, grid, and filament voltages is noted. A switch is pressed which introduces a resistor into the plate circuit and then reduces the grid potential to zero. This resistance, connected into the plate circuit, is so pro-

portioned that when a normal tube is tested no change of plate current is observed. The magnitude of the change is a measure of the inferiority of the tube.

The values of filament or heater voltage, grid voltage, plate voltage, plate current, and cathode voltage, measured at the sockets of the tubes on the amplifier panel all serve to check the remainder of the equipment. For example, should the heater voltage be too high or too low this could be caused by improper adjustment for line voltage. A lack of heater voltage may indicate an open transformer or lead wire. Improper plate voltage may be caused by a defective rectifier tube, a defective high potential transformer, faulty condensers, *etc.* Improper plate current may indicate an improper grid potential. Improper grid voltage may be caused by a defect in the resistance used to obtain this potential or by a defective grid battery. When making these tests it is only necessary to remove each amplifier or rectifier tube in turn and place it into the socket provided on the test set; the test set is then connected by means of the cord and plug, to the socket on the amplifier panel. The instruments on the test set have suitable ranges for properly measuring the various currents and voltages, and suitable switches for connecting these instruments, with their respective ranges, into circuit. All instruments used on the test set have bakelite cases or are otherwise insulated to protect the operators. The voltmeter used to measure the filament, grid, plate, and cathode voltages is of the permanent-magnet, movable-coil type. and requires less than one milliampere for full-scale deflection. Its readings may be relied upon to within one per cent of the full-scale value, and will indicate voltages from about 1 to 1500 volts.

The milliammeter of the test set used for measuring plate current is also of the permanent-magnet, movable-coil type, and has the same scale-length and accuracy as the voltmeter, with ranges suitable for carrying out the tests. Ranges up to 300 ma. should prove satisfactory. A desirable feature is the range-changing switch, having a spring control which leaves the milliammeter always set for its highest range, preventing possible damage when defective tubes or circuits are encountered.

The voltmeter provided to measure the heater voltage of a-c tubes, a-c line voltage, or transformer secondary voltage, is of the movable-iron type, with a scale-length and accuracy such that readings are correct to within two per cent of the full-scale value. Errors due to temperature changes, *etc.*, are within this value and provision is

made for preventing the series resistors from overheating and altering the voltages which it is desired to measure. That such qualifications are quite important may be realized when it is considered that voltages from approximately 1 volt to 3000 volts are encountered and suitable ranges and switches are necessary in order to carry out these measurements.

The d-c voltmeter is also designed so that it may be used to measure resistances of circuits or parts of the apparatus, or to test for continuity of the wiring of circuits. The type of resistances encountered require that it be capable of giving an accuracy of about two per cent for resistances from about 10 to 100,000 ohms. A small battery is self-contained in the case, connected so that its voltage changes may be compensated for. It is easily removable for replacement and is of a standard size readily purchased.

It is very desirable to have a means for measuring the a-c output voltage at various places in the amplifier system or across the voice-coil of the speakers. This requires an a-c voltmeter with a number of ranges, consuming a small amount of power and having a fixed value of impedance; a value of 4000 ohms is generally used. A very convenient method is to use a permanent-magnet, movable-coil instrument in conjunction with a rectifier. Copper-oxide rectifiers are used, giving very satisfactory results for this type of test work. If this meter is used in conjunction with a test record or film having an assortment of frequencies, a very convenient and useful test may be made of the complete installation, which should also prove of value in determining the relation of modulation to ground noise. The scale may be calibrated in terms of effective values or a curve can be employed to allow the use of the d-c scale already on the meter.

Numerous condensers are employed in the amplifier circuits, and the test set is also designed to measure capacitance to a fair degree of accuracy. This is accomplished by using a low-voltage range of the a-c voltmeter, in series with a suitable resistance and the condenser to be measured, connected to a source of alternating current of known frequency and voltage. The voltmeter then simply acts as a milliammeter and indicates the current flowing in the circuit. Marks are provided on the scale of the instrument by previous calibration with reference to known condensers connected in series with a 60 cycle, 115 volt supply. Marks corresponding to 1, 2, 4, and 8 microfarads are provided on the scale, and a curve plotted from these can be used where more accurate readings are desired. The

adjustable series resistance affords a means of compensating for line voltages higher or lower than 115 volts. The adjustment is made by first closing the circuit where the condenser is to be inserted, and then adjusting the resistor until full-scale deflection of the instrument is obtained.

Fig. 1 shows the arrangement of a set provided with means for making the tests and measurements outlined above.

Beginning at the upper-left of the panel, there will be found a fuse connected in the filament circuit; along the upper part of the panel

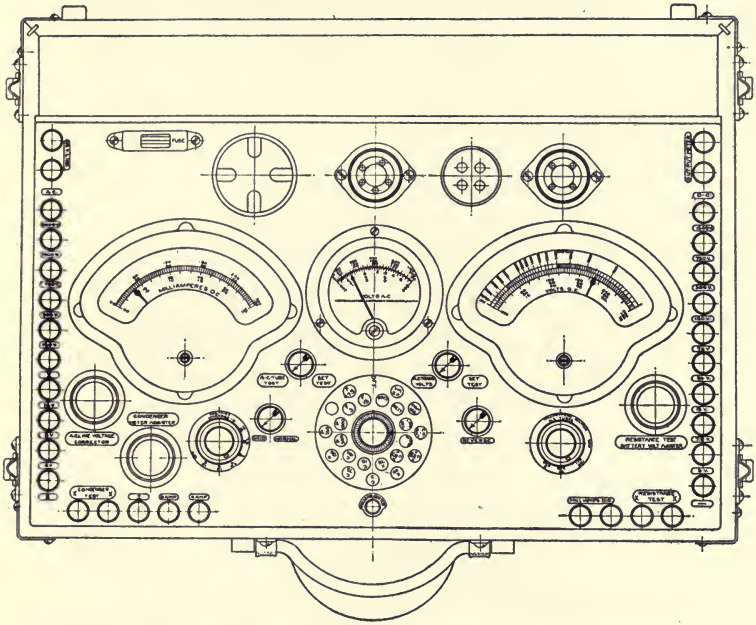

FIG. 1. Top view of test set for servicing motion picture equipment.

will be found sockets for the various tubes mentioned. There are shown, from left to right, a socket for 211, 845 or similar tubes, a UY socket for all 5-prong heater tubes similar to the 227, a socket for W.E. 205 tubes, and last the UX socket for all standard 4-prong tubes as the 112, 171-A, 245, 210, 250, 226, 239, 280, and 281.

The instrument on the left is the milliammeter for plate-current measurements; its ranges are selected by the switch directly below the right-hand instrument, providing for ranges of 3, 75, 150, 300 ma. Regardless of the setting of any switch, this milliammeter

with its shunts is always connected in the plate circuit. Its ranges are also available for other measurements by using the binding posts marked "Milliamperes D.C.", at the lower right-hand corner.

The instrument in the center is the combination a-c voltmeter, milliammeter, and ammeter. It is a movable iron type of instrument and will also indicate when direct current is used. However, more current is required to operate it than is required for the d-c voltmeter, so that it could not, therefore, be used as a substitute for the latter. A two-winding, two-circuit field coil is used, allowing for ranges of 4, 8, and 16 volts requiring a current of exactly 100 ma. for full-scale deflection, and all errors are kept small enough to provide an accuracy of two per cent of the full-scale value. Ranges of 150, 300, 750, 1500, and 3000 volts, requiring exactly 20 ma. for full-scale deflection, are provided. The low ranges are for use in measuring filament or heater voltage, and are available for use with the plug and cable or at the binding posts. The higher ranges are for line voltage and transformer secondary voltage. These measurements can be made only at the binding posts at the left-hand edge of the test set. An additional winding is provided for ranges of 4 and 8 amperes, which may be used for measuring line currents. Marks are drawn on the scale corresponding to 1, 2, 4, and 8 microfarads, using 115 volts, 60 cycles; the rheostat at the lower left provides the compensation for line voltage.

The instrument at the right is the volt-milliammeter. This is also a permanent-magnet, movable-coil instrument, and is principally used to measure filament, grid, cathode and plate voltages when the test set is connected to the amplifier panel by the cord and plug. Its ranges of 3, 7.5, 15, 30, 75, 150, 300, 750, and 1500 volts and the connections for making these measurements are brought into circuit by the double-pole multiple switch shown directly beneath the a-c voltmeter. A shunt is provided in the grid circuit so that this meter may be used to measure one of the plate currents when full wave rectifier tubes are tested. All the ranges are available at the binding posts shown at the right edge of the test set. A circuit is also provided for measuring resistance, including a self-contained 3-cell battery, a variable resistance shown below and to the right, and the binding posts marked "Resistance Test." It is first necessary to short circuit the binding posts marked "Resistance Test" in order to first adjust the variable resistance for full-scale deflection of the meter.

The short circuit is then replaced by the unknown resistance to

be measured. A scale is provided having ranges of 0 to 10,000 and 0 to 100,000 ohms, permitting values of resistance to be read directly.

The two-pole, multiple switch is provided with a position to allow this instrument to be used with a copper-oxide rectifier for measurements of output voltage. Suggested ranges would be 3, 30, and 150 volts, each with an impedance of 4000 ohms. The other switches on the panel are to bring about the tests and measurements previously referred to, such as changing the grid potential, measuring transformer secondary voltage, and reversal of the d-c voltmeter.

The test set may be used for other tests about the theater such as line voltage measurements, measuring resistance of circuits, tracing for open or short circuits, loud speaker voltage or currents, fuse testing, battery voltage tests, and many other tests which will present themselves with experience.

CINEMATOGRAPHY WITH THE LARYNGOSCOPE*

CHARLES A. MORRISON**

Summary.—*An instrument for obtaining full-screen motion pictures of the vocal cords at the rate of 16 frames per second is described. A laryngoscope, illuminating system and viewing finder, are combined into a self-contained diagnostic unit. The problem of lighting is solved by using a quartz rod which directs the light from a small incandescent lamp to the larynx.*

Many early attempts to photograph the larynx were made, but it was not until 1884 that T. R. French[1] succeeded in obtaining consistently good results, using the sun as an illuminant. In 1897[2] he had successfully applied the arc lamp to the problem. Although the motion picture reached a practical state shortly after this no results of its application to laryngeal photography were reported until those of Panconceilli-Calzia[3] in 1920. The need of relatively long exposures under the poor lighting conditions constantly defeated the attainment of satisfactory photography at normal speeds.

Some problems connected with the early development of medical films made necessary the investigation of the possibilities of obtaining motion pictures of the vocal cords. For this purpose it is highly desirable to obtain full-screen pictures. In these experiments, encouraged by Dr. Richard S. Lyman, Dr. Clyde A. Heatly assisted in preparing patients and in passing the instrument. This association led to Dr. Heatly's suggestion that the apparatus be developed for clinical use as an aid in the study of the pathology of the larynx. The apparatus described in this paper is a solution of the problem.

An instrument of this type must necessarily be as simple to use and handle as a camera, in order that the physician may not be much more encumbered than if he were using an ordinary form of the laryngoscope. The crux of the problem of obtaining full-frame motion pictures at the rate of sixteen frames per second lies in sufficiently illuminating the larynx without interfering with the

* Presented at the Fall 1930 Meeting at New York, N. Y.

** Eastman Teaching Films, Inc., Rochester, N. Y.

limited channel by which light reaches the camera lens. This difficulty was overcome by using a quartz rod by means of which a large quantity of light is carried through the tube of the laryngoscope without encroaching seriously upon the field.

Fig 1 is a side view of the instrument. Fig. 2 is a bottom view, showing the plan of the optical system as is diagrammatically illustrated in Fig. 3. The unit consists of a model B Ciné-Kodak attached to a metal plate, which also serves to hold the laryngoscope and illuminating system. A viewing system is fastened to the side of the camera.

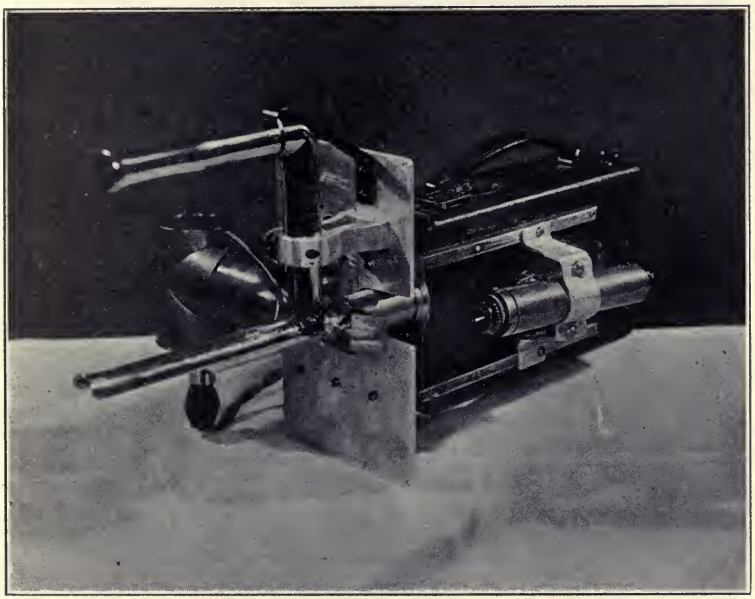

FIG. 1. Side view of camera and attached laryngoscope.

An $f/3.5$, 50 mm. objective lens replaces the standard one of 25 mm. equivalent focal length. This is so placed that the object plane lies 19 mm. in front of the lip of the tube on the laryngoscope. A lens of larger relative aperture would reduce seriously the depth of focus. Illumination is provided by a 21 cp., 6 volt automobile headlight bulb, using a voltage 50 per cent greater than the rated value. Both filaments are used simultaneously. A condenser of high relative aperture consisting of three spectacle lenses, having a

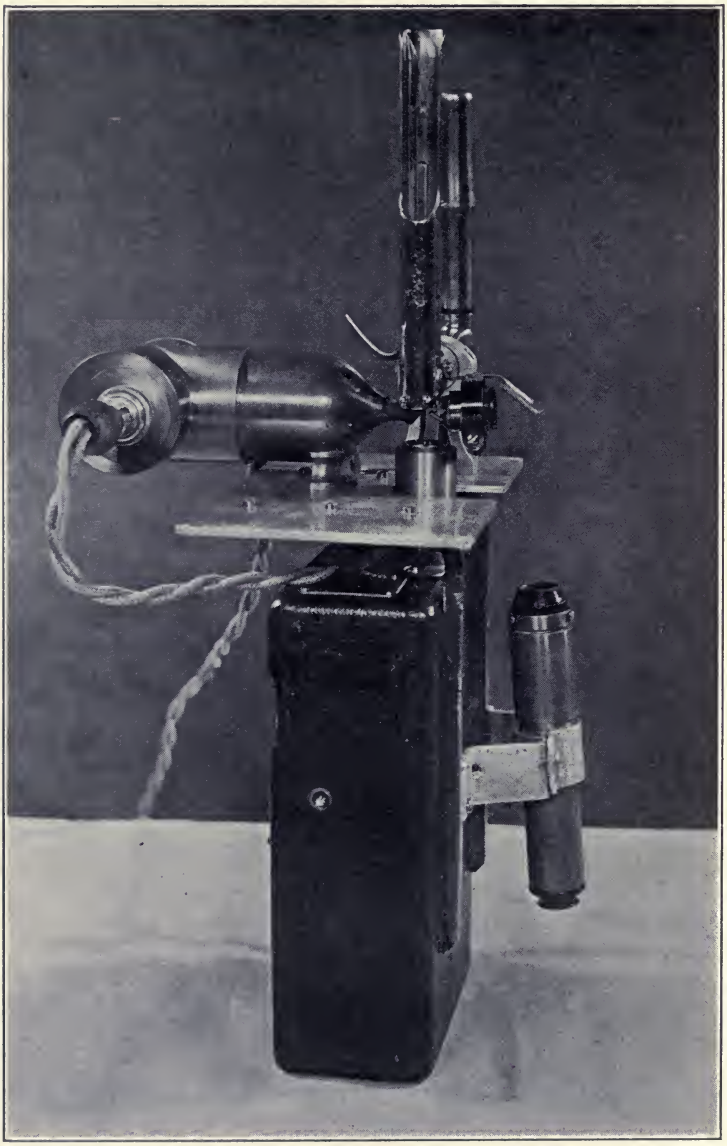

FIG. 2. Under view of laryngoscope and camera.

power of twenty-two diopters and so chosen to give the least spherical aberration, has a free aperture of 41 mm. and an equivalent focal length of 45 mm. This condenser images the filaments of the bulb at the end of the quartz rod, the end of which is ground to form a 45-degree prism. The prism, silvered on the hypotenuse, reflects the light along the 4 mm. quartz rod from the end of which the light is virtually sprayed over the photographic field. The center of interest lies somewhat off the axis away from the lip of the laryngoscope; therefore, the end surface of the rod is ground to form a 15-degree prism in order to center the light on the field.

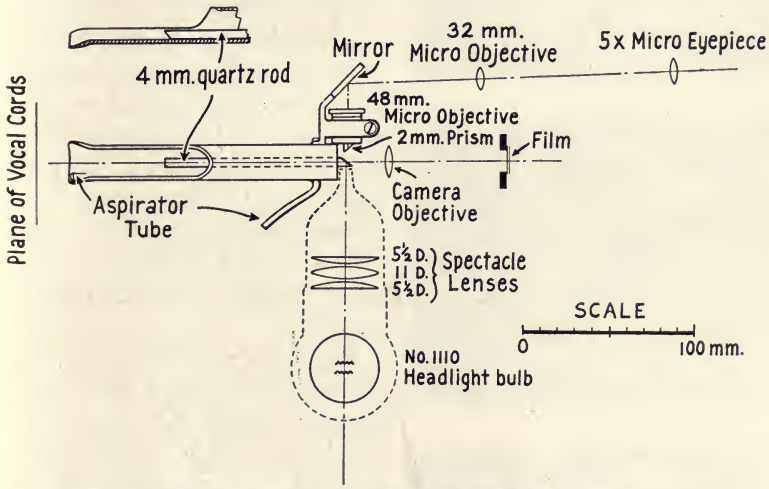

FIG. 3. Schematic diagram of the optical system of camera, lighting system, and finder, attached to laryngoscope.

This method of illumination provides a cool light with an intensity of 400 to 600 foot-candles on the larynx.

A par-focal viewing system is attached to the side of the camera and enables the operator to focus the instrument on the vocal cords and to observe the field while the camera is running. The entire system is conveniently formed by a combination of microscope optics or their equivalent. A 48 mm. objective is used, stopped down by a 3 mm. diaphragm. The erecting system is a 32 mm. objective and the eyepiece is a 5x ocular. The field is seen by the eye in the same position as it will appear on the screen. The mirror attached back of the objective lens of the finder and the 2 mm. prism mounted just ahead of it serve to alter the direction of the

optical axis for convenient placing of the eyepiece. The small tube originally built into the laryngoscope to hold the pea-lamp, which served as an illuminant for visual use, is extended to the lip of the instrument to serve as an aspirator for the removal of excess mucous which may collect in the field.

FIG. 4. Full-frame enlargements from a sequence showing closing of vocal cords.

In using the instrument at room temperature there is a possibility of moisture condensing on the camera objective. To prevent this the entire apparatus is warmed to about 37°C. just before passing it into the oral cavity. The heat from the lamp housing and contact with the throat structure will hold the temperature at the proper level to prevent condensation during the taking of the pictures. One winding of the camera motor usually suffices for the record of a patient.

Fig. 4 is a group of three single-frame enlargements from a sequence showing the closing of the vocal cords of a normal larynx incident to the production of a sound. The anterior portion of the larynx is in the upper part of the field. Although this instrument is not satisfactory for the study of the function of the larynx, owing to the presence of the tube in the oral cavity and the pharynx, it presents a ready means of making case records in which the larynx is shown in various phases of its movements.

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THE CALL ANNOUNCER: A TELEPHONE APPLICATION OF SOUND PICTURE IDEAS*

O. M. GLUNT**

Summary.—*Fundamental research and development work carried on with a particular objective in one field contributes in many cases to the solution of problems in other fields. A typical example is the application of the sound reproducing elements, developed for use primarily in sound picture theater reproducing systems, in the solution of an intricate problem in telephone system operation. This article outlines the communicating problem which was presented and describes the apparatus which was developed, employing adaptations of sound picture principles to meet the need.*

It is well known that the fundamental research carried on in the telephone field by Bell Telephone Laboratories has served as a basis for the development work which it has done in the sound picture field. As is to be expected this development work, which produced the sound pictures, is also being applied to the solution of problems arising within the telephone system.

One such problem is a result of the present transition from manual to dial operation of telephones, in which there are frequently two different telephone systems in operation in the areas involved, and it is necessary to interconnect these two systems in some manner.

Suppose, for example, a subscriber connected with a dial operated office wished to talk with a subscriber connected to a manually operated office. It would be a simple matter to arrange a circuit so that he might dial the desired number and thereby select and cause a series of pulses to pass over the wire to the manual office. These pulses, however, would be unintelligible to the operator. Some means of translating these pulses into a signal which she would understand and which would give her sufficient information to set up the desired connection is required.

This problem first arose a number of years ago, when the installation of dial telephones was undertaken on a large scale. It was then solved by the use of the "call indicator," in which the pulses from the dial telephone caused certain numbers and letters to be dis-

*Received by the Editor, February 1, 1931.

**Bell Telephone Laboratories, New York, N.Y.

played before the operator. This apparatus, however, was limited in use to circuits of relatively short length. The terminal equipment was expensive and for the smaller suburban offices it could not be "proved in."

These objections were not important as long as the use of the call indicator was limited to setting up local calls in city offices. With the growth of the dial system, however, dialing was used to set up connections over longer and longer distances, and it became evident

FIG. 1. Call-announcing apparatus with covers removed. At the top can be seen the driving motor and the 8 drums, each bearing 8 strips of film. Associated with each strip of film is an exciting lamp, optical system, and photo-electric cell.

that the call indicator would have to be replaced or supplemented by some other type of apparatus which would be generally applicable to the telephone system, of relatively low cost, and which in operation could be adapted to existing practices. It was therefore decided to determine the possibility of translating the pulses of the dial into speech, as such speech could naturally be carried anywhere over the telephone system.

After some preliminary investigations, such as a series of measure-

ments on the time duration of spoken digits, work on the first experimental apparatus began in 1927. There had been public showings of sound pictures for almost a year, and the sound picture industry was entering upon a period of intensive growth. For this reason there was available a rapidly growing wealth of sound reproducing apparatus together with experience in its operation. This was of great value in the development of the "call announcer."

The first call announcer consisted of a large brass drum with four-

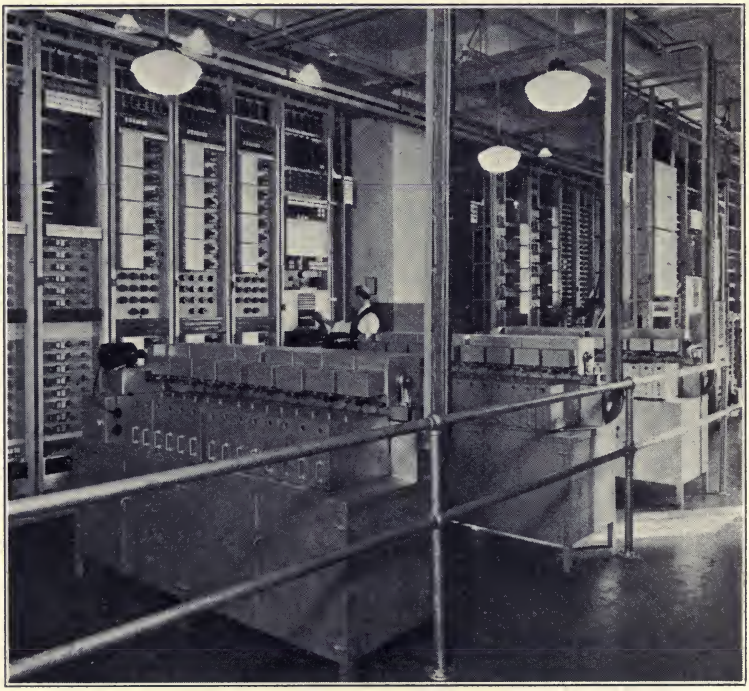

FIG. 2. Commercial installation of call-announcing apparatus. At the left can be seen the frames carrying the telephone repeaters which form the last stage of amplification, together with other telephone apparatus.

teen slots running around it. Over each of these slots was placed a sound film—one for each of the digits, and one for each of the call letters, J, M, R, W. Inside the drum and associated with each of these strips of film was a lamp and a lens system which focused the light from the lamp on the film. After passing through the film, the light was picked up by a photo-electric cell outside the drum. The

electrical output of the cell was then passed through a three-stage amplifier associated with it. By means of relays actuated by the dialing pulses the proper film reproducing circuits were connected in the correct order to inform the operator of the number dialed.

During the latter part of 1927, the feasibility of the project was demonstrated with this first model, and it was determined to proceed with the work. The question immediately arose as to the compara-

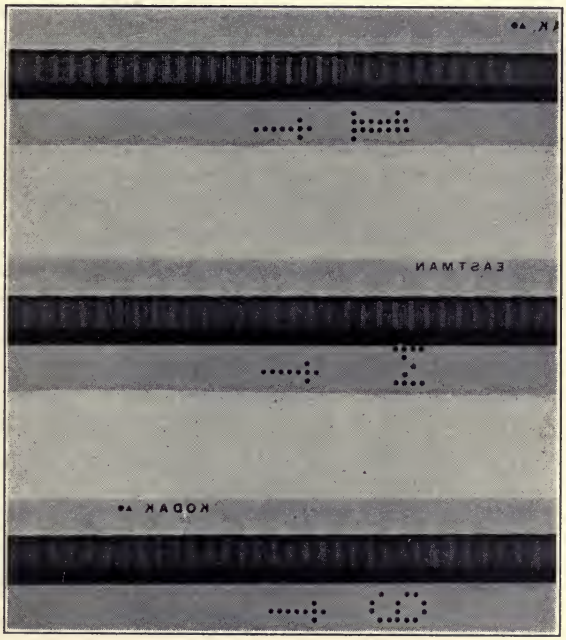

FIG. 3. Three typical strips of sound film as used on the call-announcer drums slightly enlarged to show the characteristics of the sound track of the recorded characters 1, W, and 9.

tive length-of-life of film and disk sound records. The importance of this in a call-announcing mechanism for the telephone system can be readily appreciated from the fact that it must be possible to play the record continuously many thousand times a day over a long period of time with a minimum amount of replacement.

Under the conditions met in sound picture projection, neither film nor disk records entirely satisfy this requirement. Disk records would need replacement much more frequently, as would the pick-up

needle. From the standpoints of cost for records and of attention in operation the film record was selected in preference to the disk.

The question of replacements also arose in connection with the lamp and photo-electric cell which, as used in a sound picture projector, have an average useful life of 150 and 1500 hours, respectively. Due to the intermittent use of sound picture projector equipment, short-lived consumable items such as lamps are not a serious operative matter as long as they involve only a small cost. In the call announcer, due to their continuous use, the frequent replacement of these elements would present a serious operating obstacle quite apart from the cost of replacement. Fortunately, the needed signal level conditions of the call announcer made it possible to depart from the sound picture operating practice. This departure consists in operating the lamp at a much lower illumination level, obtaining a longer operating life for lamp and cell. As a result, the average life of these elements in a call announcer under normal conditions is about 200 days.

While the final form of the call announcer is much the same as in the first experimental model, a number of changes have been made. The photo-electric cell is now inside and the lamp and lens system are outside the drum, making it easier for the heat generated by the lamp to be carried away, thereby prolonging the life of the film. Other advantages of this arrangement are the greater accessibility of the various parts and the ability to use a greater amount of standard sound picture apparatus.

In its present form the apparatus includes a group of eight drums. These drums are arranged to carry four strips of sound film on each outer edge. One of these drums is a spare and each of the other seven carry two groups (4 strips each) of sound film; a total of 14 groups. On each of the four strips of the 14 groups is recorded one of the ten digits or one of the four call letters J, M, R, and W. These drums are mounted on a common shaft and are driven by a small motor through a suitable reduction gear to give a constant peripheral drum speed of 90 feet per minute. In front of each film is a small lamp which is focused on the film by means of an optical system and behind each film and within the drum is a photo-electric cell.

The drum on which the film is mounted must be large enough to permit a photo-electric cell to be mounted within the shell. This requires a circumference much greater than that required for a single repetition of a number or letter; four announcements of the number or letter are therefore recorded, one on each piece of film, and these

four strips are mounted symmetrically around the circumference of the drum. The actual speaking time required for a single digit is about 0.27 second, and the silent interval allowed is 0.08 second. These values are for a film running at the standard speed of 90 feet a minute.

The three-stage amplifier associated with each of the sixteen (including two spares) sound reproducing systems is located just beneath and in front of the rotating drums. By means of these amplifiers the current from the photo-electric cell* is brought up from an acoustic level of about −70 or −75 db. to a level of about −25 db. From these amplifiers, the current is fed into telephone repeaters mounted on an associated relay rack, which act as final power amplifiers and bring the acoustic level up to approximately the zero reference point, 6 milliwatts. When a number is dialed, it is recorded on relays in the sending mechanism, where it remains stored until the operator who is to complete the call is free to do so. She then pushes a button and the relays, in which the number is stored, actuate other relays to cut in the proper films in the correct sequence in order to announce to the operator at the manual board the number which has been dialed.

These call announcers, at least for the present, will not be placed in dial exchange offices, but only in dial tandem offices, which are used to connect widely separated telephones. Three call announcers will be placed in each of these offices, one of which is held in reserve, the load being automatically distributed between the two in service. The call announcers in service are monitored automatically by relays in each reproducing circuit. These relays are held operated as long as the reproduced speech in each circuit is maintained at a predetermined level. If, through failure of the photo-electric cell, the lamp, or from any cause, the volume falls appreciably in any reproducing circuit, the particular call announcer is switched out of service and the spare one connected in its place and a signal is given to the maintenance force.

Development work on the call announcer was completed and a public demonstration was made in 1929. It was demonstrated to members of the Society on the occasion of their visit to Bell Telephone Laboratories during the Fall Meeting, October 20–23, 1930. This apparatus has given entire satisfaction in the numerous tests made with it and the first commercial installation was put into service January 3, 1931.

*Due to the lower illumination level of the lamp, this current is much less than in sound picture practice.

COMMITTEE ACTIVITIES

New Committees.—The following new committees have been appointed:

Practical Projection

H. Rubin, *Chairman*
T. Barrows
S. Glauber
J. H. Goldberg
C. Greene
H. Griffin
J. Hopkins
R. H. McCullough
R. Miehling
F. H. Richardson
M. Ruben
H. B. Santee

Projection Theory

W. B. Rayton, *Chairman*
F. A. Benford
J. F. Leventhal
W. F. Little
C. Tuttle

Two additional committees are in process of formation which will deal with projection screens and fire protection. The Color Committee is arranging for an exhibition of representative films prepared by the various commercial color processes at the Spring Convention. The Historical Committee is likewise arranging for an exhibit of apparatus and films of historical interest.

Meeting of the Practical Projection Committee.—The first meeting of this new committee was held at the Paramount Building, New York, on Wednesday evening, January 21, 1931. Chairman H. Rubin, in his introductory remarks, stated that the meeting was called for the purpose of gathering technical information relating to the practice of projection, and to make a report to the Society at the Spring Meeting. In discussing the ideal lay-out of the projection room, the chairman remarked that it would be necessary to deal with its location, size, equipment, safeguards, ventilation, painting, lighting, wiring, *etc.*, and lay-outs suitable for vaudeville theaters, regular theaters, and *de luxe* houses should be prepared. Recommendations should also be secured from acoustical experts relating to the best treatment for lessening noise in the projection room. The distance between projector centers as related to the projection

distance and the matter of auxiliary automatic ventilation as an emergency safety measure should be considered.

Mr. J. H. Goldberg presented to the chairman three sets of preliminary lay-outs for projection rooms for class A, B, and C theaters and these blue-prints and plans were discussed. A subcommittee was then appointed to prepare an ideal projection room lay-out for large, medium, and small theaters. The committee is composed of the following members:

J. H. GOLDBERG, *Chairman*
J. J. HOPKINS
LESTER ISAACS
H. B. SANTEE
L. M. TOWNSEND

Mr. F. H. Richardson then moved that the Practical Projection Committee should consider holding a meeting with theater architects or representatives of their association for discussing the ideal projection room lay-out and its location with respect to each type of theater mentioned above. This motion was carried and Chairman Rubin promised to make the necessary arrangements.

The problem of the relation between screen brightness and the illumination level in the auditorium, in so far as it affects the eyesight of the observer, was referred to the Projection Theory Committee.

The following subcommittees were also appointed:

Screen Illumination

(*To investigate and prepare standards for proper screen illumination as contrasted with the illumination level in theater auditoriums.*)

H. GRIFFIN, *Chairman*
S. GLAUBER
R. MIEHLING
L. TOWNSEND

Projection Room Routine and Maintenance

(*Embodying daily inspection of equipment and preparatory work to insure perfect performance.*)

J. J. HOPKINS, *Chairman*
S. GLAUBER
LESTER ISAACS
R. H. MCCULLOUGH
M. RUBEN

Monitoring and Control of Sound in Theaters

H. B. SANTEE, *Chairman*
L. ISAACS
R. MIEHLING
F. H. RICHARDSON
M. RUBEN
L. TOWNSEND

Progress and Improvements in Projector Design and Accessories

H. GRIFFIN, *Chairman*
S. GLAUBER
J. J. HOPKINS
L. ISAACS

The problem of film buckle was referred to President Crabtree for consideration by some other committee. The subcommittee on "Progress and Improvements in Projector Design and Accessories" will also consider this question.

The chairman briefly described a new curved film track which was designed to aid in the projection of buckled film and announced that a technical paper on this device, written by its inventor, will be submitted to the committee at the next meeting.

The new standard release print was discussed and Mr. Richardson voiced an objection to the black circle motor and change-over cues which are now a part of the standard change-over practice. The chairman ruled that the standard should be given a further chance to function before any changes are advocated.

ABSTRACTS

A Meaningless Jubilee. G. Seeber and K. Wolter. *Filmtechnik*, **6**, November 15, 1930, pp. 1–4. The suggestion of a celebration for the Skladanowsky brothers prompts an editorial chronological review of the beginnings of motion pictures in the various countries. The article points out the fallacy of any claims that the Skladanowsky brothers gave the first public showing of motion pictures. The date of their showing in Berlin was November 1, 1895, long after the public exhibitions of Edison, Jenkins, Paul, the Lumière brothers, and Acres. L. E. M.

Damage to Sound Films in Projection. A. Szekely. *Filmtechnik*, **6**, December 13, 1930, pp. 9–10. The suggestion is made that the projection life of sound films is low because of drying out during the time that the films are threaded in the projectors and exposed to temperatures of 35°C. to 40°C. Such troubles may be minimized by using larger sprockets and better idler devices for keeping the film on the sprockets. L. E. M.

Sound Film's Production Cost Near Ten Times That of Silent. *Ex. Herald-World*, **101**, December 27, 1930, p. 7. According to a preliminary report of the U. S. Census Bureau, more than 1000 sound films were produced in 1929 at a total production cost of $100,000,000, while 1500 silent pictures were turned out costing less than $17,000,000. There were 143 establishments included in the census and their total expenditure was over $180,000,000, compared with $134,000,000 for 142 concerns reported in 1927. Negative films used in 1929 cost $125,000,000 and positive films over $10,000,000. G. E. M.

Comparative Investigation of Electric Pick-Ups. P. Hatschek. *Filmtechnik*, **6**, December 13, 1930, pp. 12–14. Pick-ups of German manufacture were tested for response characteristics. Curves are given which show their behavior over a frequency range of 60 to 5000 cycles per second. L. E. M.

Metal Film for Motion Pictures. *Film Daily*, **55**, January 14, 1931, p. 8. Metal film, claimed to be more durable and resistant than the present celluloid preparations, is reported to have been invented by L. Lumière. C. H. S.

Distortion of a Variable Density Modulation in Printing the Positive. Leenhardt. *Tech. Cinemat.*, **1**, November–December, 1930, p 11. The negative sound record produced in the variable density method of sound recording has a logarithmic distortion, on account of which no accurate appraisal of recorded sound quality is possible by direct reproduction of the negative. A corresponding distortion in the process of printing the positive compensates for it. Mathematical and graphical demonstration is given for an originally pure sinusoidal sound wave. C. E. I.

Yield of the Fixing Bath in a Machine. R. Landau. *Tech. Cinemat.*, **1**, November–December, 1930, p. 8. In a tube type of developing machine the utmost yield of useful work is obtained from the fixing bath by a system of

countercurrent flow. A convenient method of controlling the flow is one which takes advantage of the difference in density of the liquid at the last (film) stage and at the first where the bath is being diluted by developer carried on the film. If all the tubes are connected by small pipes at the bottom, the step-by-step change in gravity from one end of the machine to the other will cause a difference in liquid level from the first to the last tube. Although each tube is equipped with an overflow hole near the top, liquid will overflow only from the one or two tubes (of ten) nearest the developer because of the greater dilution with the consequent high liquid level. Thus the liquid is always discharged at the diluted (and exhausted) end. (In American practice where the water enters the fixing bath from a water rinse, this effect is also present.—Abstractor's Note.)

C. E. I.

Orthochrome Screen Eases Eye Fatigue. *Mot. Pict. Daily*, **29**, January 20, 1931, p. 6. A description of a motion picture screen which regulates the spectral character and brilliance of the reflected light and thus is claimed to minimize eye fatigue. The surface of the screen is divided into a multiplicity of uniformly distributed areas, part of which are covered with a light filter, absorbing all or part of any predominant wave-length. A surface of uniformly distributed units results, each pair of which is claimed to reflect a composite of the wave-lengths, the sum of which presents to the eye white light or light to which the eye can react harmoniously and rationally. The nature of the filter chosen helps diffuse the light to reduce glare.

G. E. M.

Increasing Light Efficiency in Projection. F. HAUSER. *Filmtechnik*, **6**, December 13, 1930, pp. 1–6. Tests of the Busch Neospiegel mirror reflector for increasing the efficiency of the projection arc show it to be superior to the ordinary spherical reflectors. The newly developed reflector is claimed to overcome some of the objectionable properties inherent in elliptic and parabolic shapes. The results of tests of new large-aperture projection lenses developed by the same firm are given. A large number of illustrations are used which show the benefits obtained with the various optical trains.

L. E. M.

Testing of Sound-Picture Channels. G. F. HUTCHINS. *Electronics*, **2**, No. 2, February, 1931, p. 500. In sound picture production, it is important to have a complete knowledge at all times of the condition of each recording channel. This should be tested as a matter of daily routine and this paper is concerned chiefly with the details of these tests.

A. C. H.

Frequency Characteristics of Optical Slits. J. P. LIVADARY. *Electronics*, **2**, No. 2, February, 1931, p. 512. An analysis is made of the attenuation due to the finite width of the slit in sound recording. A table is included showing the attenuation losses as a function of frequency for slits having a width of 0.5, 1.0, 2.0, and 3.0 mils.

A. C. H.

Sensitizing the Photo-cell. RICHARD FLEISCHER. *Electronics*, **2**, No. 2, February, 1931. The sensitizing of photo-electric cells by means of a glow discharge in hydrogen has been known since the time of Elster and Geitel. This sensitizing process produces a marked increase in sensitivity and a shift in the spectral sensitivity. The constancy of a sensitized cell depends principally upon the establishment of a condition of equilibrium between the residual gas and the photo-electric

surface. Various experiments are described in the present paper which bear on the cause of the increase in sensitivity. A. C. H.

Television in Color from Motion Picture Film. HERBERT E. IVES. *J. Opt. Soc. of America*, **21**, January, 1931, p. 2. It is shown that the Kodacolor motion picture film lends itself particularly well to the solution of the problem of transmitting colored motion pictures over the wire or radio. A. C. H.

A Multi-Channel Television Apparatus. HERBERT E. IVES. *J. Opt. Soc. of America*, **21**, January, 1931, p. 8. An excellent summary of the fundamental difficulties that must be overcome before "fine-grained" television images can be transmitted. If a single channel is used, television signals must be sent at the rate of 7,000,000 per second. This would be impossible with the frequencies used at present in radio broadcasting. One solution is to use several relatively narrow frequency bands. The paper contains a description of a three-channel system. The multi-channel scheme has some advantage in compactness but, as the several circuit elements must perform uniformly, there is increasing difficulty as the number of channels is increased. A. C. H.

A New Photographic Effect. FRANKLIN E. POINDEXTER. *J. Opt. Soc. of America*, **21**, January, 1931, p. 59. It is found that the application of pressure to a photographic emulsion prevents the formation of a latent image to a remarkably large extent. This effect is of interest in connection with theories of the latent image. A. C. H.

World's Theaters Wired for Sound. *Mot. Pict. Daily*, **29**, January 24, 1931, p. 4. According to an approximate survey made by the Motion Picture Division of the U. S. Department of Commerce, 34 per cent (*i. e.*, 19,894) of the 58,082 motion picture theaters of the world were wired for sound as of November 1, 1930. Charts are shown giving data for Europe, the Far East, Latin America, Africa, and the Near East. Data for the chief countries are as follows: U. S. 22,731 theaters, 12,500 wired; Canada 1183, 653 wired; Great Britain 4500, 2602 wired; Germany 5360, 939 wired; France 3236, 460 wired; Brazil 1600, 125 wired; Japan 1327, 25 wired. G. E. M.

Combination Frost Screen and Cooling System. *Film Daily*, **55**, January 14, 1931, p. 2. A metal screen, back of which is placed a refrigerating system, is a late development in theater equipment. The metal becomes covered with a white frost and the visual effect of this surface is said to be an improvement over the frosted glass screen. Fans directed on this screen, blow cool air from it to the audience. C. H. S.

A Line Filament Exciter Lamp and Accompanying Slit-less Optical System for Sound Film Reproduction. L. DUNOYER. *Tech. Cinemat.*, **1**, November–December 1930, p. 43. By substituting a line filament exciter lamp for that using a coiled filament it is unnecessary to include a slit in the reproducer illumination system. Reference is given in this article to the patents on a lamp having such a filament and a plane parallel glass side. The optical system is designed to correct for the astigmatism resulting from the finite thickness of the glass. C. E. I.

The Artisol 75 Ampere Lamp. *Tech. Cinemat.*, **1**, November–December, 1930, p. 44. A reflector arc lamp for motion picture projectors is announced

which is suitable for currents between 45 and 75 amperes. In order to avoid the risk of the arc flame reaching the glass mirror and cracking it, the flame is drawn slightly upward by an electromagnet. C. E. I.

Screen Characteristics and Natural Vision. L. M. DIETERICH. *Mot. Pict. Projectionist,* **IV,** Jan., 1931, p. 17. A discussion of the question of screen proportion in relation to the natural field of view of the normal eye. The angular limits of unstrained binocular vision are shown in diagram form. The zone of comfortable seeing on such a chart is found to correspond closely to the 5 to 8 ratio of dimensions which has been suggested as ideal for the motion picture screen. A. A. C.

New Brenkert High Intensity Lamp. *Mot. Pict. Projectionist,* **IV,** Jan., 1931, p. 15. The design and construction of the latest Brenkert projection lamp are here described and its advantages are listed in detail. It is claimed to give unusually even illumination on screens up to a 40 foot size. A. A. C.

New Projection Optical System. I. L. NIXON. *Mot. Pict. Projectionist,* **IV,** Feb., 1931, p. 13. A descriptive article on the Super Cinephor projection lenses and condensing systems designed by the Bausch & Lomb Optical Company for use with wide film. The necessity for exact spacing of the condenser system is emphasized. A. A. C.

New "Ortho-Krome" Screen Development. *Mot. Pict. Projectionist,* **IV,** Feb., 1931, p. 21, also p. 18. This screen material is said to so regulate the amount of light reflected to the eye that strain and fatigue are much reduced for the observer. It consists of a pattern of small square pigmented areas intermingled with white squares in proper proportion so that the quality of the illumination more nearly resembles sunlight. The size of these individual squares is made small enough to prevent their being resolved at the normal viewing distance. A. A. C.

Light Reflection Factors of Acoustical Materials. A. L. POWELL AND C. L. DOWS. *Trans. Illum. Eng. Soc.,* **XXV,** Dec., 1930, p. 882. There is a growing practice of lining the ceilings and walls of interiors with sound absorbing materials. Many of these have relatively high light absorption, and this must be taken into account in the design of lighting systems. The results of tests on the reflection factors of most of the types of acoustical materials in common use are reported. A. A. C.

Sound Picture Equipment in U. S. S. R. M. J. MOSHONKIN. *Amer. Cinematographer,* **XI,** Dec., 1930, p. 9. Apparatus has been developed for sound recording and reproduction during the last four years in Russia, under the direction of Prof. Shorin. The principle employed is that of the single ribbon oscillograph, and can be applied to both variable-area and variable-density methods. The paper gives a general description of the apparatus and contains illustrations showing the assembled units. Of interest is the statement that the Soviet five-year plan calls for forty thousand sound picture installations. A. A. C.

Warner Brothers' New Camera. WILLIAM STULL. *Amer. Cinematographer,* **XI,** Dec., 1930, p. 11. The first public showing of this new product took place at the October meeting of the American Society of Cinematographers; it is reported to be a distinct advance in camera design, and absolutely silent in opera-

tion. The optical system is the outstanding feature of the design, the objective lenses being mounted on the turret in fixed mounts with the entire turret movable for focusing. The focus adjustment is observed through a prism which reflects up to a horizontal ground glass, and the image at this point is again reflected back through the finder to a binocular eyepiece at the rear of the camera. By the turn of a lever a second prism reflecting 25 per cent of the light may be substituted for the first in the finder system, allowing the operator to focus his lens during the operation of the camera. A. A. C.

The Noiseless Motion Picture Camera "Cinephon." L. KUTZLEB. *Kinotechnik*, **12**, December 20, 1930, pp. 644–6. A camera, for which the minimum of noise is claimed, is constructed especially for sound work according to the design of Slechta of Prague. The mechanism and the pull-down are said to operate almost without sound. The remaining sounds, including that caused by the perforations of the moving film, are deadened by a double housing of sound-absorbing material, which increases the size and weight of the camera only slightly. The film magazines, mounted on the top of the camera, hold 300 meters of film. A revolving turret of four lenses is provided. A prism and 7x magnifier permit focusing on a ground glass in the film aperture without opening the camera. A scale indicating the sector shutter opening and a control handle for the automatic dissolve mechanism are found on the back of the camera. A lamp is mounted in the camera for exposing the edge of the film outside the perforations to aid in synchronizing the picture with the sound record. M. W. S.

Projectophone System. D. VON MIHALY. *Filmtechnik*, **6**, December 13, 1930, pp. 6–9. A system of reproducing sound on film known as the Projectophone is sponsored by Mihaly, who devised it. The system comprises the customary necessary units, but has in addition a long focal length lens by means of which the sound record can be projected to the photo-electric cell located outside the projection room. This method of projecting the sound record permits the photo-electric cell and amplifier to be located together, at a distance from the projector and other electrical equipment. It is suggested that the principle employed in the Mihaly system may be of value for the projection of home movies. L. E. M.

European Sound-on-Disk Equipment Data. P. HART. *Filmtechnick*, **6**, December 13, 1930, pp. 9–10. Data on methods of coupling, synchronizing, electrical equipment, *etc.*, characteristic of the various European makes of sound–on–disk systems are presented compactly in the form of tables. L. E. M.

Television Process. *The Film Daily*, **55**, January 18, 1931, p. 7. This process, including a newly developed screen, is claimed to make possible the projection of pictures onto an ordinary full-sized screen, to televise people and objects illuminated only by arc light or daylight, and to show an unlimited amount of detail in the picture. The principle of the process is to divide the subject into zones and televise each zone from a separate amplifier and through its own line to the receiver. A system of revolving mirrors is used to convey the light from the receiver to the screen. Any number of zones can be used, each necessitating a separate amplifier and receiving set. The method is a modification of the Baird method of television. C. H. S.

Noiseless Recording. H. C. SILENT. *Ex. Herald-World*, **101**, December 27,

1930, p. 30. A dark print of a variable density sound record gives low volume reproduction and low ground noise, but as the print is made lighter, the ground noise level increases. A new auxiliary electrical circuit permits control of recording so that the volume is reduced for low volume sounds and automatically increased as the volume rises. The ribbons of the light valve have been set 0.001 inch apart in the past for recording and the strongest currents just bring them together. For weak currents the space was greater than necessary. According to the new system, the ribbons are set closer and the space is widened automatically to accommodate loud volume sounds. Thus the amount of light which reaches the film or the reproducing photo-electric cell has been unaltered even though the total amount has been decreased. No volume distortion on reproduction, therefore, is introduced. The device has been arranged so that photographic overload and light valve overload occur simultaneously when the set is adjusted for normal recording. Ground noise is claimed to have been reduced ten db. under commercial tests, and sounds previously completely obscured by ground noise may now be recorded and reproduced satisfactorily.

G. E. M.

New Type Microphone. *Mot. Pict. Herald*, **102**, Jan. 24, 1931. p. 42. A corrugated aluminum ribbon 0.0001 inch thick, $^3/_{16}$ inch wide, and 2 inches long is placed between the poles of an electromagnet. Minute changes in air pressure produced by sound waves cause the ribbon to vibrate and set up an electric current, which is led to a transformer connected to a vacuum tube amplifier of the conventional type. The microphone is contained within a perforated box fastened to the base of an amplifier. A feature of the new microphone is its directional pick-up characteristics, sounds normal to the face being reproduced completely whereas the reception in the plane of the face is zero. Thus, if the camera is placed in this plane, any noise coming from it, is not recorded.

G. E. M.

ABSTRACTS OF RECENT U. S. PATENTS

1,753,530. **Sound Recording Apparatus.** F. H. OWENS. April 8, 1930. Relates to an electromagnetically operated light slit in which a constant light source is provided in optical relation to a film in a sound recording system. The light slit consists of a pair of slidable shutter members, each being connected to separate diaphragms which are electromagnetically controlled from a voice control circuit. The diaphragms are adjustably connected with each of the shutter members constituting the light slit. Operation of the voice control circuit controls the position of the shutters and the exposure of the light-sensitive film with respect to the light source.

1,758,221. **Motion Picture Camera.** H. A. DEVRY. May 13, 1930. A motion picture camera in which the operating parts are compactly arranged within a portable case for utilizing standard size film, the parts being readily accessible for threading of the film and the inspection of the parts when the case is open. The camera is provided with a hinged side which may be swung outwardly from the casing to permit access to the supply and take-up spools, each of which may be removed end-wise from the casing.

The intermittent film driving mechanism, the shutter mechanism, and the film guide are all arranged to be accessible from one side of the casing when the hinged cover is swung open.

1,759,914. **Producing Films for Color Cinematography.** A. PILNY. May 27, 1930. A method of producing film strips for cinematography, comprises splitting a series of images rectangularly and projecting them onto longitudinal parallel portions of a film strip by folding the strip longitudinally at right angles to unite the portions of the film for receiving the partial images. A film is employed in the making of the color motion pictures which is of double width and which is folded longitudinally upon itself. Partial pictures are produced in symmetrical arrangement to each other on the folded film, enabling a simple production of a positive color film by placing a film consisting of a colored layer impervious to light between the emulsion coatings on the folded film.

1,774,097. **Pocket Cinematograph.** P. HAUSER AND EDUARD PROBST. August 26, 1930. Relates to a diminutive motion picture projector which may be carried in a pocket. The projector is said to have a dimension of 2 in. by 4 in. by 1 inch. Two side plates are provided between which the film reels are journaled. One of the reels is driven through a hand crank and a gear system. The casing of the projector includes a lens system and a step-by-step movement mechanism for successively exposing the film to a light source which may be connected through a flexible cord with any suitable source of power. The particular feature of the invention is the telescopic portion of the case which may be telescopically dropped down from the casing to receive the end of the film as the projection process continues.

1,778,351. **Motion Picture Projector Using Pictures on a Disk.** L. W. BOWEN. October 14, 1930. A motion picture machine wherein a series of pictures are arranged spirally and radially on a transparent plate or disk film. The film is given both a rectilinear and an intermittent rotary movement in the course of projection of the pictures. The apparatus is housed inside a casing within which there is a carriage mounted for rotatively supporting a disk film.

A system of gears connected through a drive shaft enable rotary motion to be transmitted to the disk film. Rectilinear motion may be imparted to the carriage whereby a spiral record on the film may be reproduced through an optical system by the advancing of the film at the end of each complete revolution thereof.

1,780,311. **Home Motion Picture Projector.** A. PAPO AND A. GENTILINI. November 4, 1930. Relates to a home projector for motion picture film in which an optical system and reflector are mounted on a carriage and movable in a line normal to the optical axis of the projecting machine. The reciprocatory carriage contains a reflecting prism adapted to be aligned with the light source for directing the light rays through a projecting lens upon an exhibiting screen. The carriage is reciprocated by the engagement of a pawl with the film. A shutter is actuated as the carriage is reciprocated by engagement of the pawl with the film, thereby obscuring the picture during the return movement of the carriage under action of the spring. The reciprocating carriage, containing the shutter mechanism, a prism, and a reflecting lens, eliminates the usual construction of rotary shutter and renders the construction of the machine more compact for home operation.

1,781,945. **Alignment Guide for Sound Track on Motion Picture Projector.** T. W. CASE. Assigned to Case Research Laboratory, Inc. November 18, 1930. Covers a guide for film having a sound track thereon where the film rides over a body portion of the guide and is held in contact therewith so that the sound record on the film registers with a longitudinal channel in the guide at one side of the picture record on the film. The shoe which maintains the film against the guide is spring-pressed and is designed to eliminate wear or scraping of the film while maintaining the film in accurate alignment so that the sound track is directly in alignment with the channel portion of the guide through which light rays pass to the sound portion of the film.

1,783,169. **Means for Winding Endless Cinematograph Films.** M. HARPER. November 25, 1930. Relates to a drum for the winding of endless films. The drum comprises two plates, one made in the form of a flat ring and the other solid, with rollers carried around the periphery of the flat ring and the plate. There is an aperture in the plate in which a roller is mounted for the passage of the beginning of the film as it is unwound from the lower layer on the peripheral rollers. The entire rotatable drum is mounted in a horizontal position adjacent to the projection machine and adjusted to continuously take the film from the center of the reel and restore the film after projection to the exterior of the reel.

1,783,399. **Binocular Motion Picture Camera.** A. AMES, JR. December 2, 1930. Relates to a method of and apparatus for making motion pictures of the type in which the screen image is binocular in the sense of containing a composition of images from two different points-of-view representative of two-eyed vision. The invention is particularly concerned with obtaining the effect of retinal rivalry, so-called characteristic of normal human binocular vision. Images are formed from different points-of-view and different parts of a sensitive film successively exposed during separate exposures, following each other at intervals within the time of the persistence of vision of each of these images severally. Thereafter the successively different parts of the film are exposed

to the images simultaneously. The resultant effect is that the form of the object observed on the screen appears real and relative distances are given with effect of depth in the picture.

1,784,138. **Nonstop Motion Picture Projector.** C. M. GOTTSCHAU. December 9, 1930. A motion picture projector of the type having a continuous film without the necessity of rewinding of the film prior to a subsequent exhibition. The driving mechanism for the film includes a running drive for the reel which is adapted to slip under a predetermined resistance. A starting drive is provided which is more positive than the running drive. Means are provided for automatically disconnecting the starting drive after a predetermined movement of the reel.

1,784,515. **Binocular Nonstop Motion Picture Camera.** H. K. FAIRALL. Assigned to Multicolor, Ltd. December 9, 1930. A device for intermittently advancing the film in a motion picture camera. The movement comprises a pair of cranks each adapted to directly support and operate the film advancing means. The cranks operate simultaneously to shift the film advancing means in step-by-step movement at uniform speed for each frame of the picture.

1,785,336. **Stereoscopic Motion Picture Film and Method of Making.** J. BURKHARDT. Assigned to Third Dimension Pictures, Inc. December 16, 1930. A motion picture film for securing relief or stereopticon effect in reproduction. The pictures are printed in miniature in pairs disposed transversely on the film. The film is of standard width and stereoscopic or third dimension effects or illusions are obtained by the pairs of pictures. The background of each pair has thereon a mask of the foreground picture of the pair.

1,786,025. **Optical System for Reproducing Sound Records.** F. H. OWENS. December 23, 1930. Covers a system for subjecting a film to a beam of light where the gates through which the light passes may be removed out of contact with the film. The movement of a film directly against the usual slit results in the accumulation of dirt and other foreign matter in the slit which clogs it and interferes with the function of the optical system.

An optical system is used which produces a converging beam of light, the focus of which passes through a slit located substantially at the focus of the light beam, the beam diverging from the slit for illuminating a film which is spaced from the slit. There is a second slit on the other side of the film for producing from the light beam a beam of light of reduced divergence which is focused upon a light-sensitive cell. The slits which control the passage of light from the source upon the light-sensitive cell are disposed in spacial relation to the film and do not contact with the film in the course of the movement of film past the slits.

1,786,026. **Lamp House for Sound Picture Apparatus.** F. H. OWENS. December 23, 1930. A lamp housing for the light source in the talking picture attachment for a motion picture projecting machine. The lamp housing is constructed with a pair of integrally connected sides through one of which the optical system extends and on the other of which the light source is supported in alignment with the optical system. A hinged structure comprising the two remaining sides of the housing provides a support for the cathode control rheostat, the required meters, the control switches for the light source. The lamp housing may be compactly mounted with respect to the parts of the motion

picture projector, and affords a convenient means for adjusting or repairing of elements associated with the light source.

1,786,027. **Reproducing a Plurality of Photographic Sound Records on One Film.** F. H. OWENS. December 23, 1930. A sound reproducing system utilizing a film which carries a multiplicity of sound records. A single light source is provided for all of the parallel extending sound channels on the film. There are separate light slits disposed in alignment with the channels recorded on the film and aligned with independent photo-electric cells so that all of the sound channels recorded on the film may be reproduced simultaneously. One sound channel may bear the record of one musical instrument while the other sound channels may bear the records of other musical instruments which have been officially recorded over different frequency ranges. Provision is made for adjusting the sides of each of the light slits by shutter members whereby the relative amount of modulated light received by each of the photo-cells may be adjustably regulated.

1,786,274. **Synchronous Motion Picture and Sound Reproduction.** F. VON MADALER. Assigned to National Vision-Tone Corporation. December 23, 1930. Discloses the design of a talking picture apparatus having sprockets and film feeding mechanism spaced at predetermined intervals and adapted to receive a film having markings thereon at spaced intervals to indicate the position in which the film must be mounted for initially feeding the film in proper position through the projecting machine.

1,786,301. **Sound Recording and Reproducing Apparatus Utilizing a Film Having a Plurality of Sound Records.** C. L. HEISLER. December 23, 1930. An apparatus for recording and reproducing sound from film where the sound is recorded successively in a plurality of tracks on the film. The film is moved longitudinally in opposite directions at substantially uniform speed. A narrow beam of light is projected on the film and the film-supporting device shifted transversely in order to effect reproduction or recording from the different sound channels.

1,786,368. **Synchronizing Photography and Sound Recording.** J. J. F. STOCK. December 23, 1930. A camera for coördinating the taking of pictures with the recording of music. A film-winding shaft is provided in the camera. A device for feeding equal lengths of film through the camera during equal intervals of time is provided, comprising a continuous drive for the film-winding shaft. A friction clutch is connected between the drive and the shaft on which a pawl and ratchet arrangement is provided. An electro-magnet is arranged for actuating the pawl. The clockwork mechanism is provided for energizing the electromagnetic means in definite timed relation for operating the pawl in predetermined order for controlling the operation of the film-winding shaft. The speed at which the film is advanced is automatically regulated in accordance with the production of music.

1,787,023. **Camera and Method of Special Process Photography.** J. F. SEITZ. December 30, 1930. Covers a method of making mats by exposing a film to two component parts of a picture simultaneously, one part photographing on one face, and the other on the other face of the emulsion or film. The film is developed and the picture projected on a screen and utilized in the making of a mat. In this manner photographs may be taken through different lenses

on the same film or plate at the same time and the different pictures may be superimposed on one or the other or may be matted separately and in a manner complementary to each other so that when brought together on the same film they will make a composite picture.

1,787,426. **Compound Ventilating Shutter.** A. DINA. Assigned to International Projector Corporation. January 6, 1931. A rotatable shutter for a motion picture projection machine which is arranged with spaced separate fixed portions, the leading one of which is disposed in the plane of rotation of the blade and the trailing one of which is disposed at an angle to the plane of rotation of the blade, the adjacent edges of the said portions overlapping to prevent the transmission of light. The shutter provides a ventilating and cooling device for the projection head of the motion picture machine, while at the same time the effective width of the blade in the plane of rotation is unchanged so that the light-cutting capacity of the blade is unchanged regardless of the variability of the angle of the portions of the shutter. The intervening spaces in the shutter are effectively shadowed to prevent the transmission of light during the cutting movement of the blade.

1,788,740. **Method of Making Composite Pictures.** R. J. POMEROY. Assigned one-half to Paramount Publix Corporation. January 13, 1931. A color motion picture system in which two component images are produced. One component is illuminated with light of a selected color before a ground illuminated with light of a color having a minus relation to the selected color. The other component is illuminated selectively with light from the ground. Different parts of a fresh actinic film are exposed selectively to the second-mentioned illuminated component and to the illuminated first-mentioned component in lights of their respective colors. This invention provides a method whereby the scheme of complementary or distinctive illumination colors (colors that may be described as having a minus relation to each other) may be utilized for the production of composite pictures without the necessity of preparing a special photographic transparency in one of said colors, whereby an ordinary black and white photograph may be utilized in the place of such a color transparency.

1,788,808. **Motion Picture Apparatus Using a Disk instead of a Film.** S. F. STEIN. January 13, 1931. Relates to a projection machine wherein the film is in the form of a disk having pictures arranged in circular paths around the circumference thereof. A multiplicity of light beams are projected through the rotatable picture carrier for projecting pictures upon the same screen. The movement of the rotatable picture carrier is coördinated with the movement of a phonograph. Different pictures pertaining to the same event may be superimposed upon each other on the same screen or the pictures may be projected in succession from the circular record on the picture carrier.

1,789,607. **Device for Projecting a Film Having a Plurality of Sound Records.** J. H. STEURER. January 20, 1931. Relates to a sound reproducer consisting of a film-moving apparatus which is adapted to reversibly feed a film first in one direction and then in the opposite direction for the reproduction of sound from a multiple-track sound record on the film. The shifting apparatus which changes the position of the light gate transversely with respect to the film is operated automatically to bring the light gate into alignment successively with the separate

sound tracks whenever the feed of the film is reversed, so as to form a practically continuous operation from one sound track to the next. The inventor describes the apparatus as the "talking book," as a long sound record which may be instruction from a text-book may be recorded and reproduced as the film moves first in one direction and then in the opposite direction.

1,790,232. **Motion Picture Camera Having a Movable Lens System.** ROLLA T. FLORA. January 27, 1931. A motion picture camera having a movable lens system controlled by an operating device by which short-focal, telephoto, or any intermediate focal characteristics with respect to a given focal plane, may be obtained quickly.

The camera is set up to take a long shot and while the film is being exposed the lenses are moved to cause the gradual magnification or increase of linear dimensions of the image on the film, thus giving the effect of a gradual change from a long shot to a close-up. Or, a long shot may be made and then exposure of the film stopped until the lenses have been moved to such a position that the image on the film will be magnified to a predetermined degree.

The shifting of the lens system may be rapidly effected by movement of an oscillatory arm connected through a link with the lens mount.

BOOK REVIEWS

Elements of Optics. JOSEPH VALASEK, PH.D. *McGraw-Hill Book Company, Inc.*, New York, N. Y., 1928, XIII + 215 pp., $2.00. The author, associate professor of physics at the University of Minnesota, states in the preface that this book was" written to fill the need for a modern text-book of optics for a beginning course of college grade extending over three months." Within the short space of 191 pages of text, he has compressed a certain amount of information on an astonishing number of topics covering the entire realm of optics. There are fourteen chapters with chapter-headings as follows: (1) Light and Its Propagation; (2) Photometry; (3) Velocity of Light; (4) The Wave Theory of Light; (5) Reflection; (6) Refraction; (7) Lenses; (8) Optical Instruments; (9) Color; (10) Interference; (11) Diffraction; (12) Double Refraction and Polarization; (13) Radiation; and (14) The Theory of Relativity. The chapter on lenses contains 16 pages and the chapter on optical instruments 14 pages; it is obvious that this amount of space cannot permit a discussion of these subjects in sufficient detail to meet the needs of anyone who requires more than the most elementary principles. As the basis of a preliminary course in optics, designed to give a student in physics the basic principles of the subject and some comprehension of the range of the subject-matter content of the science, the book is admirable. As a reference book for the projectionist or cinematographer, it would generally be disappointing because of the meagerness of the information presented on the majority of subjects in which he would most likely be interested. It can be recommended, however, as a supplement to other books dealing more adequately with geometrical optics, lenses, and optical instruments as a source of very well presented and easily comprehended information on such subjects as the nature of light, interference, diffraction, *etc.*, concerning which the average projectionist or cinematographer may feel some interest but not enough to justify him in an attempt to read the more elaborate treatises dealing with these subjects.

W. B. RAYTON

Basic Photography. Training Manual No. 2170–5, U. S. Army Air Corps. *Government Printing Office*, Washington, D. C. This text-book on standard photographic practice, issued primarily for the training of officers and enlisted men, contains much valuable information of interest to the still photographer and technician. The subject matter includes a description of cameras and equipment, negative exposure and development, printing, enlarging, and the making of lantern slides. The use of filters is treated in connection with various types of reproduction problems. An adequate index adds to the usefulness of the volume.

G. E. MATTHEWS

Panchromatic Photography. F. H. WILDING. *Photo-Miniature No. 203*, **17,** December, 1930, pp. 551–604, *Tennant & Ward*, New York, N. Y. In view of the increased use being made of panchromatic materials, this handbook should find a useful place in the library of most cameramen and commercial photographers. It presents in clear, concise language the fundamental principles under-

lying the use of panchromatic films or plates and the application of color filters. The characteristics of various illuminants such as incandescent tungsten, carbon arc, sun arc, flame arc, mercury vapor, and neon are dealt with briefly, although the author's practical knowledge concerning the application of the last two materials appears somewhat meager. A comprehensive section of the booklet discusses the composition and use of color filters, which are classified under their applications as taking, viewing, and safelight filters. The use of desensitizers is treated, and mention is made of a plate backed with a desensitizing material which dissolves in the developer and acts on the plate during the early stage of development. Consideration is given in a closing section to the use of panchromatic materials in several fields, landscape, portraiture, telephotography, aerial photography, *etc.* The manuscript was prepared, unfortunately, before the introduction of certain high-speed panchromatic materials, a discussion of the properties and uses of which would have made a valuable addition.

G. E. MATTHEWS

The Talkies. JOHN SCOTLAND. *Crosby Lockwood and Son,* London (The Industrial Book Co., Inc., New York), 1931, 194 pp. A popular and elementary account of the history and present technic of sound motion pictures, written primarily from a British view point. The author briefly traces the development of the art, beginning with the early experiments of Edison in 1888, and credits Eugene Lauste with "the first development of talkies as we know them today" in England twenty-three years ago. References to the early British talking picture productions by Cecil M. Hepworth are given. The remainder of the book is devoted to a description of the photographic and sound recording apparatus used in making sound pictures, with considerable emphasis on British equipment, and to a general review of the apparatus and problems of sound reproduction in theaters. The author next deals with color pictures, and closes with a chapter giving the reactions of various American stars to talkies as opposed to silent pictures. The book is of elementary character, suitable for reading by laymen who have an amateur interest in the technic of the art. It is entertainingly written, but its comparative lack of reference to American practice would render it of greater interest to the British rather than the American reader.

J. WEINBERGER

The Talkies. ARTHUR EDWIN KROWS. *Henry Holt & Co.,* New York, N. Y., 1930, $2.00. Mr. Krows has attempted in this volume to present a summary of the history, mechanical technic, status as an art, and probable future of the motion picture, embracing both the silent and sound phases of the medium. The exposition of the artistic considerations is most praiseworthy, involving as it does the duties of the scenarist, director, film editor, and the difficulties commonly encountered by each. The evolution of the existing scheme of production is clearly shown, together with an appreciation of the economic factors which beset all departments of the film industry in attempting to elevate the motion picture to higher artistic levels. The history of picture and sound, preceding their union into the sound picture, is told in great detail, perhaps too much detail for the lay reader. That section which describes recording and photographic technic is not too satisfactory from the standpoint of the engineer. There are a number of glaring inaccuracies which could have been eliminated by submission to technical men for proof-reading. Though written for the layman, there is

no justification for creating misconceptions in the mind of the uninitiated. The excellence of this work in considering the dramatic factors is marred by the deficiencies in the technical section J. L. CASS

Photography—Theory and Practice. L. P. CLERC. Edited by George E. Brown. *Pitman & Sons, Ltd.*, London, 1930, 556 pp. This voluminous text, which is an English edition of *La Technique, Photographique*, published as two volumes in 1926, represents a compilation of material giving the fundamental facts of photography. Yet no attempt has been made to make the work encyclopedic, or to load it down with references; rather it has been the purpose " . . . to bring into one volume as complete a treatise as possible on modern working methods and apparatus . . ." For more than thirty years, the author's professional duties have necessitated his reading a good share of the literature published on photography as well as to conduct experiments in many fields of photographic work. He is thus particularly well equipped for the task which he so admirably has completed. The volume has been written to emphasize the practical aspect of photography and therefore should prove a valuable addition to the library of every serious photographic worker. The first fifteen chapters deal with light, perspective, optical systems, diaphragms, shutters, lenses, types of cameras, and the negative. Subject matter taken up in the following ten chapters is related to the properties of negative materials, darkroom design and equipment, chemicals, lighting, and focusing. Then, in ten succeeding chapters, the author discusses exposure, development, fixing, washing, drying, negative failures, reversal processes, after-treatment, classification, and storage. Concluding the treatment of negative materials, the next five chapters are devoted to printing. The last 175 pages are reserved for a consideration of special subjects including, among others, pigment processes, trimming and mounting prints, copying, enlarging, lantern slide making, color photography, an outline of cinematography, photo-mechanical processes, and radiography. An excellent chapter is included on the theory and practice of stereoscopy. G. E. MATTHEWS.

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Optical Co., 1914–19; instructor in Physics, University of Rochester, 1923–25; assistant in Vital Economics, 1925–27; biophysicist, Research Laboratories, Eastman Kodak Co., 1927–28; Eastman Teaching Films, Inc., 1928 to date.

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Robillard, P. M.: Born January 30, 1897, at Ottawa, Canada. Communication division, Radio Corporation of America, 1920–28; recording division, development and maintenance of portable and location equipment, RCA Photophone, Inc., 1928 to date.

Ross, John Franklin.: Born June 19, 1900, Guinda, California. Graduated from the University of Michigan with the following degrees: B.S. (Chem.), 1921; M.S. (Chem.), 1922; Ph.D., 1924. Teaching assistant in analytical chemistry, University of Michigan, 1920-21; DuPont Fellow in Chemistry, 1921-24; research chemist in photographic chemistry department, Eastman Kodak Company, Rochester, New York, 1925-29; director of analytical laboratories of the J. T. Baker Chemical Company, Phillipsburg, N. J., 1929 to date.

Schlenker, Vesper A.: B.S., University of Chicago, 1919; meteorological section, Signal Corps, A. E. F., 1917–19; instructor in physics, Culver Military Academy, 1919–20; Massachusetts Institute of Technology, 1920–21; graduate, Officers Field Artillery School, U. S. Army, 1922; graduate, Officers Signal School, U. S. Army, 1923; engineering department, Western Electric Company, 1923–25; supervisor, special electrical and acoustical research, Bell Telephone Laboratories, 1925–27; acoustical research and development, Vitaphone Corporation, 1929–31. Consulting acoustical engineer, 1931 to date.

Shea, Timothy E.: S.M., Massachusetts Institute of Technology, 1919; instructor in electrical engineering and physics, 1918–20; manufacturing department, Western Electric Company, 1920–21; engineering department, Western Electric Company, 1921–24; development of sound picture equipment, public address systems, and similar apparatus, Bell Telephone Laboratories, 1925 to date.

Wolferz, Alfred H.: B.S., Cooper Union; design and development of electrical measuring instruments, Weston Electrical Instrument Corporation.

SOCIETY ANNOUNCEMENTS

The Spring Convention.—Full details concerning three alternative railroad routes to Hollywood have been circulated by the Arrangements Committee. Extra copies can be secured from the General Office. The Board of Governors has voted to extend the convention over a period of five days so as to allow ample time for sightseeing and visits to studios.

Headquarters will be at the Roosevelt Hotel but the technical sessions will be held at the American Legion Auditorium. The Society is greatly indebted to the American Legion for kindly donating the use of their headquarters for our convention.

Arrangements are being made for an exhibition of newly-developed motion picture apparatus during the Spring Convention in order to better acquaint the members with the newly-devised tools which may be of value to them. This will not be of the same nature as the usual trade exhibit. There will be no booths, although each exhibit will be allotted definite space by the Exhibits Committee and all exhibits will be arranged in one large room. The following regulations will apply:

(1) The apparatus to be exhibited must be new or have been developed or improved within the past 12 months.

(2) No pamphlets or advertising literature will be permitted.

(3) Each exhibitor will be permitted to display one small card giving the name of the manufacturing concern and each piece of equipment shall be labeled with a plain label which shall not include the name of the manufacturer.

(4) A technical expert capable of explaining the technical features of the apparatus exhibited must be present during the period of the exhibition.

(5) The hours of the exhibition will be determined by the Apparatus Exhibits Committee and the exhibits will be closed during the papers sessions.

(6) All exhibition space will be furnished *gratis*.

(7) The apparatus to be exhibited will be censored by the Apparatus Exhibits Committee in order to make certain that this is essentially new as described under item (1).

Please make requests for space to Mr. Sylvan Harris, Editor-

Manager of the Society, Room 701, 33 West 42nd Street, New York, N. Y., stating the number and nature of the items to be exhibited.

The Journal.—Members are reminded that papers can be submitted for publication in the JOURNAL without necessarily having been presented at the semi-annual conventions. All members are urged to prepare papers and to suggest possible subjects and authors to the Editor of the JOURNAL.

Now that the wave of inventive progress which accompanied the introduction of sound has subsided, there is a tendency for the supply of good technical papers to decrease, and greater effort on the part of all members will be necessary in order to maintain the high technical standing of our publication.

The Board of Governors has approved the addition of two new sections to the JOURNAL, one of which will deal with new apparatus, and the other with announcements concerning technical literature distributed by manufacturers. The apparatus section is for the purpose of acquainting readers of the JOURNAL with new motion picture apparatus which has been developed or improved within the past 12 months. Manufacturers and inventors are invited to submit technical details to the Editor of the JOURNAL. These will then be referred to a Board of Abstractors for review.

To date, no letters have been received for the Open Forum. Each member should endeavor to offer suggestions for ways and means of increasing the usefulness of the Society to the industry.

New York Section.—At a meeting held at the Westinghouse Lighting Institute, Grand Central Palace, New York, N. Y., on January 23, 1931, Mr. C. E. Baer, of Eastman Teaching Films, Inc., delivered an address on "Visual Aids in Education" which was accompanied by a demonstration of outstanding examples of films for educational purposes. An interesting discussion followed.

Pacific Coast Section.—At a meeting held January 22, 1931, the following officers were elected:

Mr. Donald MacKenzie, *Chairman*
Mr. Emery Huse, *Secretary*
Mr. L. E. Clark, *Treasurer*
Mr. H. C. Silent, *Manager*
Mr. G. Mitchell, *Manager*

The new officers are making extensive preparations for the Spring Convention.

Papers for Spring Convention.—In the February issue of the JOURNAL the Papers Committee announced a plan which will be followed in connection with papers intended for presentation at the Hollywood Convention, May 25th to 29th, inclusive. This plan requires that papers must be submitted to the Society by April 1st. The response so far, in actual papers submitted, has been small and not very many members have come forward with information as to papers which they propose to present.

It is earnestly requested by the Papers Committee that all members proposing to offer papers at the Convention inform the Committee or the Editor-Manager at the earliest possible date, giving the name of the author and the title of the paper in each case. This will greatly assist in laying plans for the papers programs at the Convention.

It is felt that engineers are prone to assume that engineers in branches of the industry other than their own have a greater knowledge of specialized subjects than they actually have. It is felt that material exists for many worth-while papers which the Society is not now getting because engineers do not put themselves mentally in the place of their readers. It is suggested that members of the Society give this thought consideration, and consider broadly whether they do not have material for good papers which would be of real interest to the Society.

In the case of authors who do not expect to attend the Convention but want to have papers presented, the Committee will arrange to have the papers presented by competent members of the Society.

Chicago Section.—At a meeting held at the Webster Hotel, Chicago, Ill., January 8, 1931, Mr. R. F. Mitchell delivered a paper entitled "Notes on Color Cinematography of Today." This paper described several additive color processes such as Kodacolor, the Gaumont process, and Kinemacolor. The subtractive processes described included Prizma, Technicolor, and bi-pack methods. In the last-named processes two films are run simultaneously through the camera, emulsion to emulsion. The front film is orthochromatic and contains a red layer over the emulsion so that the rear film records only a red impression. Accommodation of the two films in the camera gate is accomplished by replacing the usual mechanism by one adjusted to have a wider opening. The back plate of this mechanism is fitted with hard rubber plugs of varying heights, simulating the effect of a slightly curved aperture plate. The concluding section of the paper dealt with the correction of lenses

necessitated by the introduction of panchromatic films. Lenses are now available which are corrected for red rays at a wave-length of 6563 and for blue rays at a wave-length of 4340.

At a second meeting held on February 5th at the headquarters of the Electric Association, Mr. J. E. Jenkins presented a paper entitled "Condenser Microphone Design." The paper dealt with the condenser proper and the design of the amplifier. Curves were given showing the variation in audio response resulting from different damping conditions and dimensions of the diaphragm. The paper also dealt with the possible and actual effects of studio conditions on the pick-up of sound independently of the characteristics of the microphone.

The Society regrets to announce the death of Arthur Gray, January 27, 1931.

There is mailed to each newly elected member, upon his first payment of dues, a gold membership button which only members of the Society are entitled to wear. This button is shown twice actual diameter in the illustration. The letters are of gold on a white background. Replacements of this button may be obtained from the General Office of the Society at a charge of $1.00.

OPEN FORUM

One of the chief reasons why our Society changed its form of publication from quarterly *Transactions* to a monthly JOURNAL was to permit the dissemination of information which is not made available at our conventions. The transactions of a society merely record the proceedings at the society's meetings whereas it is proper for a journal to publish any matter pertaining to the welfare of the society.

Our Society will thrive only if each member takes a deep interest in its welfare. Having the interests of our Society at heart, each of you must have suggestions for making our JOURNAL and conventions of greater value to the industry. It is with this object in view, that at a meeting of the Board of Governors at New York City on December 19th, it was resolved: "That an open forum be established as a new department of the JOURNAL, in which might be published letters and communications from members relating to material in the JOURNAL or to other matters appertaining to the welfare of the Society, subject to the discretion of the Editor and Board of Editors."

May I suggest correspondence on subjects such as the following:

(*a*) Better ways of conducting the conventions.

(*b*) Problems for research.

(*c*) Problems for investigation by the various committees.

(*d*) Discussion of technical papers appearing in the JOURNAL, with comments on the success or failure of their application.

(*e*) Description of interesting or new developments which have come to your attention during your travels, thereby giving all the members the benefit of this knowledge.

(*f*) Preliminary announcements of investigations and discoveries which are to be more fully reported at a later date in formal papers.

Remember that the Society of Motion Picture Engineers is *your* Society and although many of us are widely separated geographically, let us meet monthly in the Open Forum.

J. I. CRABTREE, *President*

SUSTAINING MEMBERS

Agfa Ansco Corporation
Audio-Cinema, Inc.
Bausch & Lomb Optical Co.
Bell Telephone Laboratories, Inc.
Carrier Engineering Corp.
Case Research Laboratory
Consolidated Film Industries
DuPont-Pathé Film Manufacturing Corp.
Eastman Kodak Co.
Electrical Research Products, Inc.
General Theaters Equipment Co.
Mole-Richardson, Inc.
National Carbon Co.
Paramount Publix Corp.
RCA Photophone, Inc.
Technicolor Motion Picture Corp.

BACK NUMBERS OF THE TRANSACTIONS AND JOURNALS

Prior to January, 1930, the *Transactions* of the Society were published quarterly. A limited number of these *Transactions* are still available and will be sold at the prices listed below. Those who wish to avail themselves of the opportunity of acquiring these back numbers should do so quickly, as the supply will soon be exhausted, especially of the earlier numbers. It will be impossible to secure them later on as they will not be reprinted. The cost of all the available *Transactions* totals $46.25.

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1917	3	$0.25
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	35	2.50
	36	2.50
1929	37	3.00
	38	3.00

Beginning with the January, 1930, issue, the JOURNAL of the Society has been issued monthly, in two volumes per year, of six issues each. Back numbers of all issues are available at the price of $1.50 each, a complete yearly issue totalling $18.00. Orders for back numbers of *Transactions* and JOURNALS should be placed through the General Office of the Society, 33 West 42nd Street, New York, N.Y., and should be accompanied by check or money-order.

JOURNAL
OF THE SOCIETY OF
MOTION PICTURE ENGINEERS

SYLVAN HARRIS, EDITOR

Volume XVI **APRIL, 1931** **Number 4**

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JOURNAL
OF THE SOCIETY OF
MOTION PICTURE ENGINEERS

SYLVAN HARRIS, EDITOR

Published monthly at Easton, Pa., by the Society of Motion Picture Engineers

Publication Office, 20th & Northampton Sts., Easton, Pa.
General Office, 33 West 42nd St., New York, N. Y.

Subscription to non-members $12.00 per year; to members $9.00 per year; single copies $1.50. Order from the Society of Motion Picture Engineers, Inc., 20th and Northampton Sts., Easton, Pa., or 33 W. 42nd St., New York, N. Y.

Entered as second class matter January 15, 1930, at the Post Office at Easton, Pa., under the Act of March 3, 1879.

THE TALKING FILM*

P. BONNEAU**

Summary.—*The first part of the paper is mainly historical, tracing the development of the motion picture art, particularly from the French point of view. Various processes used for synchronizing sound and picture from about 1899 to the present are mentioned. Among these processes are those employing engravings on the film, and reliefs which act to vary the capacity in a high-frequency circuit. Reference is also made to magnetic wire processes and finally, the present-day method of recording sound photographically. Two variations of the latter process, viz., the fixed density method and the variable density method are explained. The discussion continues with various types of light valve recorders and sources of light.*

The second part of the paper deals with the particular processes now employed in France, discussing particularly the various mechanical, electrical, optical, and acoustical processes which intervene between the studio and the review room. The matter of acoustics of the studio and the effect on the sound record is discussed at some length, as well as the effect of speed changes in the driving motor of the camera or recorder. Various other apparatus used in the studios are described.

No technical man can afford to lack interest in, or to misunderstand the essential principles involved in the sound pictures of today. In fact, one finds in them a marvelous linking of devices, and of electrical, mechanical, optical, chemical, and acoustic methods. The chief branches of physics have close analogies among themselves, and in the processes used in making sound pictures, these analogies are impressed on the electrician and the mechanic, as they are on the acoustic expert. Many problems present themselves to these technicians between the moment when the microphone picks up the voice of the artist, surrounded by the scenery of the studio, and the time when the spectator, seated in a chair before the screen, listens to the reproduced sound; but these incidental problems are essen-

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* *Annales des Postes Telegraphes et Telephones*, **XII** (December, 1930), p. 1009. Translated by I. H. Parsons, Bell Telephone Laboratories, Inc. This article was abstracted primarily to give the French point of view on recording practices, and although some of the practices referred to are not in accordance with current American practice, the article contains many interesting features which should be placed on record.

** Technical Director, Gaumont Studios, Paris, France.

tially analogous to, and always reduce themselves to, a study of the propagation of a sound wave over a telephone line.

The discussion which follows is divided into three parts. The first part provides a summary of the history of sound pictures, from which the natural classification of the various processes in use follows.

In the second part, the actual methods of operation and the most important apparatus utilized in the sound picture industry are examined. These will be considered in the order in which the operations occur; that is to say, beginning with the recording studio, the study terminates behind the screen of the review room, at the group of loud speakers used for reproduction.

In the third part, the advantages and disadvantages of various systems are briefly discussed, suggesting the directions in which one should aim, and the goals toward which science and the ingenuity of research workers should be particularly directed.

HISTORICAL: CLASSIFICATION OF PROCESSES

Phonographs.—In the earliest days of sound pictures cylinder or disk phonographs were used almost exclusively, operated in synchronism with an ordinary motion picture film. Over thirty years ago numerous investigators conceived the idea of combining the phonograph and the cinematograph, but in practice two difficulties were encountered. In recording, the wax impression was not made electrically, but directly, by means of a stylus operated by the diaphragm receiving the sound waves; it was therefore necessary for the artists to speak quite close to the receiver, which made it impossible for them to move about. This was contrary to the technic of motion pictures, which requires, above all, the representation of motion. Moreover, in reproduction, it was necessary to place the phonograph behind the screen in order to produce the illusion that the voice came from the mouth of the subject in the picture; the phonograph had to be very powerful and had to be synchronized with the motion picture projector so that no divergence occurred in starting.

Several tentative efforts were made in 1899 by Edison. To obtain a sufficient reënforcement of the sound in reproduction, three phonographs were used simultaneously; there was no synchronous coupling whatever between the phonographs and the projector and it was necessary for an operator to regulate the speed constantly in such a manner as to maintain synchronism of the sound and the picture.

The first actual industrial application was begun in France in 1900 by the Gaumont organizations, which, under the leadership of their founder, M. Leon Gaumont, brought forth successively: in 1902, electrical synchronization of the phonograph and of the projector; in 1906, electrical recording on wax by means of a microphone and an electromagnetic recorder; a little later, the amplification of sound reproduced on a phonograph by means of compressed air.

Beginning in 1910, these different arrangements led to a system which was commercially exploited. The series of Gaumont's "photoscenes" and the reproducing apparatus termed the "chronophone" were distributed throughout France and abroad. Nearly four hundred of these appliances were placed in service before this expansion was stopped by the War; one of them was even used in New York for public demonstrations in June, 1913, at the 39th Street Theater.

Finally, when thermionic amplifiers became practicable, the Gaumont organizations brought out in 1918 (their patent is dated May 15, 1918) the electrical reproduction of phonograph disks by means of an electromagnetic reproducer, which has since been known universally as a "pick-up."

Sound Films.—The recording of sound vibrations, not only on a phonograph disk but on motion picture film, followed from principles which had long been known. As a matter of fact many physicists have worked on the analysis of sound by the oscillograph, and on its synthesis, with purely scientific aims in view. Moreover, investigations undertaken since the middle of the last century for telegraphic picture transmission rendered the application of some very ingenious methods possible, which could immediately be applied to the recording of sound waves.

Various Processes.—We first find some old methods based on engraving the edge of the film in such a way that this edge would be shaped into a curve reproducing the form of the sound vibrations. These indentations could be used either mechanically as in a phonograph record, or optically to produce a telephonic current by passing before a selenium cell. This latter process was thought of in 1889 by Wikszemski.

Other similar but better perfected methods may be mentioned. These consisted in engraving a track to various depths in the film, after having softened it locally by means of a suitable solvent. There are numerous varieties of this process, among which may be

mentioned the Faucon-Johnson process and that which the German inventors, Bothe and Waltz, are attempting to develop. Waltz's method of reproduction is ingenious; it consists in passing the film with variable reliefs between two light metallic rollers. One is fixed, while the other is lightly supported on the film and more or less separated from the fixed roller by the thickness of the relief. These two rollers form a small condenser, of which the separation of the electrodes varies in reproduction according to the sound record. The two rollers may even be held at a constant separation, the variations of the dielectric being obtained simply by the variations in the thickness of the celluloid film. In order to obtain sufficient sensitivity this condenser is inserted in a high-frequency circuit.

In the category of films in relief, electrically resistant films should be included. Variations in the resistance of a track rendered more or less conductive are utilized in this case. This process, which was particularly recommended by Timm about 1911, does not seem to have been developed Lastly, a tendency to apply Poulsen's well-known magnetic wire process to sound pictures must be noted. This method was taken up and perfected by Stille. In this field, Ruhmer's attempts about 1909 should be mentioned; in these a metallic powder which could be magnetized was spread on the film.

Photographic Recording Processes.—Sound film processes which rely on recording sound photographically are much the most interesting, and the only ones which are practically used at the moment. These processes are divided into two very distinct categories:

In the first category, the image of the sound vibrations forms a constant photographic density which, however, varies in width. This is termed the "fixed density method." The curve representing the sound vibration separates a uniformly dense photographic region from one which is uniformly transparent. This method of recording is carried out by displacing a very narrow luminous beam on the unexposed emulsion while the film is moved lengthwise at a uniform speed.

The second category employs a track of constant width but of varying photographic density. This method is termed the "variable density" method. The successive density variations correspond to the variations of intensity of the sound. This type of recording is produced by varying either the brilliancy or the height of a fixed line of light which falls upon the film transversely while the latter

passes lengthwise at a uniform speed. Fig. 1 indicates diagrammatically the way in which these two processes are carried out.

The acoustic reproduction from the photographic sound record is brought about, in principle, by passing the brightly illuminated film at constant speed before either a real or a virtual slit. The light variations transmitted through the film to a photoelectric cell produce currents which are amplified to operate a group of

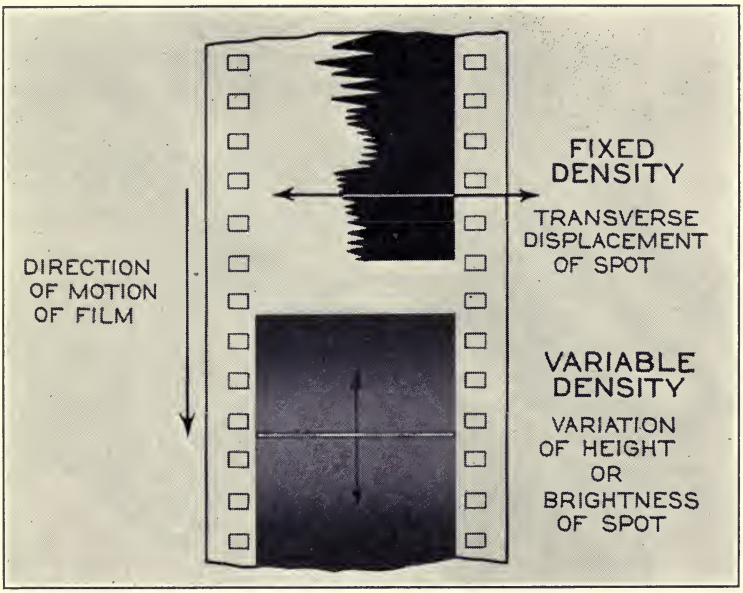


FIG. 1. A diagrammatical illustration of the way in which the fixed density and variable density methods are carried out.

loud speakers. This arrangement is utilized for both types of photographic sound record. It is for this reason that the different sound film processes of this category differ as regards the apparatus used for recording, but both types employ the same apparatus for reproduction.

The method most widely used for producing a fixed density record, that is to say, a record obtained by moving across the film a very narrow luminous image, consists in deflecting a ray of light by means of the mirror of a galvanometer. The English physicist, Duddell, took out a patent, dated November 10, 1902, which had this as its

object, and which can be considered as the prototype of the modern processes in fixed density work. Fig. 2 shows the two original diagrams in this patent. The upper drawing represents the plan view of the recorder diagrammatically. We see at *A* the light source, at *d* a rectangular diaphragm, at *m* the small mirror of the oscillograph, at *c* a cylindrical lens which concentrates and narrows the beam of light to a very narrow line, by which the exposure is made at *e* on the film *f*, which unrolls from the magazine *D* toward the

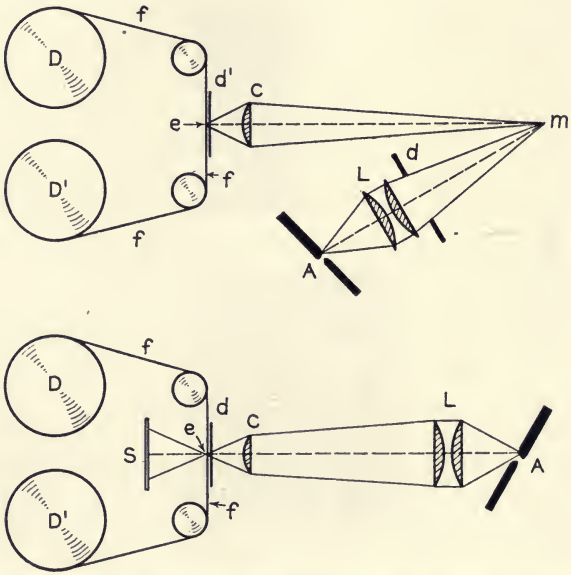


FIG. 2. The two original diagrams in Duddell's patent of Nov. 10, 1902.

magazine *D'*. It is remarkable that, for this purpose, Duddell recommended the use of a Blondel bifilar type galvanometer and claimed priority for it in his patent. This galvanometer is almost universally used in practice for recording fixed density sound films. The lower diagram shows schematically the method of reproduction: the luminous beam issues from the source *A*, is narrowed at *e*, and, more or less diminished by the opaque record on the film, is received by the selenium cell *s*. One notices on these two figures, almost in contact with the film, a screen having a very narrow slit, the object of which is to limit the height of the light beam. The use of this

slit, which rapidly becomes filled with foreign matter, has had to be completely abandoned. It has been replaced by an optical arrangement by means of which the reduced image of an illuminated slit is formed on the film. This optical device has a larger slit which does not come in contact with dust in the path of the light rays.

Indeed, the development of the method devised by Duddell has brought about some important improvements in the galvanometer. In fact, it has been possible to build bifilar instruments having a natural frequency of oscillation of over 10,000 cycles per second.

There are other methods of recording with fixed density: The concentrated light beam is passed through a small rectangular diaphragm whose length is controlled by the sound vibrations. This slit is generally formed by means of a horizontal slit in a diaphragm with two parallel wires very close together, forming a string galvanometer and arranged vertically (at 90 degrees) in contact with this diaphragm. These wires, in receding from and approaching each other, cause the horizontal dimensions of the little aperture to vary.

It is particularly in producing variable density photographic sound records that the ingenuity of investigators has been given full rein. The methods employed can be classified into two groups:

(*a*) Those in which the intensity of the light source is variable and controlled by the intensity of the sound wave.

(*b*) Those in which the pencil of rays from a constant light source passes through a valve whose characteristics vary as a function of the sound wave.

In the first category, we find the devices of the Dutchman, Hedick, who in 1887, used the well-known properties of flames which can be affected by means of sound waves. About 1900, Ruhmer used an arc lamp for the same purpose and built a recording apparatus for sound waves which was termed the "Photographon." In 1903 Korn constructed an instrument having two electrodes between which electric discharges were produced, by means of high voltages. Furthermore, many experimenters employed simple incandescent lamps in which the filament possessed very little inertia. As a matter of fact, for this type of light recorder, tubes in which discharges are produced in a gaseous atmosphere are used almost exclusively. Such tubes are filled with argon, nitrogen, or helium under a pressure of a few millimeters of mercury. At a suitable voltage the space between the electrodes becomes luminous and forms a light whose intensity is related to the anode current by a law which is

almost exactly linear. There are many types of these lamps using luminous gas. One of the best is provided with a steel anode and an oxide-coated cathode of platinum. At 350 volts, the gas, which is rich in helium, emits an intense and highly actinic glow.

In the same general class Göercke's tube should be mentioned: in this tube, near the two electrodes which are in a rarefied atmosphere, a light is produced which varies as a function of the modulated

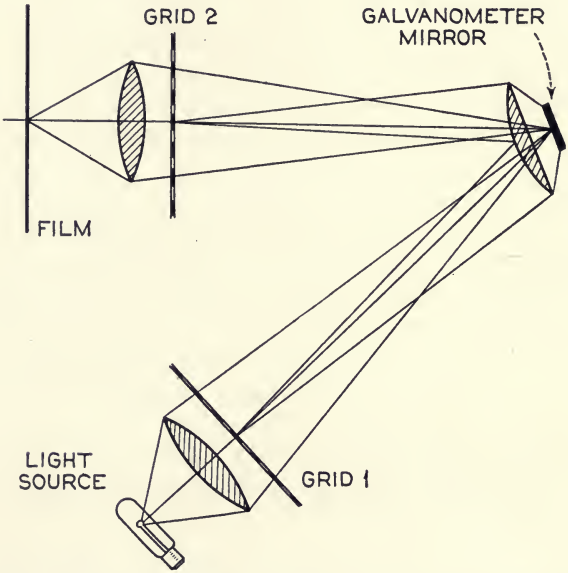


FIG. 3. Piedfort's light valve recorder employing two gratings.

intensity of a high-frequency current. This device has also been used for fixed density recording.

In the second category, that is to say, in the group of recorders which employ a light valve, it is most important to mention the valve designed by the Bell Laboratories. It operates on the principle of the bifilar galvanometer, which we have already found used in the case of fixed density recording. But in this case, the valve is not required to cause variations in the length of the line of light transversely to the film, but rather in its width. These variations are ultimately impressed on the developed film as density variations.

In this same category of light valve recorders fall the types with

two gratings. These employ the principle patented May 4, 1894, by Piedfort for multiplex telegraphy over submarine cables. The optical arrangement used is shown in Fig. 3. By means of the galvanometer mirror, the image of the first series of slits is shifted. It will be seen that, depending on the superposing or divergence of the image of the first grating on grating No. 2, the light will pass from the maximum possible to complete extinction.

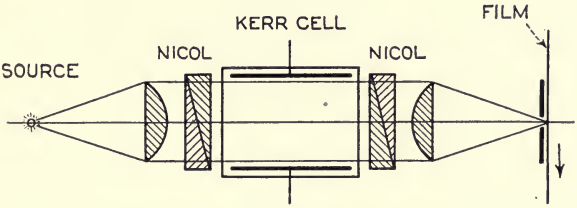


FIG. 4. The light valve system employing Kerr's cell, using nitrobenzine.

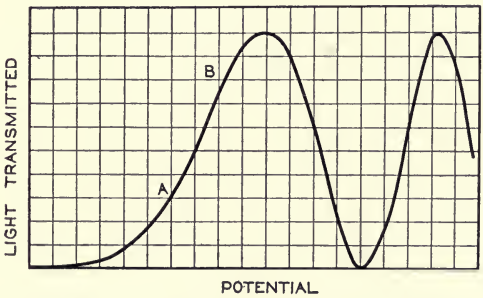


FIG. 5. The light transmission curve for the Kerr cell.

The system derived from Kerr's principle, previously used for telegraphic picture transmission, must also be placed in the light valve class. This method has been extensively developed in Germany for sound film recording. The principle of the optical system, which is well known, is represented in Fig. 4. The recording system includes a light source of constant intensity, from which the light first passes through a polarizing Nicol, then through a Kerr cell using nitrobenzene, and finally through a second Nicol prism. The light transmission curve for the Kerr cell is shown in Fig. 5. Of course, only the nearly straight portion between A and B is used. The polar-

izing voltage for the cell is about 700 volts and the modulating voltage 200 volts.

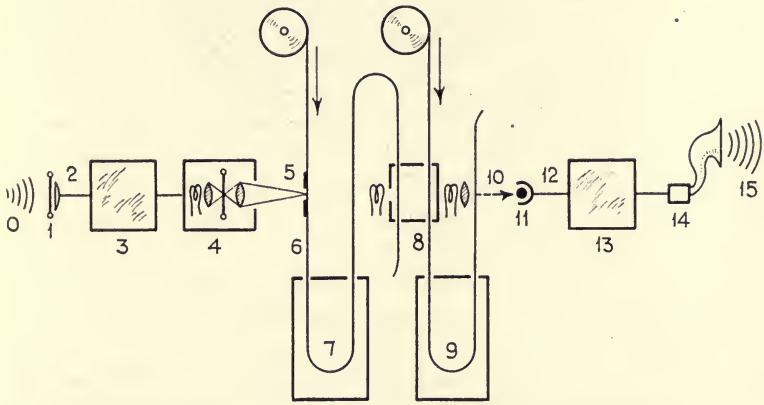
PRACTICAL PROCESSES

We shall now examine the successive operations of taking pictures, recording sound, and reproducing it, the interconnection of which processes constitutes the sound film art. We use the term, sound film, intentionally; in order to restrict ourselves, we will set aside the branch of this industry which uses phonograph disks in synchronism with the pictures of a motion picture film. This branch, however, is important, and its applications to sound pictures are not as yet destined to disappear. Very appreciable progress has taken place in this direction, and it must be realized that sound reproducing appliances for disks alone are simpler and cheaper than those using photographic records on film. Certainly it can be admitted that soon the film process will render possible more perfect sound reproduction than the disk method, for the photographic record has broader possibilities than the physical record obtained mechanically on a plastic substance. Looking at the question from the sole point of view of the sound quality, it may be said that at the moment these two methods are approximately equal. In fact, the reproducing apparatus used in sound picture work is normally arranged for the use of either of these processes, and many distributors of sound films release the sound production in the film or disk form indifferently. There is, however, a reason of a practical nature which will advance, for a long time to come, the cause of the disk. The sound track on the film rapidly becomes spoiled in use, while the part which carries the pictures remains in sufficiently good condition for a large number of further projections. If disks were employed from this point on, with the same synchronism and the same sound version, it would be possible to prolong the commercial life of the film.

Fig. 6 shows schematically the different mechanical, electrical, optical, chemical, and acoustic processes which must be carried out between the studio and the review room. Fourteen may be counted, besides those at the beginning and end of the classification; the microphone diaphragm vibrates under the action of the sound waves; this produces a feeble current which is amplified; this current operates an instrument, which in the figure shown, is a bifilar galvanometer; the galvanometer modulates a beam of light; the latent image is formed on the film, reduced by development and the negative is obtained; the positive is printed from this, and then developed.

By passing this positive before a photoelectric cell, a feeble current is formed, which, after amplification, operates the loud speakers.

Such are the links in the chain which we are going to follow. It may be pointed out in passing that excellent experimental proof of the theories of vibratory phenomena is given by this chain. Also the degree of confidence which can be placed in certain perfected



RECORDING

0 = SOUND
1 = MECHANICAL VIBRATIONS
2 = FEEBLE CURRENT
3 = AMPLIFIED CURRENT
4 = MECHANICAL VIBRATIONS
5 = MODULATED LIGHT
6 = LATENT IMAGE
7 = METALLIC IMAGE

REPRODUCING

8 = LATENT IMAGE
9 = METALLIC IMAGE
10 = MODULATED LIGHT
11 = ELECTRON EMISSION
12 = FEEBLE CURRENT
13 = AMPLIFIED CURRENT
14 = MECHANICAL VIBRATIONS
15 = SOUND

FIG. 6. A schematic representation of the various mechanical, electrical, optical, chemical, and acoustical processes occurring between studio and review room.

instruments is impressive, since this chain of fourteen distinct processes leads us, after the complete cycle, to a satisfactory result.

RECORDING SCENES WITH SOUND

The Studio.—The sound studio is a large building into which no daylight or sound penetrates; in short, it is a place completely isolated from the outer world. The walls of the studio must meet two conditions: they must prevent the passage of external noise, and they must, inside, partially absorb the sound waves which fall on them in order to avoid excessive reverberation. It is impossible in

practice to realize these two conditions by means of one single homogeneous material. In fact, a substance prevents transmission of the sound wave when it reflects it completely, and if it is capable of thus totally reflecting the sound, it is because none is absorbed. In spite of this fact, some firmly established legends exist on the subject, and one finds in commerce materials, with magic properties, of which one layer would suffice to form ideal walls. In general, materials of a fibrous or porous texture provide, if used alone, a very inferior acoustic insulating capacity compared to that given by heavy, hard, and impermeable materials. In fact, to build a wall which prevents the passage of exterior noises, one of two equally efficient methods are used: either a thick wall of heavy materials may be built, or a series of materials in which the speed of sound has very different values may be used. Following this second method, structures with two walls are built, having two partitions separated by an air space. For a moderate weight this offers a high degree of acoustic insulation. Furthermore, in order not to lose the benefit of an expensive type of construction, the partitions must not be connected together by sound-conducting material, and the doors and windows must be sound-proof as well as the walls themselves. This is why the doors are usually very thick, of two layers, and with perfectly fitting seams. A wooden stage is necessary for supporting the scenery; attempts are made to isolate it from the floor by resting it on a layer of massive insulating material. Finally, to prevent the strong vibrations on the stage from being transmitted to the building, its foundations are surrounded by a continuous depression.

Inside the studio a microphone arranged to receive an artist's voice will pick up three sound effects in succession: first, the energy which comes directly from the mouth of the performer; then, the sound waves which are completely reflected as echoes by the large plane surfaces of the walls and scenery; finally, a continuation of the sound, which persists for an appreciable time, and which is due to a multiplicity of secondary reflections following each other until the initial energy has been practically absorbed. This last phenomenon constitutes the "reverberation" of the sound, which is measured by the time necessary for the sound intensity to fall to one-millionth of its initial value. This phenomenon is also sometimes called the "room effect."

The study of reverberation forms the most important part of

architectural acoustics, a science which has naturally been considerably developed since the arrival of sound films. In its details, the study of reverberation is very complicated, since it depends on the wave-length of the sound, on its intensity, on the complexity of its harmonics, on the size of the room, on the structure and nature of the walls and all the obstacles reached by the sound waves. Fortunately, as a basis for this subject, there is a simple formula, due to Sabine, according to which the reverberation is proportional to the volume of the room and inversely proportional to the sum of the absorbing units formed by the walls and other obstacles. It is for this reason that in a cathedral where the walls have a negligible absorbing capacity, the reverberation time is often over ten seconds, while it is practically zero in a padded telephone booth.

In a sound picture studio the formation of definite echoes is obviously undesirable, but the walls are not generally sufficiently distant for the effect to be marked. This is not the case with reverberation phenomena which are, on the contrary, very important.

Should reverberation in a studio be considered favorable or injurious in taking sound pictures? It is a question of degree, which the director should take advantage of, if possible. In a studio which is too dead, giving too short a reverberation time, the sounds appear suffocated and do not carry; the effect of distance is absent and music lacks volume. In a live studio which is too large, with a reverberation time of several seconds, the sound is reflected, giving the effect which is familiar in a cathedral; music takes on relief, the various tones being more easily differentiated. The spoken word becomes confused, for on each spoken syllable are superposed reverberations of preceding syllables. Recording carried out under such conditions will appear greatly distorted, for it must not be forgotten that in this case it is a microphone which picks up the sound waves, and not the two ears which possess a physiological capacity for distinguishing one sound among a medley of others. This is why before taking sound pictures, the reverberation time of the studio must always be tested by listening with only one ear.

In the earliest sound pictures, studios were deadened excessively by furnishing them with hangings. Then it was noticed that much more life was given to sound reproductions by introducing a reasonable degree of reverberation, varying for example, from 1 to 2 seconds. It then became sufficient to line the studio walls by means of panels

of compressed vegetable materials, of which a considerable variety exists. These materials possess an excellent absorbing power, which reaches 50 per cent of the energy received as sound, a value comparable to that of a padding formed of long hair of good quality. Most modern studios employ an exterior wall separated by an air space from an interior wall of compressed material.

The materials used for insulating the walls acoustically are, in general, easily inflammable and must be carefully fireproofed. Fire risks are very great in the studio, where the overheated atmosphere dries such materials very rapidly. That is why attempts are made to replace them by drapings formed from asbestos wadding, from glass wool, etc.

There is a very practical method of reducing the reverberation time by dealing with the shapes of the reflecting surfaces rather than with the material used. By corrugating the walls asymmetrically, the dispersion of sound waves is favored and their energy is rapidly attenuated. A hemp mat, even if somewhat stiff, hung with large folds, provides an absorbing power of 75 per cent. By covering the walls and stage more or less in this way it is possible to vary the reverberation time according to the effect desired. This method has been used in the auditorium of the Gaumont Company, so that the absorption of the walls may be quickly regulated as wished. It should be remarked that this absorption is selective, since, depending on whether the folds of the cloth curtains are wide or narrow, the absorption of low or high notes is favored.

A clever director can produce unexpected effects from the sound reverberations. The use of this phenomenon gives him a means of creating a more or less accentuated sensation which may be called "sound perspective," and of producing physiologically a kind of depth to the projection screen.

It is often desired to combine several different sounds on a single film, for example, a dialog and a distant musical accompaniment. If the two types of sound have been recorded with very different reverberation times, they can be combined without danger of being confused by the ear when reproduced, since the ear knows intuitively that the two sources of sound have distinctly different points of origin. Such measures are, however, very difficult, for it would be necessary to give an exact impression of the reverberation time corresponding to the volume of space represented on the projection screen. Theoretically, it would even be necessary to consider in recording, the

reverberation time of the motion picture theater to be used for projection, and to know how its characteristics vary depending on whether loud speakers with horns or baffles are employed.

All this is further complicated by acoustic disturbances contributed by the shapes of the scenery. There are always some points at which the sound becomes concentrated and at which are created interferences and resonance effects which our two ears reject physiologically in ordinary life, but which the microphone, a single ear, picks up indiscriminately. Furthermore, the different parts of the scenery do not all offer the same degree of sound absorption, and this absorption differs for low and high notes; sometimes it is only necessary for an artist to move a few feet on a set to suddenly change the pitch of his voice when heard through the agency of a microphone. Naturally this phenomenon always causes surprise; on first thought one attributes it to a fault in the microphone or to a speed variation in the recording apparatus. These annoying effects are diminished by using light materials of coarse texture with sufficient absorbing capacity. Thin panels of compressed vegetable materials, very porous and painted with sizing, are very useful in this case.

Studio Fixtures.—The motion pictures are taken on a first film, by means of the motion picture camera. Sound, picked up by the microphone, is recorded separately at the same time, but on a second film and by another apparatus termed a sound recorder. From these two negative films, of which the first is the picture and the second the sound film, a single positive film will finally be produced.

The only apparatus which we should find in the studio is, in theory, the camera and the microphone. The sound recorder is usually placed in a special room, which is often some distance from the studio.

The sound recorder and the camera are driven by synchronous electric motors, thanks to which, one is certain that the two machines will use exactly the same amount of film in a given time.

The motors generally used are those whose speed is in synchronism with the frequency of the alternating current supply. Within what limits can this method provide a sufficiently constant speed, so that an expert ear will be unable to notice any tone variation during reproduction? The smallest musical interval, which the human ear can detect, establishes what is termed the sensation of coma. This

interval is approximately 5 *savarts*.* It may easily be calculated that to produce an equivalent interval in the speed of a synchronous motor, it would be necessary to change the frequency of the current from 50 to 50.6 cycles per second. Such a large variation is very rare and, without an accident, could only take place gradually, in a period greater than a minute, because of the enormous inertia of the rotors of the alternators. But the sensation of coma corresponds to a sudden variation. In the case of a slow variation the ear can only notice a greater interval. Admitting that most supply companies, because of the necessity for interconnecting central stations, find it necessary to maintain an exact frequency for their current, it will be seen that the use of synchronous motors for operating sound film apparatus assures a sufficiently constant movement of the film.

In spite of the delicacy of the camera mechanism, a certain amount of noise is always caused by it which must be prevented from reaching the microphone. This is why this apparatus, its motor, its support, and even the cameraman, are frequently enclosed in a sound-proof booth, which can be rapidly moved about the stage. In practice it is preferable to enclose the appliance and its motor in a sound-proof box. Alternatively, this box being of necessity very cumbersome, the camera and motor may each be placed in a padded container, connection being made by a noiseless flexible coupling.

The importance of keeping out extraneous noises from the studio while pictures are being taken has imposed special precautions in lighting the scenes. To "shoot" a film a considerable amount of light energy must be used, amounting to several hundred kilowatts, which are used in a large number of lamps and arc light projectors. If we recall the properties of the singing arc, it will be realized that the ordinary type of arc lamp produces a whistling whose note corresponds to the variations, however small, of the continuous current feeding them. The studio arcs follow this rule and sing very faithfully on the note of the commutator at the substation.

One must, therefore, prohibit arc lamps in the studio for sound picture work, and use incandescent lamps. We have gone a long

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* Translator's Note.—The "savart" is apparently equal to the musical term, the "cent." The cent has the common ratio 1: $\sqrt[1200]{2}$ = 1:1.0006 approximately. From this difference of 6 parts in 10,000, 5 cents (or 5 *savarts*) would equal 30 parts in 10,000 or 0.3 per cent, the accepted value for frequencies between 500 and 4000 cycles per second.

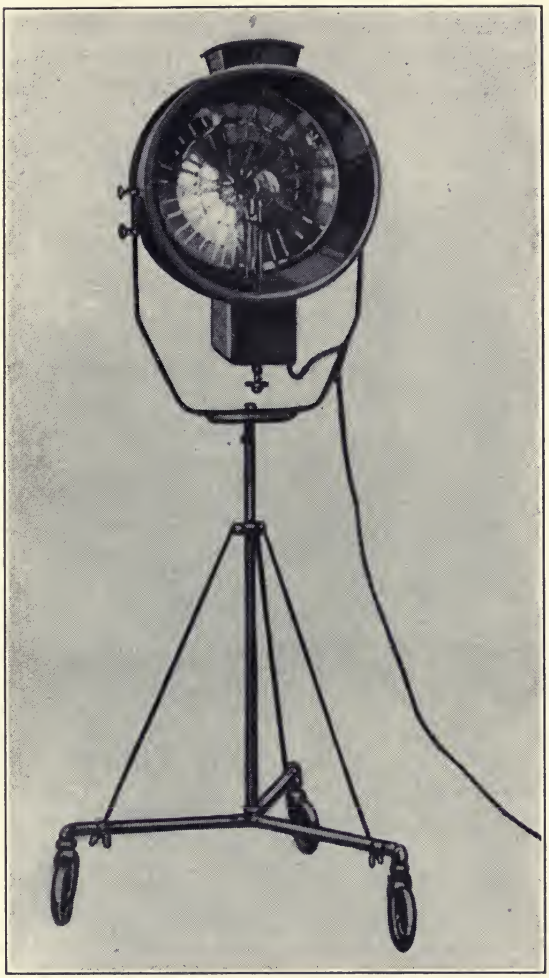

FIG. 7. A faceted projector using a 10 kilowatt lamp for providing a fairly diffuse beam of light.

way in this direction since 10 kilowatt lamps have been built for this service. Fig. 7 represents a faceted projector which gives a fairly diffuse beam of light. Fig. 8 shows a large mirror $1^1/_2$ meters in diameter, combined with a 10 kilowatt incandescent lamp.

These different lighting systems are inconvenient in that they radiate an enormous amount of heat energy. Studios thus equipped must be supplied with good ventilation, so that the overheated air

can be rapidly replaced between the filming of two scenes. Also, it is difficult, by means of an incandescent lamp, even if backed by a mirror, to obtain an intense, uniform, and well directed light

FIG. 8. A large mirror projector $1^1/_2$ meters in diameter, using a 10 kilowatt incandescent lamp.

beam, giving, for example, the impression of a ray of sunlight which will produce some shadows and sharp outlines.

To obtain certain lighting effects in the case of large scenes, it has been necessary to return rather definitely to arc lamp projectors. To diminish the noise, a strong reactance coil is arranged in series with each arc. This remedy is often insufficient, and the commutator

harmonics must then be filtered out completely by connecting across the generator a battery of electrolytic condensers of a thousand microfarads capacity or greater. It is not sufficient to prevent modulation of the flame from the crater by variations in the supply current to make an arc absolutely silent. The burning of the carbons naturally produces humming and crackling noises which are difficult to eliminate. To diminish these noises, it is necessary to deal with the volume, the shape and the course of the flame by means of a suitable electromagnetic blower and to design the metal covering of the projector so as to prevent the formation of a resonant chamber. Some successful tests have recently been carried out for the studios with a diffuse, cold light which is nearly white, using a combination of mercury vapor and neon lamps. Finally there may be mentioned, for the same purpose, perfected tubes filled with argon under a pressure of 5 millimeters and fitted with cadmium cathodes. Such tubes give a very intense white light when operated at 25 amperes.

The Microphone.—One of the principal factors on which the quality of a sound film depends is undoubtedly the microphone. It is desirable that it should have as uniform a sensitivity as possible from 30 to 30,000 cycles per second, that it should be stable, that it should not produce appreciable crackling or blasting noise, and that it should not be too highly directive. The condenser microphone and Reisz's microphone are principally used: the latter employs a very thin fixed layer of powdered carbon. Each type has its partisans; but it must be admitted that the judicious use of either leads to substantially identical results. The condenser microphone must be near the first amplifier tube, so this is generally mounted in the base of the microphone support. This results in a rather cumbersome arrangement. The Reisz microphone, which generally requires one less stage of amplification, can be conveniently connected to the amplifier by a long line and is sufficiently compact to be hidden in the drapings of the set if necessary. Lastly the sensitivity of the Reisz microphone decreases less rapidly than that of the condenser type when the source of sound is moved farther away.

Generally the microphone is hung in front of the artists by means of a boom, the height of which is adjustable. In principle, it is better to reduce the sensitivity of the microphone and to use several of them, three, for example, conveniently located on the set. If music is being recorded, one can, in this way, regulate the relative importance of the different parts of the orchestra in monitoring.

Also, in recording voices, the artists can move about freely without variations of distance causing too much variation in the audition. Most important of all, by requiring a lower degree of sensitivity in each microphone, a smaller proportion of foreign noises and reflected sounds is recorded. The placing of the microphones obviously depends on the roles of the artists and on the field covered by the camera, that is to say, on the scenario. Locations can only be chosen with a complete understanding of the acoustic conditions of the studio and its scenery.

We must, on this same subject, note the efforts made to use microphones in combination with large concave surfaces which act as collectors of sound waves, in order to obtain special effects or to more completely exclude parasitic noises from the sound it is desired to record.

The Control of Sound.—The different microphones working in the studio can be controlled together by means of special mixing circuits, or alternatively, connected in sequence. Besides this, it is necessary every instant, to decrease or increase to a suitable degree, the magnitude of the microphone current, not only to obtain a natural mixing or a special effect in sounds recorded, but also to maintain this amplitude within the limits imposed by the process. Lastly it is necessary to control by ear the quality of the sound impressions picked up in the studio, throughout the recording process, thus checking the correct performance of the microphone and the recording amplifier.

These three functions, judicious placement of the microphones, regulation of the intensity, and control of quality, are carried out by a monitor, who is usually located in a room adjoining the studio. This room has sound-proofed walls and communicates with the studio by a window which enables the monitor to watch the performance of the artists. This window, which must also prevent the passage of sound, is formed by a series of several thick glasses, separated by air spaces. The monitor has before him a panel which carries the controls of the different microphones and the graduated volume indicators for each microphone. These circuits are naturally designed so as not to produce frequency distortion in transmission.

A loud speaker is located in the same room and repeats everything picked up by the microphone in the studio to the monitor, thus enabling the quality of the sound to be controlled. Theoretically, for this control to be complete the acoustic output of this

speaker should be identical to that given by the loud speaker to be heard later by the audience in the theater. Therefore, between the studio microphone and this control speaker the entire series of operations necessary in making and reproducing talking film should be interposed. This condition is approached by using a control speaker and amplifier identical to those used in the motion picture theaters, and by tapping off the microphone current in the circuit of the recording machine after it has passed through as many transformations as possible. A further step in this direction is taken by monitoring, in addition, the light modulation of the recording unit by using a photoelectric cell of the type employed in the reproducing machines. For this purpose, it is sufficient to locate this cell further along the light beam producing the photographic exposure. The cell is excited through the unexposed film, which passes about 5 per cent of the incident light. Alternatively, the cell may be placed at the side of the light beam, part of the latter being deflected into it by means of a prism. In short, by this arrangement, the chain of operations is duplicated, with the exception, of course, of the printing process and of the chemical process of development.

The bay window which communicates with the studio does not always afford a view of the scene when the latter is entirely surrounded by hangings. For this reason, in certain cases, it is preferable to install the monitor and his appliances in a movable booth which is enclosed by sound-proof glass. This booth, which contains a means of transmitting instructions and from which the sound can be controlled, is rolled into the studio close to the scenery, so that the monitor will lose none of the action which takes place. In this manner, the director can, if he wishes, take his place in this booth and assure himself of the quality of the sound effects.

Let us watch the monitor at work. Posted behind the glass windows, he sees the artists, and when they speak, hears them indirectly through the medium of the control loud speaker. He has, therefore, the illusion of being near them, although actually separated by many thicknesses of glass which insure silence. The scene is repeated. He listens, and communicates his impressions by microphone and loud speaker to the director. He points out any cracking noises or unpleasant intonations, increases or decreases the sound intensity, modifies the orientation of the microphones, and indicates any acoustic anomalies produced. His control, which is exercised through the medium of a microphone, is much more

critical and severe than that of the director in the studio; and yet in the last analysis both ultimately rely on the judgment of their ears, which are accustomed to the same tolerances. As regards the monitor, this is a very curious case of physiological lack of adaptation which simply proves that our reproduction by microphone and

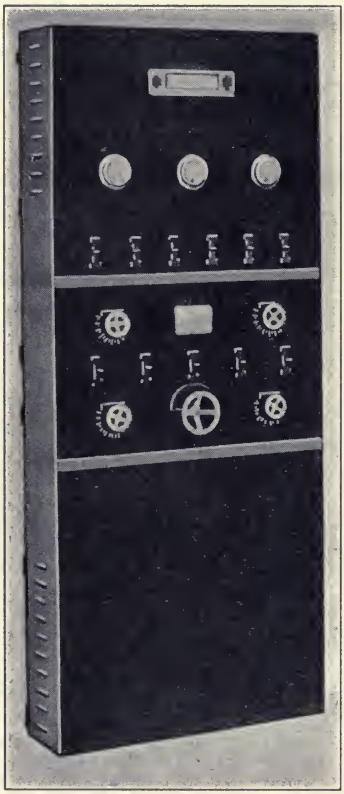

FIG. 9. Recording amplifier used in the Gaumont Studio.

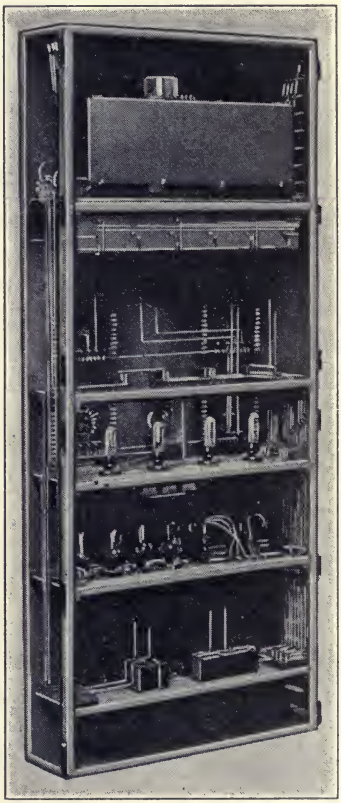

FIG. 10. Interior of the recording amplifier shown in Fig. 9.

loud speaker, while it appears satisfactory, should not be confused with a natural process. Having determined the sounds to be recorded by several repetitions controlled in this manner, the scene is at last definitely shot. During this process the monitor restricts himself to adjusting the attenuators in the microphone circuits in order to perfect the regulation. In this he bears in mind, not only the

general impression desired, but equally the size of the figure which will appear on the screen as well. It is evident that a performer in the front will speak more loudly than one toward the rear of the stage.

There is an indirect method of control used in some studios, which consists in recording on wax with an electromagnetic phonograph recorder at the same time that the photographic recording is made. A few seconds after recording the wax record can repeat the sound just recorded by using a pick-up and operating a loud speaker in the studio. This arrangement is useful in that it enables the performers to correct themselves; but it is obviously less efficient, as regards the final result, than control effected during recording by means of a photoelectric cell placed in the recorder behind the unexposed film.

The Amplifier.—According to the arrangement of the rooms, the recording amplifier is located either near the monitor or in a special room, generally the recording room.

It is usually a three- or four-stage amplifier, coupled by resistances and capacities, and built with very great care. Its response to different frequencies should obviously be related to the responses of the microphone and the sound recorder employed, which latter it is difficult to modify. The amplifier is therefore equipped with equalizing circuits which the technical staff frequently check, and on which the quality of the talking film depends to a large degree.

Fig. 9 shows a recording amplifier. The measuring instrument located at the top of the panel is a dead-beat milliameter with a very large scale, which is connected to the output of the detector circuit and indicates the average value of the sound picked up by the microphone. Fig. 10 shows the interior connections of this same amplifier.

The recording amplifier and all circuits directly or indirectly connected to the microphones must be suitably protected against external inductive and electrostatic effects. This precaution is particularly necessary when the studio is subject to electromagnetic fields produced by high-voltage supply cables for lighting purposes.

The Recording Machine.—The sound recording machine includes: a mechanical device driven by a synchronous motor and designed to drive the film at a very constant speed; film magazines; a lamp and a special optical arrangement which generally includes some perfectly corrected cylindrical lenses; the sensitive recording agent, which may be a light valve, Kerr cell, or bifilar galvanometer; and

finally an optical arrangement enabling the operator to control the recorded light variations continuously, either by means of a microscope, or by a device which projects the magnified spot of light.

In one type of recorder the light falls on the film on the circumference of a toothed drum, which carries it along without any vibration or slipping. Such a regular movement demands special precautions. These consist in connecting the drum to the driving shaft

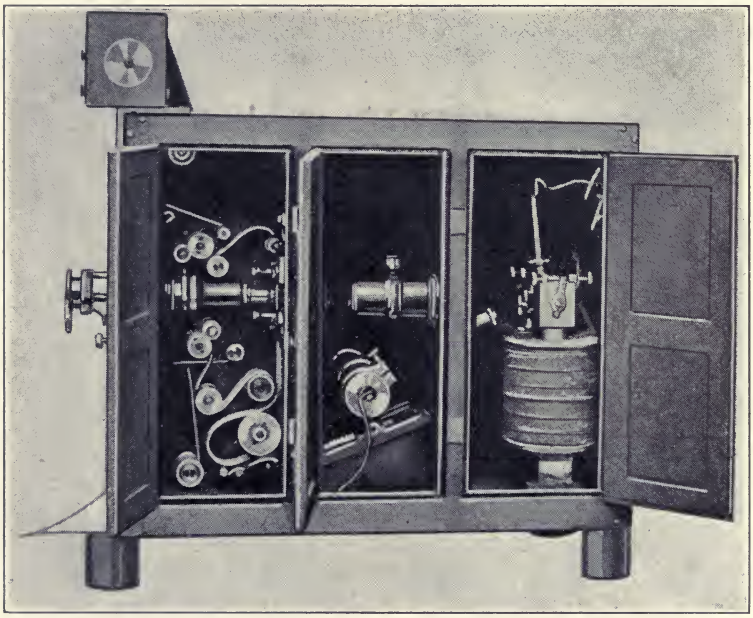

FIG. 11. A Gaumont recorder of the Peterson-Poulsen type.

of the motor through a "mechanical filter." It acts, on the rigid series of shafts and gears, to oppose propagation of vibrations of different frequencies, of which the lowest is obviously equal to the frequency of rotation of the synchronous motor. Very perfect mechanical filters can be made in which the required damping is introduced by means of liquids. The film perforations are not always perfectly regular. The distance between two successive perforations, termed the "pitch of the film" is not always precisely 4.75 mm., its theoretical value. It follows that some disturbances in the passage of the film may be introduced by the toothed drum which carries it forward. This is why, in a second type of recorder, it is preferable to move the

film by means of a smooth roller, to which it is caused to adhere by means of pressure pads. This smooth roller is keyed to the shaft of a larger flywheel which provides steady movement.

Fig. 11 shows a Gaumont recorder of the Peterson-Poulsen type. In this machine, the film is the driving agent and turns the flywheel

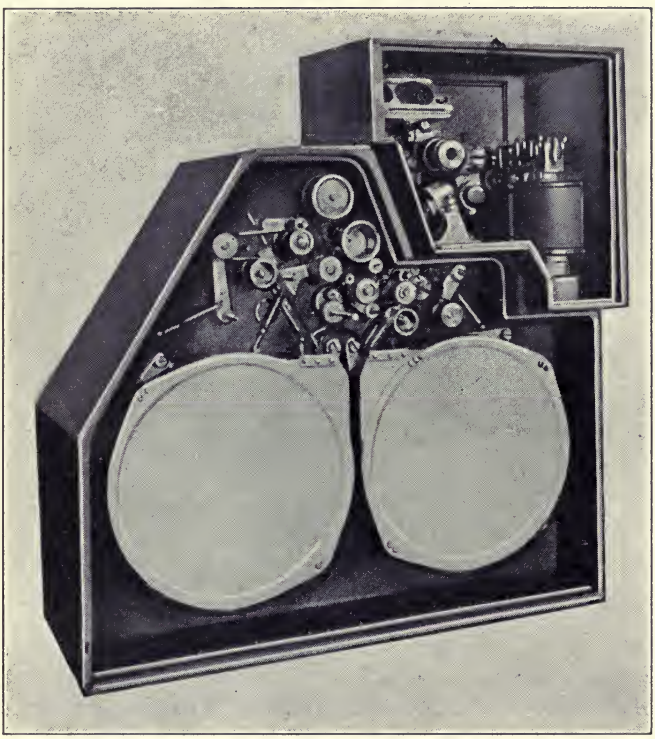

FIG. 12. Special recorder developed for maintaining constant tension on the film band and to counteract other defects usual in recorders.

which is quite free and is employed merely because of its inertia. In some other machines, on the contrary, the smooth cylinder carries the film forward. But here some difficulty is encountered. The standard conditions for synchronizing sound film require that a length of film equivalent to 24 frames pass every second, or what amounts to the same thing, a length including 96 perforations. But these 96 perforations represent an indefinite length, for the pitch of the film

is never exact and it can, moreover, contract a certain amount in a short time. If, therefore, the film be moved by a smooth flywheel the speed of rotation must be regulated to maintain the passage of 96 perforations per second. Some very ingenious arrangements have been built which achieve this result automatically.

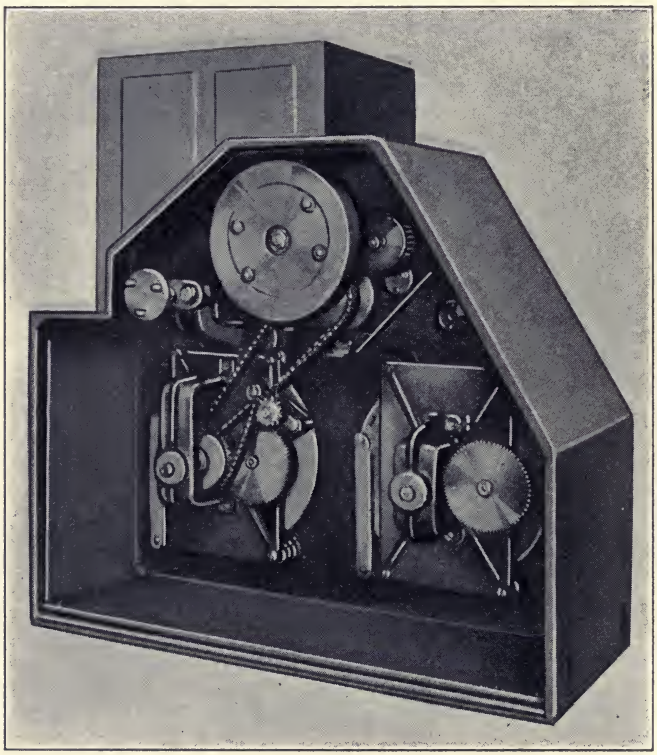

FIG. 13. The regulating mechanism on the rear side of the recorder shown in Fig. 12.

Unsteady film movements during recording cause flutter of the voice in reproduction, or an intolerable *tremolo* or *vibrato*. Vibrations in the film during recording of large amplitude introduce a less disagreeable sensation when reproduced; but in the voice a certain thickness of pronunciation is noticed, and in musical notes a rather unpleasant effect. Lastly, very rapid longitudinal vibrations in the film, and those of extremely small amplitude, are not

directly audible in reproduction, but can cause, when very high notes are recorded, a flutter which diminishes the purity of the reproduced sound. Unexposed film is, unfortunately, a material which does not lend itself well to such severe requirements. It is elastic to a marked degree and vibrates when stretched. It rapidly contaminates things against which it is pressed. Moreover, film manufacturers are compelled to cover it with a viscous coating, which introduces unequal degrees of friction during unwinding. The object of this coating is

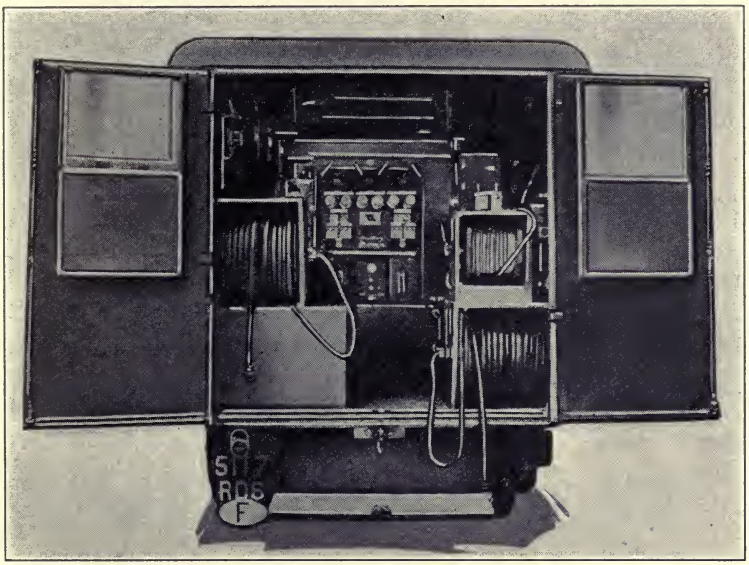

FIG. 14. An automobile installation for taking sound pictures out-of-doors.

to prevent the formation of electrostatic charges which expose the emulsion.

Recorders are made in which the film movement is protected against these difficulties. Fig. 12 shows the mechanical part of such a machine. The means adopted enable the tension of the film band to be regulated throughout its course to one constant value, which may be as small as desired. Fig. 13 shows the regulating mechanism on the other side of this recorder.

The optical system of the recorder must be very accurate. The light beam which exposes the film must be very fine and sharp, with a height of about 0.025 mm., without stray light, degraded zones or

chromatic residues. It must also possess a very great luminous intensity.

The bifilar galvanometers used in sound film recorders are very highly perfected instruments. Their natural oscillation frequency sometimes exceeds 10,000 cycles per second. The mirror is generally very small, its sides not exceeding 0.3 or 0.4 mm. The choice of the liquid used for damping is of great importance, for on its viscosity depends the critical damping of the equipment.

Mobile Installations.—We have reviewed the studio and its lighting arrangements, the camera for taking pictures, the microphone, the monitor's controlling instruments, the amplifier, and the recorder. Instead of locating these appliances in definite places, it is possible to install the control apparatus, the amplifier, and the recorder in booths mounted on wheels which are brought on the stage before the scenery. We are led to this arrangement less from technical considerations, than from the flexibility thereby introduced in working conditions, and because it provides a better means of supervising the personnel responsible for the sound quality. This method is only adapted to simple cases, however, but without doubt, simplicity is one of the characteristics toward which recording apparatus will tend more and more in proportion to its improvement. Finally it must be pointed out that similar installations are built into automobile trucks for taking sound pictures out of doors. See Fig. 14.

SOUND AND SPEECH IN SILENT PICTURES*

ARTHUR EDWIN KROWS**

Summary.—*According to this writer the new factor in the talkies is sound for its own sake and not speech, speech having found its place long ago in the printed captions of silent films. Study of these old subtitles, it is said, quickly defines screen dialog, while pure sound, no longer confused with spoken words, becomes a great artistic force. It was explained when presented, that this paper was really a chapter in "The Talkies," an immediately forthcoming book. Its appearance here is with the express permission of the author and of the publishers, Henry Holt & Company, of New York.*

The voice that is now brought to the heretofore silent screen is not in itself a new expression, but a new *aid* to expression. That it enables the artist to approximate life more nearly is comparatively unimportant, because the purpose of art is not the precise imitation of life but its interpretation. The films of the future will not be any more original in essential thought because of the super-addition of voice than bygone silent pictures; but because of voice their expression will be more flexible.

The prime caution is never to think of the spoken word merely as sound. The voice makes a sound, but the word uttered may express the reverse of sound. For instance, the clerk of the court may call out in stentorian tones, "Silence." Or, going into other seeming contradictions, the well-known giant, muttering his "fe-fo-fi-fum," may continue, "I *smell* the blood of an Englishman." Or Gaffer Hexam (in *Our Mutual Friend*) may remark, as he steals a sixpence from a body floating on the Thames, that, "It *feels* cold and clammy and wet." Or the proud Balboa, extending his vision by poetic license from "a peak in Darien" to the Pacific Ocean, may utter raptures concerning what he *sees*. In short, the spoken word may easily appeal also to any of the five senses other than that of hearing.

So it is that the spoken word is usually, and perhaps quite invariably, a symbol for something else. It requires translation by the

* A chapter from *The Talkies*, Henry Holt & Co., New York, N. Y.

** Electrical Research Products, Inc., New York, N. Y.

listener, whose imagination completes the suggested idea. It is that something else—whatever it may be—that measures the true effectiveness of the speech. Speech is the vehicle and not the end. The eloquence of Demosthenes, as that of Lincoln, was less in what he said than in what he literally thought. Thus it is that the expert stage dramatist writes his play not in words but in the ideas that the words are intended to convey—the reactions of the audience; and in this attitude of mind he is able to detach himself from the tyranny of words as such, and not use them at all if some of the other resources of his medium will at the given moment serve him better. In the theater of today dialog is crisp and snappy in its interchange partly because the great alteration in living conditions demands a more telegraphic style, and more because many other factors have been developed to carry on the play. Shakespeare's stage was so meagerly equipped that the dialog had to state that the scene was a forest, a palace, a street—that it was day or night, and many more clues to circumstance that a random dip into any of his masterpieces will soon disclose. Nowadays scenery and lighting particularly relieve dialog of these unfair burdens and relate it far more nearly to every-day speech.

TALKIE LESSONS FROM MOVIE TITLES

Strictly speaking, the strange new element is sound and not speech. Speech has been joined with motion pictures since their infancy in the shape of the printed "titles"—or "legends" or "captions"—upon the screen; and in the artistic sense speech of that sort is not much more second-hand than that which is directly spoken. As the word that is heard by the ear commonly has to be translated afterward by the brain as something other than sound, the printed word seen by the eye frequently also has to be translated because it has nothing to do with sight directly.

When the talkies permanently came, speech was already so far a part of motion picture practice that one-third of the footage of the average reel consisted of titles. Attempts had been made, every couple of years, to prove that the motion picture art was in its zenith when a picture had no titles, among the interesting later productions of this sort being a version of James Whitcomb Riley's *The Old Swimmin' Hole*, starring Charles Ray, and *The Last Laugh*, starring Emil Jannings and directed by another superb artist, F. W. Murnau. But because speech, even in printed title form

is so naturally and easily a part of motion picture appeal, its elimination upon such arbitrary grounds as provided by what here seems to be an over-nice and possibly mistaken artistic sense, has not been approved by the industry at large. On the contrary, titles have been pushed to the apparent limit of their expression, the records showing a wide variety of experiments to develop their effectiveness.

EXPERIMENTS WITH PRINTED SPEECH

As many years ago as the heyday of the old Lubin Studio at Philadelphia, there was tried out a scheme whereby the witnesses in a courtroom scene gave their testimony in words double-exposed in dark areas over their heads on the actual picture. In a much later but now long-past feature called, if memory serves true, *Sporting Life*, the action of the scene suddenly "froze," so to speak, and became a background of the printed title imposed over it—a method tried anew by George Loane Tucker in 1915–1916, when that gifted producer was director-general of the then recently organized Goldwyn Pictures Corporation.

The cut-and-try worker, urged to explain the abandonment of these devices, probably will say after brief reflection that mechanical delays entailed, and, above all, the item of translation for the foreign market, made them impractical. The fact lies deeper. They were given up because in effect they didn't *seem* right—the titles didn't "get over" as well as by the established plan of "cutting" them in. And whether those persons in the game divined the reason or not, it was this: the spectator appreciates best when he is able to concentrate; and his mind is so constituted that he concentrates best on one thing at a time. To watch the scene in the courtroom, however familiar it already may have become, to restudy the orientation of characters and their varying facial expressions and at the same time attend their speech presented in this fashion, was a little like dividing one's attention over a three-ring circus.

Now, of course, in the regular theater one does not literally blot out the scene while he listens to the speech—and yet, if the production is carefully made, that is, in effect, what happens. As in concentrating on a word one is reading on a printed page he is also vaguely conscious of an area of printed text around the focal point, the engrossed audience listens to the player's telling words with a momentary dimming of the unrelated parts of the scene, the dimming being done by themselves. If attention is genuinely concentrated on the

speech, the physical scene, to all intents and purposes, is not there save as one wishes to recall it. And what the venerable "cut-in" title does is artificially to assist such concentration by *complete* elimination of the scene for a brief interval. Thus, the universally used, traditional title was, in one respect at least, firmly rooted in approved psychology.

The stumbling-block here was the lack of uniformity in the audience itself. One person could read and appreciate quicker than another; and if he was not loud in his complaints that the title was held on the screen too long—in other words, that the scene was blotted out too long—the tenuous thread of interest snapped for him and he became restless. In this quandary the producers hit upon a device which was to decorate the title background with something that would divert the eye that too quickly had exhausted the meaning of the lettering. Being specific about it, probably the first decorated titles were made about 1908 by Richard Klaussen, the artist for many years in charge of the title department for the old Vitagraph Company of America at Brooklyn, N. Y. They seem to have been re-invented independently a few years later at the Thomas H. Ince Studios in California, by Irvin V. Willat and Mon W. Randall, the former then a master-cameraman and the other an artist less celebrated then than later for a highly original, vigorous technic. The Vitagraph Company had virtually abandoned the decorated title because there were too many other novelties to engage public attention for films; but early in 1915 the Ince picture *Peggy*, starring Billie Burke and with decorated titles throughout, was submitted to the distributors, Triangle Film Corporation, with a request for approval of the title backgrounds, in particular, that the practice might be continued for all Triangle-Ince releases. Approval readily given, the adornment became regular practice not only for the Ince division but for most of Triangle's competitors. Curiously enough it never was favored by D. W. Griffith, who at that time headed another division of Triangle. But the public liked it; and an even more potent reason for widespread adoption was the fact that it helped so much to "pretty" or "doll up" otherwise mediocre films.

In the half-dozen years following those in which workers in the first celebrated companies accepted and developed such basic advantages as the close-up, fade-back, double exposure, one-to-one shooting and shooting through scenes painted on glass, there was no organization that contributed more to picture technic than that at

Culver City, California, dominated by the far-seeing genius of Thomas H. Ince. Hence the eager interest in title development of his chief of camera staff, Irvin Willat, was aided and abetted. Willat carried title decoration to its high-water mark represented by such achievements as one in a play of big city politics, starring William H. Thompson and Charles Ray, showing a living spider actually ensnaring a fly, and, more remarkably still, a tiny frieze with living figures acting out an allegorical prologue back of the opening titles of *A Gamble in Souls*, starring William Desmond.

FINDING WHERE WORDS BELONG

These experiments were only incidental to other pioneer work which had to do with matters more fundamental than ingenuity of background. It was discovered, for instance, that titles should not anticipate action, which was precisely what had been learned about spoken words centuries earlier by stage folk. Of late years one has not seen much of the anticipatory title—that is, anticipatory in that sense; but in the first decade or so of the present century, it was one of the commonest technical sins. A title would read something like this—"Next day John Smith took his wife out driving;" and the succeeding picture-sequence would forthwith show John Smith doing precisely that thing, with the inevitable boring effect on the audience of having done it twice. The title should not "give the snap away"—should not, by telling too much, "take the edge off the story."

Then it was found, too, that the decorated title background slowed the tempo by inviting, without concentrating, further attention. The outcome here was that the best practice eschewed decorated backgrounds in all titles that belonged expressly to the pictorial action—"cut-in" titles, as they say—using them only for "editorial" titles leading up to action, or for those covering lapses between sequences or chapters of action. This explains the distinction drawn in the usual shooting script, of the silent picture days, between "titles' and "spoken titles." The former only were to be decorated.

Nor was this all. The title writer began to learn that the words were very definitely related to the pictorial action, and that writing one was by no means like composing a sentence for a printed page. In Erich von Stroheim's interesting and in many respects notable picture *Foolish Wives*, there was a "lapse-of-time" title something like this: "Night . . . music . . . women's voices . . . surf . . . fra-

grance . . . fireflies." No subject and predicate, no questions of syntax, no harrassing infinitives or metaphors—just those items of the *milieu* necessarily omitted by the silent picture and here supplied.

To the casual eye the title in its more advanced forms seemed more remarkable for what it left out than for what it said. Compression seemed the rule. One writer, Roy Summerville, on the scenario staff of old Triangle-Fine Arts, boasted occasionally that he was the first to use the three dots of elision to suggest the continuance of conversation not actually given on the screen; and there were other forms of editing words that forcibly reminded one of Henry Holt's famous advice to authors to practice their art by writing telegrams. There were also efforts to avoid the distractions of punctuation marks; and if Roy Summerville should go down to fame for three asterisks, the present writer may claim the innovation of "no periods at ends of titles." In William De Mille's production of *The Fast Set*, made from Frederick Lonsdale's stage play *Spring Cleaning*, even the usual quotation marks were cut from spoken titles. The reason back of all this is the same that applies to newspaper headlines where punctuation also is frowned upon. Nothing there is permitted to interfere with reading the full meaning at the first glance. And in spoken titles the word uttered "trippingly upon the tongue" is of high importance.

The title differs from the printed sentence in this other particular—there can be no turning back to read it again. It comes but once in the ideal telling of the story, and then in the most effective succession of bids for attention in which acting and scenery also figure. The title is now seen as essentially confirmatory of the pictorial action—a supplement to things literally seen. By and large this endorses and carries on a long-standing practice of the stage where speech interprets the gesture, gesture there being commonly made first. This order of precedence, that the gesture is before the speech, is psychologically based on two points—one that the eye is quicker than the ear, and that the spoken word, being oftenest a symbol of something other than mere sound, requires more interpretation.

But with the coming of talkies it is observable that this is no final statement of the case. Words are *generally* secondary to the pictorial action; yet there are times when the words are quicker in point of time. Certainly it is more economical (to revert to a celebrated anecdote of Barrie and Granville-Barker), to say in words that one has "a red-headed brother who drinks port in Shropshire"

than to try to show it altogether in pictures. There indubitably is a time when the spoken word, despite its familiar character as a symbol of something else, comes to the forefront as the most effective of the available means to the given end; and it is a very short-sighted director or continuity writer who does not seize upon it at that moment as a thoroughly legitimate means of artistic expression.

Perfection of the motion picture title has brought about an economy of words. This telegraphic character, however, is little more than has been attained by stage dialog, in which every phrase is fraught with meaning to just that extent that it may be comfortably absorbed by the audience—not to do less with words but to do better. The tendency has been not to dispense with words, but to boil them down to elemental strength, just as the poet prunes and polishes his verse without meaning in the slightest degree that he is thereby relinquishing his verbal medium.

SOUNDS BEYOND WORDS

Turning from the symbolism of speech, one sees that there is a power of pure sound, proverbial and known first-hand to all music-lovers. There is the force of rhythm, used so effectively in the incessant beating of tom-toms off-stage in Austin Strong's celebrated play, *The Drums of Oude*, or even more closely knit into the plot of an early sound picture, *The Dangerous Woman*, with Milton Sills and Baclanova, where the savage ceremonies of an African tribe stir the sensuous nature of a white woman till she becomes a vampire. But even music tries mostly to express more than sound. One composition is *The Awakening of Spring*. Another is *The March of the Wooden Soldiers*. Still another is *The Moonlight Sonata*. Virtually all are interpretative of things other than what "delights the ear" alone.

And yet even pure sound is not altogether new to the makers of titles. For many years they have been underscoring words for emphasis, or having the words appear successively upon the screen in imitation of staccato utterance, or having speeches run in criss-cross to approximate the chatter of gossips, or having significant words like "War" and "Murder" and "Help!" grow from nothing till they fill the field, or having the cry "Police!" or "Fire!" in quivering letters, or having dialects suggested with occasional misspellings. Borrowings from the fine practice of typography have long given biblical utterances in the ecclesiastical black letter or "Old English," and

growing discernment has uncovered the force that lies in delicate faces of type for plays of fragile sentiment, and more vigorous forms for virile stories. There has come about, it must be added, an all-around but peculiar style of lettering for titles that the type-founders have done the reciprocal compliment of casting in fonts. It is a generally round, open-faced letter, with heavy ceriphs, easy to produce and to read and not seriously modified by varying laboratory developments of the film upon which it is used.

Quite naturally it will be some time before the industry as a whole realizes the true affinity of motion picture titles and uttered speech—naturally because in any radical departure, in art as in politics, the first overwhelming tendency is to throw out everything old—pack and baggage. Nevertheless, and this should be clear by now, there are valuable benefits from the old to be cherished and enjoyed. So, before dispensing utterly with the long-serving title, its various forms should be scrutizined, each in complete detachment from the others, to see precisely what it has to give.

THE PLAYWRIGHT SPEAKS

One common form of title, long accepted on the screen, will seem quite unadaptable, and that is the editorial title in which the maker of the picture makes observations in his own person, without the intervening medium of any character. This title may say no more than "Dawn" or "Night" or "Home;" but it clearly is the injected comment of an outsider who is assumed, by the author's own terms, to be absent.

Here, once again, it is easy for the purist in art to be over-nice in his discrimination. The editorial title has too many valuable uses to be abandoned just because the body of the picture is literally spoken. The opportunity to whisper, in a manner of speaking, into the spectator's ear, supplying him with just the right expression with which to describe and remember his moment of ecstasy, is rich in possibilities and no more illegitimate than the strains of music out of nowhere that are injected occasionally to build up the emotion of the scene. But there is a more virile function of the editorial title; and that is its service between chapters or sequences of action, bridging intervals of time or saving the periods of rest between intense emotional experiences from being gaps so great that the flow of interest falls through.

From time to time in the regular theater the printed program has

essayed this same last-named service, summarizing the preceding act and speculating, with rich promises of future pleasures, on the action to come; so there is an analogy. But the stage could never hope, in circumstances where the program is only occasionally read and then usually at inappropriate times, to attain the development of this device reached by the screen where everyone who attends the play must also, perforce, attend the title.

Another proof is here of the truth that the possibilities of an art are realized best in the direction of its handicaps, and that its greatest weaknesses lie in what it finds easiest to do. When the printed program was first added to the facilities of the theater, theater folk frequently put into it important links in the plot not otherwise obtainable. In course of time, however, misuses were curbed; and today the theater program is a mere list of players (found with difficulty in a farrago of advertising). For the fact is seen that, with a little ingenuity and patience, what the program gives so easily may be better given in the play itself. The time and place, the character names and identities and much more, are now "put across" by the action itself as it moves along.

In this respect the talking pictures are following the stage example. They are tending to dispense utterly with printed descriptive matter once the play has started. The "iris out" and "iris in" shut off one scene and disclose another just the same, to all intents and purposes, as the stage curtain; and the characters in the second scene serve to tell how long the interval has been since the first and to what new place the audience has been transported. But however much better this practice may seem, the picture folk should not debar themselves wholly from advantages of the printed word. There indubitably are cases wherein a simple printed statement of the fact is far preferable to a strained expression of it by characters who would not reasonably do it, and the time for doing which throws the whole composition out of balance.

Of course it all depends on the circumstances. The artist's good taste and fine discrimination must prevail. The great objection to the editorial title is that it is the utterance of a person outside the story and therefore tends to break the spell of the play. Well, if the artist is an artist, he will know when he may resort to this expedient and when he should not. He will know that even in moments of great dramatic stress it is sometimes not only possible but tremendously effective to put the reaction of the audience into words,

or to help them to feel the reaction by articulating it for them. He will have less compunction about using the editorial title between "iris in" and "iris out" because at that time, as in the stage intermission, the spell of complete absorption has already been broken, the audience is once more aware that it is in a theater and grateful for the opportunity to recapitulate and reflect, and the editorial title may greatly assist their state of mind. Indeed, when intermissions between chapters, sequences, or acts are as brief as they are in screen practice, a predigested opinion of the case that has gone before, with the prospect of what is to come, may easily be essential to spectators who have had insufficient time in which to work out matters for themselves.

It was found long ago that even films must have intermissions. The stage intermission, popularly supposed to be due to the necessity of changing scenes, is really for rest and thought; and when so-called "super-features" began playing for the then supposedly unattainable two-dollar price on Broadway and appeared in about eighteen or twenty reels each to give money's worth, it was found necessary to full appreciation to break performance in the middle and give the patrons a quarter-hour or so to move around.

As said before, the important working habit of mind is to appreciate verbal and printed speech for what they really are, without prejudice, and to employ them freely where they serve best. Out of this attitude will come the new art of talking pictures.

EFFECT OF THE WATER SUPPLY IN PROCESSING MOTION PICTURE FILM*

J. I. CRABTREE AND G. E. MATTHEWS**

Sumary.—*Impurities in the water supply are classified as follows: Dissolved salts, suspended matter, dissolved extracts, dissolved gases. The action of each impurity on development, fixation, and washing of films is treated. Methods of purifying water include distilling, boiling, filtering, and chemical treatment. Sea water, although not seriously harmful, should not be used excepting in an emergency. It is concluded that impurities in the water supply are not responsible for as many troubles as is usually supposed.*

Water is the most widely used chemical in the processing of motion picture film and it is important to know to what extent the impurities present in it may be harmful to the various operations and how these impurities may be removed.

Impurities in Water.—Excluding distilled water, rain water, and water from clean, melted ice or snow, the following impurities may be present:

(1) Dissolved salts such as bicarbonates, chlorides, and sulfates of calcium, magnesium, sodium, and potassium.

(2) Suspended matter, which may consist of:

(*a*) Mineral matter such as mud, iron rust, or free sulfur.

(*b*) Vegetable matter such as decayed vegetation.

(*c*) Animal matter such as biological growths and bacteria.

The suspended particles may be of colloidal dimensions in which case they are difficult to remove by filtration.

(3) Dissolved extracts, usually colored yellow or brown, from decayed vegetable matter and the bark of trees.

(4) Dissolved gases such as air, carbon dioxide, sulfur dioxide, and hydrogen sulfide.

EFFECT OF IMPURITIES ON PROCESSING

Development.—(1) If a developing solution is prepared with water containing calcium salts, a white precipitate consisting largely of calcium sulfite, but with some calcium carbonate, is apt to form on

* Received by the Editor, February 27, 1931.

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mixing. In some cases a precipitate does not form immediately but a sludge[1] consisting of fine needle-shaped crystals of calcium sulfite separate out on standing (Fig. 1). Magnesium salts, unless present in excess, are not precipitated. Such a sludge or precipitate will settle out on the emulsion side of the film and cause spots.[2] However, the white precipitate or sludge is harmless if allowed to settle, and if only the clear supernatant liquid is drawn off for use.

The developer, of course, is robbed of sulfite and carbonate to the extent required to form the sludge or precipitate, but except in the case of developers of low alkalinity, this effect is negligible. Experiments have shown that the quantity of calcium or magnesium salts occurring in average natural waters in the United States is insufficient to produce an appreciable effect on the developing power of developers containing 0.3 per cent sodium carbonate by virtue of a lowering of the carbonate content.[3] However, in the case of developers containing borax, which are very sensitive to slight changes in alkalinity, the presence of an appreciable quantity of calcium salts would be sufficient to lower the alkali content, and due allowance for this should be made.

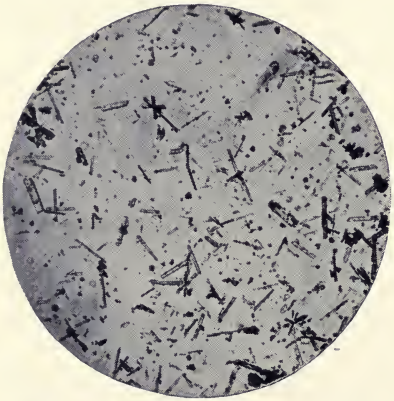

FIG. 1. Photomicrograph of developer sludge (calcium sufite) caused by presence of calcium salts in water supply.

Salts liable to be present, other than the above, are chlorides and bromides of the alkali metals which exert a restraining action. Sodium carbonate, which is present in certain alkaline waters, tends to speed up the action of a developer which is weak in alkali, although with the average developer the concentration of the alkali in the water used for mixing is insufficient to exert any appreciable effect. Developers mixed with water containing sodium or potassium sulfides will give bad chemical fog even if the sulfides are present in very small quantities.

It is customary to add copper sulfate to certain water supplies at periodic intervals in order to kill vegetable and biological growths. While the presence of 1 part in 10,000 of the copper salt in a developer

will cause aerial fog,[4] the concentration of the copper salt in the water supply usually is much lower than this.

(2) A. Dirt and iron rust suspended in the developer solution often produce spots and stains. In the case of a pyro developer the iron is apt to combine with the pyro, forming an inky compound which imparts a bluish-red color to the solution although photographically it is harmless.

Particles of finely divided sulfur which give the characteristic opalescence to sulfur waters will cause fog, owing to the formation of sodium sulfide by interaction with the carbonate present in the developing solution. If the water is boiled, the colloidal sulfur usually coagulates, whereupon it may be separated by settling or filtration.

B. Vegetable matter is usually precipitated by the salts present in the developer.

C. Animal matter is usually precipitated on mixing the developer, but frequently biological growths and bacteria thrive in a developer and form a slime or scum on the walls of the tank. Some types of these growths act on the sulfite in the developer, changing it to sodium sulfide which fogs the emulsion very badly. The sulfide is removed by developing some waste film in the solution or by adding a small quantity of lead acetate to the developer in the proportion of 25 grains per gallon (0.4 gram per liter).[5] Tanks which show a tendency to accumulate slime should be scrubbed with hot water at regular intervals and then treated with a dilute sodium hypochlorite solution.[3] Suspended mineral, vegetable, or animal matter in general has usually no harmful effect on a developer, providing the mixed developing solution is allowed to stand and only the clear supernatant liquid drawn off for use. Preparing the developer with warm water tends to hasten the rate of settling of the suspended matter.

(3) Extracts from decayed vegetable matter or the bark of trees usually discolor developing solutions but are often precipitated if the developer is prepared with warm water and allowed to stand. The staining effect of such extracts with motion picture film is usually negligible.

(4) Water dissolves about 2 per cent of air at 70°F., and when a developing agent like hydroquinone is dissolved without the addition of sulfite the oxygen present in the water combines with the developing agent, forming an oxidation product which is apt to stain the gelatin and fog the emulsion. Air in water occasionally collects on the film in the form of little bubbles or air-bells which prevent

development and produce characteristic markings.[6] When developing at high temperatures (above 80°F.) dissolved air often causes blisters.[7]

Mineral waters containing carbon dioxide rarely give much trouble, providing the water is boiled first in order to drive off the gas. If carbon dioxide is present in a developer in excessive amounts, it acts in the same way as dissolved air, producing bubbles and air-

FIG 2. Appearance of scum on motion picture film after evaporation of drops of water containing dissolved salts.

bells on the film. Hydrogen sulfide gas will cause bad chemical fog in a developer but may be removed by boiling the water or by precipitating with lead acetate before mixing.[4,5]

Fixation.—Calcium and magnesium sulfites are soluble in acetic acid and therefore are not precipitated in fixing baths. Other dissolved salts such as bicarbonates, chlorides, and sulfates are harmless. Suspended matter such as dirt, iron rust, and certain types of vegetable and animal matter usually will coagulate and settle out on allowing the fixing bath to stand.

Although most suspended substances have practically no effect on the photographic properties of fixing baths, the particles may settle

on the film, locally retarding fixation, and produce spots and stains.[2] Extracts from vegetable matter or dissolved gases do not affect the photographic properties of a fixing bath, but are liable to cause stains and blisters, and locally retard fixation.

Washing.—Dissolved salts often cause trouble by crystallizing on the film after drying, and although not always visible as crystals to the eye, they detract from its transparency (Fig. 2). Water which is free of dissolved salts also will cause markings on film providing it is allowed to remain in droplets on either side of the film during drying.[8] It is important therefore to remove thoroughly all excess water from the film before drying. This can be accomplished, (*a*) by draining thoroughly before applying a current of air; (*b*) by swabbing with wet absorbent cotton or chamois; and (*c*) by means of a pneumatic squeegee.[9]

Suspended mineral, vegetable, and animal matter usually produces a scum on film unless the gelatin surface is wiped carefully previous to drying. If the water used for washing is run into a large settling tank or is filtered before using for washing purposes, most of the suspended matter will be removed.

Dissolved extracts produce stains which are very difficult to remove. Also, if the wash water is warm, dissolved gases will sometimes produce blisters, especially if the film is not hardened sufficiently in the fixing bath.[3]

So far as is known, any small traces of impurities left in the gelatin coating of motion picture negative or positive film after drying, by virtue of the presence of these impurities in the wash water, are not liable to seriously impair the keeping properties of the films over a period of four or five years. However, films which are to be kept for long periods of time should be finally washed in distilled water.

The Preparation of Dye Solutions.—Many dyes are precipitated out of solution by calcium or magnesium salts and alum. The precipitation is not always immediate and may occur only after standing for a few days. The properties of dyes with respect to their rate of penetration into gelatin or the rate at which they are mordanted are affected considerably by the presence of metallic ions, or acids, or bases, so that in color photography or when using desensitizers, impurities in the water are apt to produce anomalous results. Distilled water should be used whenever possible for preparing solutions of dyes.

METHODS OF PURIFICATION OF WATER

Distillation.—Distilled water should be used whenever possible for mixing solutions.

Boiling.—Unless the water contains an excessive quantity of dissolved salts, it is usually sufficient to boil the water and allow it to settle. The supernatant portion then may be syphoned off or the solution filtered through fine muslin. Most colloidal vegetable and animal matter, comprising slimes and scums, coagulates on boiling and certain lime salts are changed to an insoluble condition and settle out. Dissolved extracts are not removed but dissolved gases are driven off by boiling.

Filtration.—Various types of water filters are available commercially, but these do not remove dissolved salts or colloidal matter unless the water has been treated previously with a coagulant.

Chemical Treatment.—The following methods of chemical purification may be adopted:

(1) Potassium alum may be added in the proportion of 1 gram to 4 liters of water. This coagulates the slime which carries down suspended particles and clears the solution rapidly. Dissolved salts are not removed by this method. The small percentage of alum introduced into the water has no harmful effect on the solution when subsequently used for mixing developers and fixing baths.

(2) A solution of sodium oxalate may be added until no further precipitate forms. This method removes the calcium and magnesium salts and coagulates the slime, although other dissolved salts are left in solution. Solutions of sodium phosphate and of sodium sulfite also may be used to precipitate calcium and magnesium.

(3) Most of the commercial methods of softening water may be employed although such methods do not remove sodium and potassium salts. One of the most satisfactory methods consists in passing the water through a tank containing sodium aluminum silicate (zeolite), which possesses the power of exchanging its sodium for the calcium and magnesium present in the water.

Sodium aluminum silicate (Zeolite)		Sodium sulfate
+	=	+
Calcium sulfate		Calcium aluminum silicate

When the zeolite thus loaded with calcium and magnesium is washed in a strong solution of common salt (about 12 per cent) it

exchanges its calcium and magnesium again for sodium and is thus regenerated, whereupon the chemical may then be used for further softening.

Calcium aluminum silicate		Sodium aluminum silicate (Zeolite)
+	=	+
Sodium chloride		Calcium chloride

THE USE OF SEA WATER

Sea water contains a relatively large proportion of soluble salts (about 3.5 per cent) and should not be used for mixing photographic solutions except in extreme emergencies when no other water is available. This is because the dissolved salts such as chlorides, bromides, and iodides, may retard the action of the photographic solution. When the supply of fresh water available is very small, sea water may be used for washing motion picture film, providing a last washing or soaking previous to drying is given in distilled or fresh water.[10] The film should be given a thorough washing later when plenty of fresh water is available.

A chemical analysis of the water supply usually reveals very little concerning its photographic usefulness. It may be of some assistance in indicating the quantity of lime, oxalate, *etc.*, to be added to remove dissolved calcium salts or to coagulate slimes. The quantity of total solids indicates if trouble from drying marks may be anticipated, while the presence of iron, hydrogen sulfide, or metallic sulfides should be regarded with suspicion. The only useful test is to prepare a developer with the sample and actually try it out compared with the same developer prepared with distilled water.

Also a large drop of water should be allowed to dry on the film and the amount of residual scum observed. This will indicate the extent of the trouble to be expected if the water is not removed thoroughly before drying.

PRACTICAL RECOMMENDATIONS

If developing solutions are mixed with warm water (about 125°F.) and allowed to stand over night, any precipitate or suspended matter will settle out and the clear supernatant liquid may be drawn off for use. The presence of calcium and other salts in the water supply is sometimes beneficial in so far as they tend to retard the swelling of the gelatin coating of the film during washing. This is of particular advantage in hot weather.

The only impurities liable to cause serious trouble with developers are hydrogen sulfide or soluble metallic sulfides. With such water about 25 grains of lead acetate per gallon of developer (0.4 gram per liter) should be added before mixing. This removes the sulfides as lead sulfide and any excess lead is precipitated in the developer and settles out on standing.

No trouble may be anticipated with fixing baths prepared with average samples of impure water providing the bath is clarified by settling before use.

When washing photographic materials little trouble may be anticipated with uncolored water if the following precautions are taken: (*a*) remove all suspended matter by filtering, either by means of commercial filters or by placing two or three layers of cloth over the water outlet; (*b*) remove thoroughly all excess moisture from the film before drying.

Water which is colored brown even after filtering, is very apt to cause staining of the highlights. It is a difficult matter to economically remove the coloring matter from such waters and each case usually requires specific treatment.

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THE WORLD'S MOST POWERFUL MICROSCOPE*

F. F. LUCAS**

Summary.—In the last ten years there has been developed at Bell Telephone Laboratories a new technic of high-power micrography, which has greatly extended the limits of useful magnification possible with a microscope. Since any extension of the limits of magnification of he microscope which is accompanied by a decrease in definition is useless, it was found necessary to increase the resolving power or definition of the microscope. One way in which this can be done is by decreasing the wavelength of the light used.

A microscope using ultra-violet ligh! was developed about thirty years ago by Koehler of the Zeiss works. Due to various difficulties n operat ng it, this microscope soon became a scientific curiosity and was almost forgotten. About five years ago, a microscope of this type was obtained from the Zeiss works by Bell Laboratories, and the difficulties involved in the use of this nstrument were largely solved by the development of a mechanical method of focusing. With this microscope, it is possible to obtain crisp, brilliant images of metallurgical specimens magnified 5000 to 6000 diameters. In studying the advantages and limitations of this microscope, it was found to be particularly applicable to the study of biological and medical specimens. Such specimens can be examined at high magnification under the ultra-violet microscope without the necessity of cutting, staining, or injuring them in any way.

Until recently the microscope was regarded as an instrument which had yielded its basic store of knowledge. It was commonly believed that in order to learn more of the structure of matter, some new method of approach was necessary. During the course of the last ten years, however, there has been developed at Bell Telephone Laboratories, a new technic of high-power metallography. The limit of useful magnification has been extended so that crisp, brilliant images can be obtained by photographic methods at very high magnifications and with the full potential resolving power of the microscope.

The matter of the resolving power or definition of the microscope is of the greatest importance. When working at high magnifications, we are primarily interested in bringing out every detail with the utmost fidelity, rather than in obtaining a much more highly mag-

* Presented at the Fall 1930 Meeting at New York, N. Y.

** Bell Telephone Laboratories, New York, N. Y.

nified but greatly blurred view of the surface under scrutiny. For this reason any extention of the limits of magnification which is accompanied by a decrease in definition is useless and is frequently termed "empty" magnification (Fig. 1). Until eight or ten years ago, the apparent inability to secure from the microscope well-defined images at high magnifications led to the rather general acceptance of the theory that magnification in excess of 1000 to 1500 diameters was of little value. Most work was carried out at very much lower magnifications.

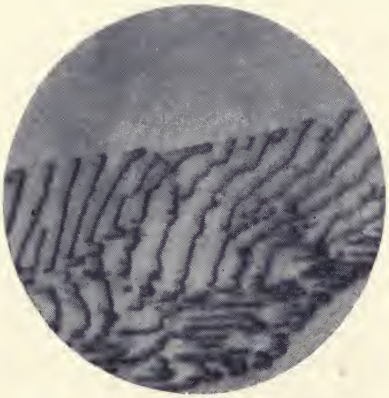

FIG. 1. Empty magnification. As can be seen from this picture, an increase in magnification is useless if accompanied by a decrease in the resolving power of the microscope.

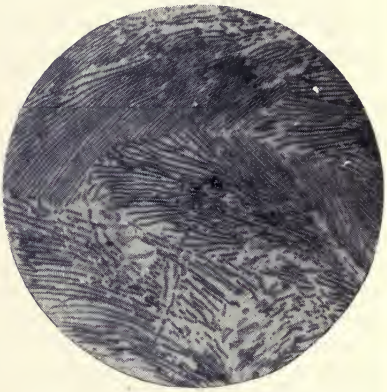

FIG. 2. Pearlite photographed with visible light.

Resolving power is usually expressed in lines per inch and is defined numerically by the equation first derived by Abbé, one of the founders of the Zeiss works:

$$N = \frac{2(N.A.)}{\lambda}$$

in which N is the number of lines per inch, $(N.A.)$ is the numerical aperture of the objective used, and λ is the wave-length of the light expressed in inches. In deriving this equation for the theoretical resolving power, it was assumed by Abbé that the detail to be resolved consisted of equally spaced lines—in other words, a very fine ruling or grating.

Metallographic specimens, however, do not consist of rulings but usually their structure exhibits the greatest variation in detail and in contrast. The microscope, then, is not dealing with a ruling,

but under the conditions, its performance must be more along the lines of the ultra-microscope. It is possible to photograph very minute details of structure in metal specimens because these details are actually single particles or lines disposed in a field of maximum contrast. If there were a succession of these details aligned side-by-side and equally spaced, the indications are that Abbé's formula would hold.

Sound picture engineers will readily recognize the analogy in the field of acoustics, where much of the theory is derived for steady-state sound waves and must, therefore, be modified in considering transient phenomena. Similarly, the formula for the resolving power of a microscope is derived from "steady-state" conditions, where "steady-state" applies, not to a time-sequence as in acoustics, but to a space-sequence considered across some hypothetical grating. At the end of this grating, it is obvious that "end-conditions" rather than "steady-state" conditions must prevail. It is due to the effect of these "end-conditions" that a small isolated dot can be detected much more readily than Abbé's formula would have us believe.

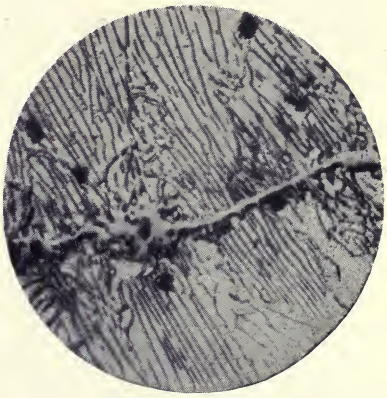

FIG. 3. Pearlite photographed with ultra-violet light.

Another factor which enters is that of contrast. A black button on a piece of black velvet is not a conspicuous object but a white button is very conspicuous because of the contrast which is developed. The black velvet absorbs most of the light which falls on it but the white button reflects the most light, hence there is maximum contrast.

Although Abbé's formula applies strictly only to a hypothetical grating, it does show that resolution may be increased by decreasing the wave-length of the light used or by increasing the numerical aperture (or light-gathering power) of the objective. While either method may be used, we shall consider only the former at this time.

When the problem of using light of shorter wave-length was first taken up at Bell Laboratories, it was found that a microscope for use with monochromatic light from the ultra-violet region had been

developed about thirty years ago by Professor Koehler of the Zeiss Scientific Staff. This microscope was intended for biological work and a number had been built and supplied to research groups throughout the world. Theoretically this microscope should furnish a resolving power nearly twice that of systems using visual

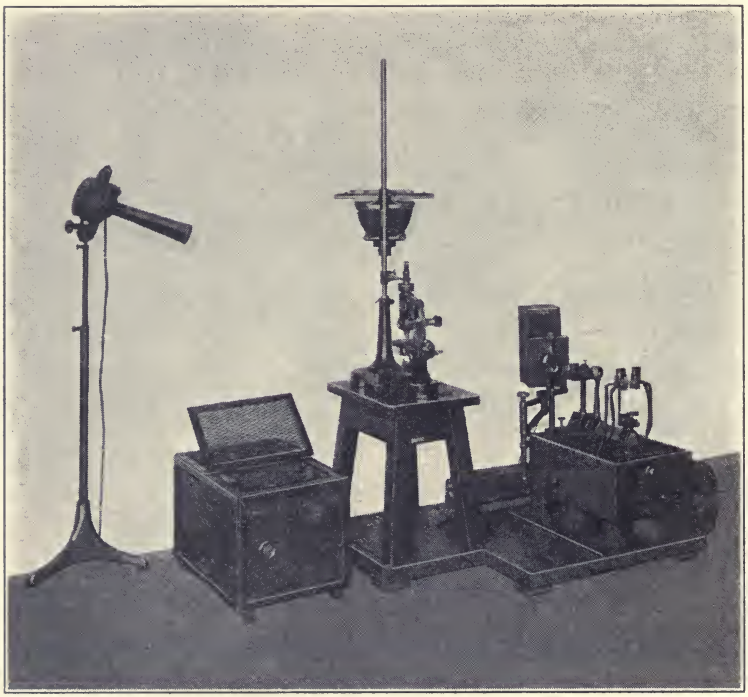

FIG. 4. Ultra-violet microscope arranged for optical sectioning of living cells. The sound and fume hood is removed from the spark generating apparatus and the searcher eyepiece is in place above microscope.

light. No one apparently could get it to work, however, and the apparatus soon became a scientific curiosity and was almost forgotten.

About five years ago, we commissioned Zeiss to construct one of these ultra-violet microscopes for metallographic work. A photograph of this microscope is shown in Fig. 4. At the right is shown the spark generating apparatus with the sound and fume hood removed. The source of illumination is a quartz slit behind which

is a spark gap. Cadmium electrodes are used because the cadmium spectrum has a line at 2750 Å which is particularly suitable for ultra-violet work of this nature. At the electrodes the potential is 10,000 volts secured from a primary source of 220 volts at 60 cycles by means of a step-up transformer. The light then passes through two quartz

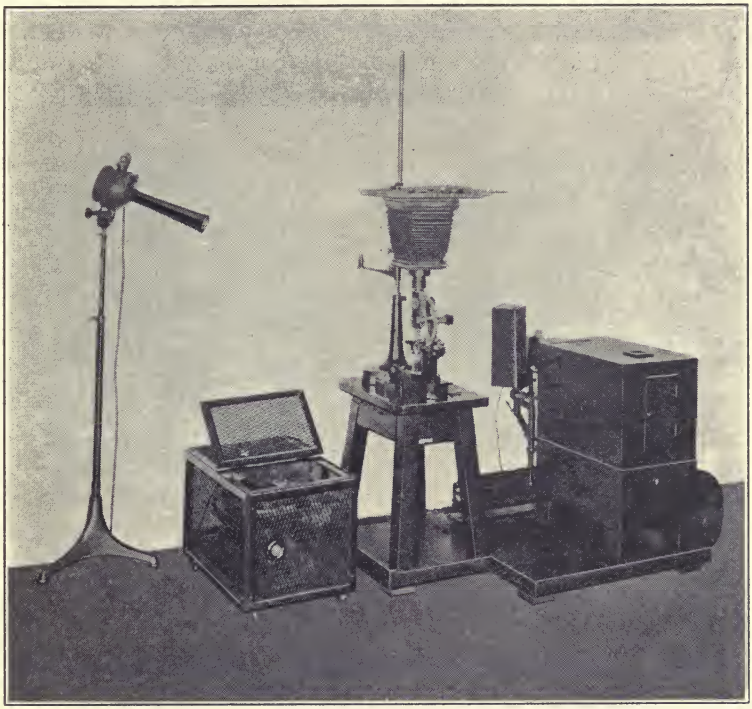

FIG. 5. Ultra-violet microscope with the sound and fume hood in place. The light emerges through the open window shown. This window is fitted with glass and excludes the ultra-violet light when closed, protecting the specimen except during the intervals of exposure.

prisms and a collimator to emerge from the prism diaphragm in the form of a line spectrum. As originally designed for biological work the desired line enters a prism at the base of the microscope and is directed upward into the substage condenser. When used for metallurgical work the spark gap and associated optical system are elevated until the desired line is focused on the vertical illuminator, which is of the same general type used in ordinary metallurgical

microscopes. By means of a suitable optical system and a quartz plate contained within the illuminator, the ultra-violet light is deflected downward to the specimen as in any metallurgical microscope using the Beck type illuminator. A schematic diagram of the optical system is shown in Fig. 6. It is interesting to note that all optical parts are made of quartz as glass is opaque to ultra-violet light.

The spark generating equipment is mounted in a case located 32 cm. from the microscope stool. It consists of a box supporting a wooden cabinet, in the bottom of which are mounted two con-

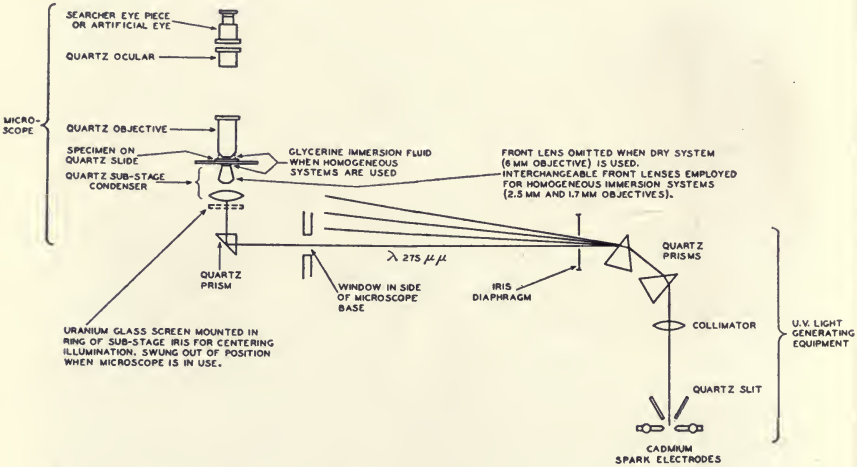

FIG. 6. Schematic diagram showing arrangement of optical system for ultra-violet microscope.

densers and a safety spark gap. On top is a T-shaped, adjustable optical bench carrying a diaphragm, a prism table, a collimator, and the spark gap, as shown in Fig. 4 and in the diagram in Fig. 6. The electrode terminals have a screw adjustment and both electrodes are opened or closed simultaneously so that the gap will function centrally before a quartz slit mounted on the frame of the spark stand. Mounted on the end of the cabinet can be seen a small metal container, which houses a mercury vapor lamp. The flask mounted in front of the opening in the lamp housing is filled with a green filter solution yielding approximately monochromatic light and it also is used as a condenser. This lamp assembly can be used in two ways. Either it may be swung around to illuminate the vertical illuminator directly or it may be swung back so that a small mirror reflects the

light through the prism diaphragm. By this latter arrangement it is possible to center the illumination with the mercury vapor light by aligning the optical system of the microscope with reference to the aperture in the prism diaphragm.

The mercury vapor lamp has another important function to perform. It provides a steady source of approximately monochromatic illumination, free from noise, by which the operator can focus the specimen, study its structure, and select a field as a preparatory step to photography with the ultra-violet illumination. Once the field

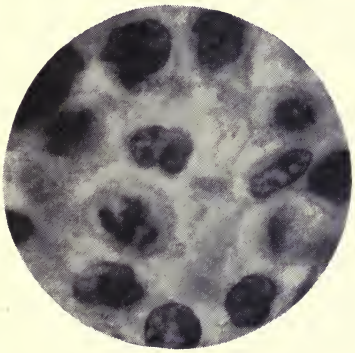

FIG. 7.

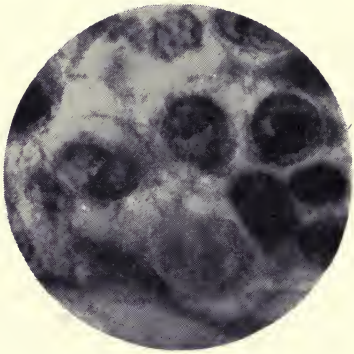

FIG. 8.

Comparison of results obtained by visual light and ultra-violet photomicrography of a biological specimen. Fig. 7 was taken with the best apochromatic system ($N.A.$ = 1.40) using visual light, while Fig. 8 shows an unstained section from the same paraffin block at 1500 ×, using ultra-violet light. The sections were identical except one was stained and mounted on glass for the visual light microscope, and the other was unstained and mounted on quartz for the ultra-violet microscope.

is selected with the mercury-vapor light, it must be refocused with the ultra-violet light. In this matter of focusing the instrument for ultra-violet light the main difficulty experienced in the operation of the ultra-violet microscope was encountered. Since ultra-violet light is invisible to the eye, the microscope cannot be focused by ordinary means, and some indirect method of focusing is, therefore, necessary. As originally designed a uranium eyepiece was provided which became fluorescent under the impact of the ultra-violet light and produced a fluorescent image of the surface under the microscope. The arrangement of the apparatus was such that if the image was in focus in the searcher eyepiece, it was also in focus thirty centimeters above.

In actual practice, however, this arrangement does not work out very well, since the intensity of the illumination is not sufficient to secure an exact focus of the fluorescent image in the uranium eyepiece. One cannot tell with certainty whether the image is exactly in focus, coming into focus, or going out of focus. Therefore, to rely on the searcher eyepiece method of focusing with the present weak source of light means that it is almost entirely a matter of chance whether a well-focused picture be obtained.

This problem was finally solved through the development of a special mechanical technic. By means of a circular scale and a pointer attached to the slow motion adjustment of the microscope, the focus of the microscope can be shifted in as small an amount as one-sixteenth of a micron. In using this attachment, an approximate focus is first obtained by means of the uranium eyepiece. It has been found that if four photographs are then taken with their planes one-quarter micron apart, at least one of the photographs will be in focus.

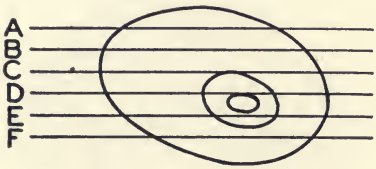

FIG. 9. Diagram illustrating optical sectioning of the ultra-violet microscope.

A transparent specimen such as a group of cells may be sectioned optically. The focal planes may be spaced as closely as $^1/_{16}$ micron—generally a spacing of $^1/_4$ micron suffices. Detail above or below the focal plane does not interfere. Successive photographs taken on planes A, B, C, etc., give a progressive record of the structure.

Magnifications as high as 5000 diameters result in crisp brilliant images with a high degree of resolution.

With this technic developed, it became possible to obtain crisp, brilliant images at very high magnification, thus making the ultra-violet microscope unquestionably the most powerful microscope in the world. With it details as small as 300 atoms across (0.000003 inch) can be detected and studied. Using this microscope, a series of studies has been made on iron and steel, on alloys for lead cable, and on many other metallurgical subjects of interest to the telephone industry.

From the technic developed for the examination of metals, there has developed another technic, also of very great value, but for use in a different field. As has been pointed out, the focus must be exact to within one-quarter micron, one one-hundred thousandth inch. Any optical system which will yield a sharply defined focal plane of about one-quarter micron should prove of great value in certain

types of work. For example, it appeared reasonable to suppose that we might substitute a transparent specimen for the opaque metal surface and, because of the transparency of the specimen, we should be able to photograph details of structure on different planes inside the specimen, without the necessity of cutting it. Obviously, if the focus is confined to a focal plane of inappreciable depth, detail above or below the exact focal plane should not interfere with the image.

Especially in relation to the study of biological specimens (for which the ultra-violet microscope was first developed by Koehler), the value of this method of examination is obvious. By its means, it becomes possible, figuratively speaking, to actually place the microscope inside a living cell, microscopic in size. Not only does this enable us to take photographs at high magnifications of the interior structure of the cell without cutting or injuring it in any way, but it is also unnecessary to stain the cell to bring out structural details, as is usually necessary in the study of biological specimens by visual light. Details of structure are differentiated from one another by the different amounts of ultra-violet light which they will absorb. Unstained specimens, therefore, respond under the ultra-violet microscope much as stained ones will under a visual light microscope.

The importance of this is evident as it is generally recognized that the structure of organic material is apt to be profoundly altered by the treatment required to prepare it for microscopic examination. In recent years, the trend of biological research appears to be toward the study of living material, avoiding the changes produced by fixation, staining, and mounting.

It may be argued that any cell removed from its normal living habitat and placed in an artificial medium is no longer a normal cell, even though it may be a living one. In some cases, well-justified doubts may be entertained as to whether the cell is actually alive. It is very difficult to decide matters in this borderland. Shall we answer by opinion, by careful laboratory observation, or by both? It can only be said that ultra-violet microscopy of living cells is in its infancy. Experimental observations on fresh and aged materials have shown that changes do occur. In some cases, these changes are quite rapid; in others a surprisingly long time may elapse before any change or deterioration can be detected. Cells of the nervous system are most delicate of all, and we have found them more difficult to work with than any other type of cell. Nevertheless photo-

graphs of this type of cell probably represent at least a close approximation to normal.

If we are to employ the ultra-violet microscope in researches of this type, two reservations must be kept in mind. The ultra-violet light itself must not have apparent injurious effects on the organisms, and the latter must not completely absorb the ultra-violet light, as any organism which does so obviously cannot be studied by these methods.

Ultra-violet light of the intensity and wave-length used in this

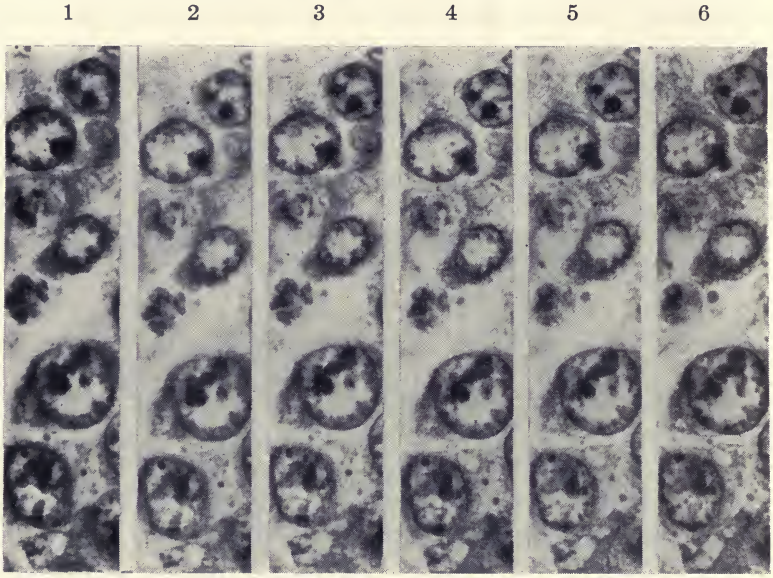

FIG. 10. Mouse tumor—1800 ×. Optical sectioning. Ultra-violet microscope. A fixed but unstained specimen

work appears to have little if any harmful effect on many types of living cells. It is true that some single-cell organisms are destroyed almost immediately; others of another species in the same mixed cultures appear mildly excited, and still others are apparently immune. From preliminary observations, it would appear that many living cell cultures may be exposed under the ultra-violet microscope as long as forty-five minutes, and, when returned to the incubator, they appear to grow and to suffer no ill effects from the exposure.

One wonders what effect wave-lengths other than 2750 Å would have on standard cell cultures. Will monochromatic light of one

wave-length cause a living cell to disintegrate immediately and similar light of another wave-length have little or no effect? If so, then a very powerful way of dealing with cells will be at hand.

To illustrate the application of the methods used, Fig. 11, A and B, show photomicrographs taken of cell structures. The tissues

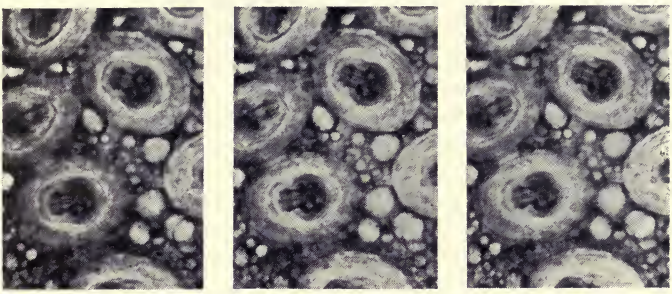

FIG. 11-A

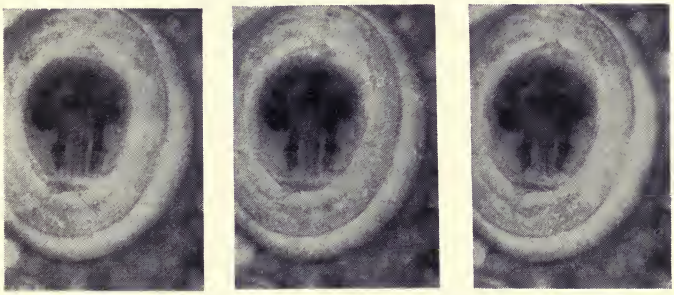

FIG. 11-B

Embryos within the segments of a small tape-worm found within the body cavity of a mouse. The preparation was mounted in Locke's solution and was unstained. Fig. 11-A shows three optical sections at 500 × and Fig. 11-B shows three optical sections at 1200 ×.

were taken from animals and transferred to physiological salt solutions. Cell smears were quickly made on quartz slides, a drop of the salt solution added and the preparation covered with a quartz cover slip, which was then sealed with vaseline to prevent evaporation from the preparation. The salt solutions were chosen with particular regard to their suitability for the purpose; in some cases body fluids of the cells themselves were used instead of the artificial salt solutions.

In closing it may be stated that the resolving power of a microscope, as computed from Abbé's formula, is a *potential* resolving power. Whether or not the full potentialities of the microscope are achieved depends on many other factors—learning the best way to prepare the specimen for microscopic examination, for example. Structures are now being clearly resolved as aggregates, which less than four years ago, appeared practically structureless under the same conditions. Improvements in technic and in the preparation of specimens have enabled us to resolve these structures very clearly with the identical optical system which four years ago failed to accomplish the same end. There seems, therefore, to be every reason to believe that we can go much further with the microscope than we have gone up to the present time.

VISUAL AIDS IN TEACHING*

C. E. BAER**

Summary.—*The purpose of this paper is to set forth the various phases of the application of motion pictures as visual aids in teaching. It is pointed out that concrete experiences are a necessary prerequisite to the use of language and that educators, recognizing the prevalence of verbalism in schoolroom practice, are demanding materials, devices, and methods to correct this weakness. Visual aids, properly used, equip a group with a common body of life experiences, useful as a basis of growth in knowledge.*

[By way of introduction to the paper, Mr. Baer presented three short film subjects of Eastman Teaching Films, having the titles *Induced Currents, Energy from Sunlight,* and *Food and Growth.* These films were presented in order to illustrate the subject matter used in films intended as visual aids in classroom instruction.—EDITOR.]

It is the purpose of this paper to do at least three things: To show that concrete experiences are a necessary prerequisite to the use of language; that educators, recognizing the prevalence of verbalism in schoolroom practice, are demanding materials, devices, and methods to correct this weakness; and that visual aids, properly used, equip a group with a common body of life experiences useful as a basis of growth in knowledge.

There are at least four approaches to a task of learning about a given thing, namely: (1) studying the thing itself; (2) studying a picture or representation of the things; (3) telling about a thing; (4) reading about a thing. The effectiveness of instruction is generally recognized as in the descending order of these approaches. This is due in part to the fact that the last two approaches presuppose some familiarity with the thing about which facts are to be presented. Furthermore, words of mouth or printed page are written or spoken symbols which have meaning to an individual only when he has within his experience the necessary sense perceptions which will serve as a basis for interpreting those symbols.

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* Presented at the New York Section Meeting, January 23, 1931.

** Eastman Teaching Films, Inc., Rochester, N. Y.

For example, the words "induced currents" take on meaning as the student associates with them a body of electrical facts. Not till then do the words become useful symbols for ideas. The phrase "energy from sunlight" has only limited meaning to the student who has never studied transformation of energy in its relation to the ultimate source, the sun. A simple illustration of mental associations which are connected with symbols appeared in an issue of a German publication:

"Mr. X stands in front of his home late at night and cannot get in. He has forgotten the key, and he decides that this shall not happen to him again. He takes his handkerchief and carefully ties one of the four corners into a large knot. This is to remind him of the key tomorrow.

"Mr. X knows nothing about psychology, but the course of action that he follows here is perfectly correct psychologically, and also effective. The following day he will take out his handkerchief at some time or other; then the knot will catch his eye, and immediately there will arise the image of the key in his mind.

"But how can the view of the knot awaken the thought of the key when there certainly is no resemblance between the knotted formation in the handkerchief and a key?

"Because Mr. X was thinking so forcibly of the key while he was tying the knot, no other image but the one of the key arose during his recent inspection of the knot.

"Between the occurrence 'knot' and the concept 'key' a relation has arisen so that the perception 'knot' almost coercively evokes the idea 'key.' In every-day language such a relation is called a 'combination of ideas.' The scientific expression for it is *association.*

"Hundreds of these associations pass daily through the brain. Above all, it is in languages that associations occur, namely, connections between word and meaning, whether the word is spoken and thus reaches the ear or comes before the eyes in written characters, whether we ourselves speak or write."

Business men and men whose business is education have long recognized that words unsupported by a backing of experiences are symbols about as meaningless as a knot in a handkerchief is to a stranger who chances to see it. For more than three centuries the use of the concrete experiences has been advocated in the educational systems of the great educators. In the 17th century Comenius, the great Moravian educational reformer, advocated learning from

the world at large. He prepared a book, the *Orbus Pictus*, which first made use of illustration to visualize subject matter. From this book as a beginning has developed the modern pictorial text-book. Advertising experts, too, have learned through continued and carefully studied experience that pictures and diagrams pay.

In the 18th century Pestalozzi, the Swiss educational reformer, and Rousseau, the French essayist and philosopher, used visual materials to a great extent in their teachings. They advocated the return-to-nature doctrine, that life might be learned by living it. Thus, a study of the thing itself has become the basis of modern laboratory work and field trips. These are other forms of visual education.

In the 19th century Froebel, the German educator and originator of the kindergarten system, stressed particularly those forms of instruction which used sight and touch. Meanwhile the invention of the photograph and photo-engraving processes have made possible the illustration of magazines, newspapers, and books on a scale undreamed of heretofore. And out of the photograph have come the stereograph, the slide, and the motion picture film—additional forms of visual aids.

During the present century changes have come about in the United States which are greatly affecting educational procedures. Public schools and colleges are crowded with boys and girls with a wide range of native interests and abilities. Faced with large classes of pupils of mixed interests and abilities, teachers too frequently have followed the line of least resistance—the use of the text-book without the use of many other approaches to learning.

The effect of this lack of use of visual material has been very marked. In his book, *Modern Methods in High School Teaching*, Professor Douglass says, "Lessons are run through by teachers as if the mere speaking of words were bound to stimulate accurate and vivid images, or even worse, as if imagery were not of prime importance in learning. It would seem as if the objective of many teachers is the reciting of words which answer questions correctly, with little regard to whether or not the pupil has any adequate understanding of the words recited."

This evil of the classroom recitation is deep-seated and far-reaching in its effect on American school life. Educational reformers of the 20th century, led by Professor John Dewey, have pointed the way to changes in the plan of school work which are removing this evil

and some of its attendant maladies. To illustrate one of many desirable changes let me present a brief contrast of formal school work with socialized school work.

In formal school work the pupil approaches tasks, memorizes, and recites, indifferent to and ignorant of values. The teacher, interested primarily in subject matter, sets these artificial tasks and too often is considered the foundation-head of all knowledge.

In socialized school work, on the other hand, the teacher, interested primarily in children, guides their natural activities and becomes a student with her pupils. The pupil explores his natural interests, thinks to a purpose, and expresses his thoughts accordingly.

But this change in aim from formal to socialized school work demands revised methods, devices, and materials. It is obvious that visual materials properly selected and used should contribute to the accomplishment of this aim. In order to avoid statements of personal opinion, I have selected quotations from a number of carefully controlled investigations, which show that visual materials are effective aids in teaching.

Dr. Freeman reported in *Visual Education* that "the function of visual aids is determined by the nature and purpose of the instruction. The purpose of instruction at one time is to lay the foundation for thought, reflection, generalization, application. This foundation consists in direct experience with material objects. At another time the purpose is to build upon this foundation the superstructure of thought . . . . The evidence is that pictures are an invaluable means of getting certain kinds of experience of a concrete sort."

Knowlton and Tilton found in the teaching of American history that motion pictures "contributed materially to the gaining and retention of worth-while knowledge, particularly of knowledge of inter-relationships, other than time." In this experiment it was found that motion pictures "produced more pupil participation in classroom discussion," and "caused the pupils who saw them to read voluntarily more supplementary history reading material than did the orally-instructed classes."

Wood and Freeman concluded as a result of the Eastman experiments in teaching geography and science that the motion picture enables "pupils to get clear-cut and correct notions of the physical aspect of the world. This is its immediate function. The material which is to be included in the film should be selected with this in view.

The ultimate purpose of securing a clear-cut, concrete idea, of course, is to promote exactness and soundness in thinking. The material which is presented to the pupil, then, should be that material which is necessary in order to furnish him with this foundation. The selection of material, of course, and the manner and context in which it is presented, must be determined by the ultimate purpose. This does not mean, however, that an attempt should be made to distort the films from their natural purpose and make them into a means of teaching abstractions directly. Mankind has invented an instrument of abstract thought which is vastly superior to the use of objects, or of pictures of objects. This instrument is language. It is not the business of the films to supplant language. It is their business to give the pupils such direct experience as will give language rich and clear-cut meaning."

The presentation of a film gives a group of people, as a necessary start in the process of learning, a common mental content. A classroom film to be a teaching film must be able to marshall pictorial facts, and present them in proper order so that the group as a whole has assembled before it a body of information out of which real knowledge may be gained. With pictures, "talk" is some evidence of knowledge on the part of the pupils. The teacher and every member of the class is able to judge the value of verbal responses, and loses little time in the progress of discussion. In ordinary classroom practice so much time is wasted in the interpretation of symbols, in collecting and agreeing upon facts that little time is left for the development of the lesson. Motion pictures shorten the time necessary for presentation of essential facts. The time thus salvaged may be used in that most important aspect of teaching, assimilation or integration of the facts through discussion in a socialized recitation. It is from this assimilation of new experiences with old experiences that knowledge grows. So much time is spent in collecting the lumber and building the scaffold of the building that little time is left to work on the building itself.

In conclusion: Films should be used for definite teaching purposes; films furnish concrete experiences of a total situation in place of inadequate and partial imagery; films furnish an objective basis for verbal symbols; films equip a group with a common body of experience held in forefront of attention; films bring school more closely in touch with current community life by bridging the gap which exists between the school and the world; films give an interest in a

new topic and an encouraging start through the use of interesting and vivid material; films are effective aids in summarizing a given topic or phase of work.

Teachers should prepare for the presentation of a film by a careful preview and the preparation of an appropriate lesson plan. Pupils should be given a definite assignment in advance of a film showing. Presentation of a film lesson should be followed by a period of discussion in which the new elements of learning are integrated into the old.

DISCUSSION

PRESIDENT CRABTREE: What are your thoughts on the use of sound pictures for educational purposes?

MR. BAER: What the possibilities are for sound pictures we do not know. Experience has already shown what can be done with the silent picture.

PRESIDENT CRABTREE: We are interested in this, of course, from an economic standpoint. Have you any hopes that in the future, schools will be able to get the necessary appropriations for this form of education?

MR. BAER: If you refer to sound equipment, I cannot answer your question, as we have had no experience in that direction. If your question refers to the comparatively cheap silent equipment, this depends on whether educational directors become sufficiently aware of the ultimate economies in learning that result from the use of concrete materials to demand a proper place for films in the school budget. We are very hopeful, as things are developing, that the use of motion pictures will become more general as time goes on. Schools quite generally are purchasing 16 mm. projectors as standard classroom equipment.

PRESIDENT CRABTREE: Would schools prefer to buy or rent the films?

MR. BAER: As a practical school man, I would prefer to have the films in a form and place where they could be used as readily as a supplementary text-book might be used. To assure such convenience, ownership of films by a board of education is necessary. Otherwise, films may be used indifferently.

Eastman Teaching Films, Inc., has been marketing its product only a little over two years. The sales the first year were all that the company anticipated, and were much greater the second year. The experience thus far justifies the belief that the film has a permanent place in classroom aids. There is a developing sentiment among teachers indicating the general use of films in the schools of the country.

MR. ROSENBERGER: Are films made for use in medical education?

MR. BAER: Eastman Teaching Films, Inc., has a series of medical pictures for professional use, which may be either purchased or rented. The pictures shown this evening were on 16 mm. film, prepared as instructional aids for classroom use under the supervision of a teacher. They are samples from our growing library. In our classroom series we have about 150 subjects classified roughly under the headings geography, health, science, and nature.

MR. ROSENBERGER: What is the life of the 16 mm. film made on safety stock as compared to the ordinary 35 mm. film?

PRESIDENT CRABTREE: If the film is stored in a fairly moist atmosphere having a relative humidity about 70 per cent, its life is of the order of several hundred runs. If it is stored in a dry atmosphere, it will tend to become brittle, and the life will be reduced considerably. If the film has become dry and brittle, it should be reconditioned by re-humidifying, whereupon its good wearing qualities will be restored. The projection life depends also upon the mechanical condition of the projector.

CHAIRMAN PALMER: Are teachers receptive or antagonistic toward films?

MR. BAER: Experience indicates that teachers are very receptive to the use of motion pictures as a tool of instruction in the classroom.

MR. SHEA: Would you care to say anything regarding the pedagogical limitations of films? I viewed these pictures as an adult, and from the point-of-view of one not too familiar with the teaching of children.

Consider the possible incompleteness of ideas represented symbolically in cartoon form; the possibly distractive character of much that is in a motion picture which does not concern the central idea but which is necessary to reality; the rapid change from one idea to another in the picture.

MR. BAER: Visual aids, motion pictures or otherwise, are *aids* to instruction, elements in a teaching procedure which looks toward the integration of concrete ideas into a form called knowledge. It is therefore presumed that before the picture has been shown there have been certain preliminary stages of instruction and that the presentation of the film is but one step in the entire process. It is necessary to move rapidly from one scene to another in order to bring the necessary amount of concrete material to the pupil's attention.

However, it is the duty of the scenario writer and the film editor to so set up scenes and situations that the flow of pictures is progressive. Occasionally a title is inserted to direct attention, and sometimes an observation-directing device, such as an arrow. After a picture has been presented to a class, it usually happens that about as many questions have been raised as have been answered. Pedagogically, this is a good thing.

To what extent thought-provoking situations should be raised is a matter which requires study; that is part of the art of teaching. In an artfully constructed film each step will be built sufficiently high that proper mental effort will be required to surmount it.

MR. SHEA: That rather confirms the thought that motion pictures, instead of replacing the teacher to any extent, demand at least as intelligent a type of teacher as we have had in the past.

MR. BAER: May I say, more so. She has to learn how to handle a new tool; however, the outcome of the instruction will be much more satisfying after that effort has been expended. The children, as has been proved by repeated experiments, get more out of it and put more into it.

MR. BEGGS: Is the classroom in darkness when the pictures are projected?

MR. BAER: The room should be as dark as is conveniently possible. This applies in general to all projection. Without an adequately darkened room, some of the action shown on the screen may be obscured by direct light falling upon the screen. Common forms of opaque window shades are quite satisfactory, and are simple and inexpensive.

MR. BEGGS: We occasionally ask about this, and seem to feel that it would

be better if the pictures could be shown under normal room-lighting conditions.

MR. NIXON: Some educators favor still pictures, which do not require as much illumination as do motion pictures. It is common practice to project still pictures with merely a subdued light. The question of discipline has also been discussed; however, if the teacher presents the subject matter in an interesting manner, this may be an item of only minor importance.

MR. BAER: I have as yet seen no case of discipline arise where films were systematically used in the regular classroom. It is my impression that when children are looking at motion pictures they become a part of the action on the screen; they put themselves right into it. This is especially true where the human element in the picture is prominent.

MR. ROSENBERGER: Are the films supplied by the Eastman Teaching Films, Inc., accompanied by a manual for the teacher?

MR. BAER: There is included with each film, a teacher's guide or manual which contains a summary of the research that the scenario writer has compiled in working up the contents of the picture, both scene by scene and on the subject as a whole. It includes suggestions for reorganization review, called problems, and selected references for teachers.

MR. WHITMORE: What is the average number of titles in these films?

MR. BAER: *Energy from Sunlight*, which you have seen, contains twenty-one titles, in which a total of 128 words are used. This film has more titles than most of our pictures. The tendency is to reduce the number of titles or subtitles to the smallest number that is consistent with the need for thought-directing statements. *Food and Growth* was for the younger grade school children, *Energy from Sunlight* was for children in junior high school, and *Induced Currents* was for the upper junior high school and senior high school.

MR. WHITMORE: Where do you find the best field for these films?

MR. BAER: The large city schools have the most complete programs of visual education, and have directors of visual education and plans for supervision and distribution of films. Perhaps as good an example as any is Pittsburgh. However, considering the total sales, it is surprising to what extent the smaller schools contribute.

Sometimes the most wide-awake executives are in the smaller places. But in the larger places, where there are worked-out plans and policies, appropriations have been set aside for films. Of course, big programs usually mean big sales.

MR. SATTLER: Are the subjects usually complete in one reel?

MR. BAER: Almost without exception. Each subject is so divided that it is not necessary to present the whole reel. It may be presented section by section at appropriate times. For instance, *Energy from Sunlight* might be split up into the different sections, *viz.*, heat, water-power, wind-power; the picture is frequently presented this way.

MR. SATTLER: Might not a school have two machines to permit changing from one subject to another?

MR. BAER: That would not be necessary in a schoolroom. One reel, fifteen minutes of motion pictures, should be ample for several periods of study and discussion.

CHAIRMAN PALMER: Is it not possible that the picture could be made more interesting if the titles were given with sound instead of having the children read

them; this would not spoil the continuity. Furthermore, the photographic quality seems to be quite an important matter. The children should be shown pictures of only the highest photographic quality.

PRESIDENT CRABTREE: These pictures were made not only by the cameramen hired by Eastman Teaching Films, Inc., but by cameramen in all parts of the world. They are good and bad in spots. Some of the prints were made from duplicate negatives; this is because it is not always possible to buy the negatives.

Getting back to the economics of the situation, Mr. Eastman is responsible for Eastman Teaching Films. He felt, many years ago, that there was a need for education by means of moving pictures, and laid aside a large sum of money to experiment along these lines. The experiment turned out successfully, and it has now got to the stage where it is necessary to make a business out of it, unless some other philanthropist comes along and supplies the schools with films at a loss. How can we extend the use of these films by the schools so that the utmost benefit can be derived from them? We, as engineers, can do our part by devising apparatus and films that will be cheaper. We should also devise better means of distribution.

MR. MANHEIMER: Is there any real opposition to this method of education? Are any educators opposing the use of motion pictures in schools?

MR. BAER: I know of no opposition; there may be some inertia; you know education moves quite slowly.

MR. WEBB: I believe that titles should be edited by one who is teaching children and who has their viewpoint, and could word the titles in terms which they could understand.

MR. BAER: To which picture are you referring?

MR. WEBB: To *Food and Growth*. The film needs explanation by the teacher, rather than by titles. The titles spoil the continuity.

MR. BAER: I have already stressed the need for active classroom discussion following the presentation of a film. Not uncommonly so many questions develop spontaneously that a repeat showing of the picture is necessary as early as the second day. Eagerness of this sort begets knowledge. The picture referred to was titled by a group of practical teachers. It is worth while for a child to get a vivid impression of how a scientific study of food and growth is carried out. The film shows a type of controlled experiment which fundamentally is so simple that a child under supervision might be able to perform it.

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COMMITTEE ACTIVITIES

PROJECTION SCREENS COMMITTEE

This committee will deal with the optical and acoustical characteristics of screens and will assemble data on screen brightness with a view to making recommendations on a standard of screen brightness for consideration by the Standards Committee. The committee members are as follows:

S. K. Wolf, *Chairman*
D. S. De'Amicis
F. Falge
H. Griffin
A. L. Raven
W. B. Rayton
C. Tuttle
D. F. Whiting
W. F. Little

STUDIO LIGHTING COMMITTEE

The following questionnaire has been circulated by Chairman Palmer to various studios with a view to accumulating data on the various items enumerated.

(1) What is the relative proportion of arc vs. incandescent lamps you are now using?

(2) How many watts of electric current do you use per square foot of floor space in your set lighting?

(3) Please give the name of the person in your organization to whom future questionnaires should be sent.

(4) Do you use photometers or any other light measuring devices on your sets to determine the amount of light?

(5) Have you developed or used any new type of lighting equipment during the past year and if so, give a short description of same, with photographs if possible.

(6) Are you using a. c. for set lighting on sound picture productions?

(7) Are you using any gaseous tube lighting on sets? If so, give a short description of type and manufacture.

(8) What type of lighting do you use for color?

(9) Please specify any new types of wiring devices, switchboards, etc., which you have found useful in studio practice. Photographs of such devices would be of great value.

(10) What lens aperture are you using?

PROJECTION PRACTICE COMMITTEE

The second meeting of this committee was held on February 19th at 8:00 P.M. in New York City. Chairman Rubin read a communication from Mr. Chauncey Greene suggesting that arrangements be made to close off the balcony when not occupied in order to avoid excessive reverberation from the ceiling and upper walls of the theater auditorium. This matter was referred to the Subcommittee on Control of Sound.

Mr. Greene also suggested that a standard floor-plate for the base of projector machines be designed which would eliminate shimming and the trouble involved in changing equipment. This was referred to the Subcommittee on Improvements in Projector Design.

Mr. Santee submitted a comprehensive report dealing with the control of sound. Mr. Richardson objected to that portion of the report which dealt with the employment of a sound observer in the theater auditorium. He stated that since an observer is on duty only during the running of pictures he might be assigned other duties to earn his salary.

Mr. Edwards recommended the installation of microphones in the auditorium which would be connected with loud speakers in the projection room and serve as a guide for the projectionist.

Mr. Richardson considered that fader control from the audience was the most practical plan if the man working the control knows his business. Mr. Isaacs pointed out that practically every producer is now equalizing the volume level in the print so that volume control is not as pressing a problem as formerly.

Mr. Edwards suggested the use of a directional horn in the projection booth to focus the sound to the position where the projectionist is normally working. He also suggested that projection rooms be treated with acoustic material. The chairman referred this suggestion to the Projection Room Planning Committee.

Mr. Hopkins reported that the Subcommittee on Progress in Projector Design and Accessories had discussed the difficulties involved with the present-day projectors such as inaccessibility, scratching of the film, and leakage of oil. The chairman suggested that this report be circulated to manufacturers of the equipment for their consideration.

The secretary read a communication from President Crabtree suggesting that the committee consider the new regulations for the

storage and handling of nitrocellulose motion picture film recommended by the National Fire Prevention Association. Mr. Richardson considered that many of the recommendations regarding projection rooms are somewhat antiquated, and Chairman Rubin referred the matter to the Subcommittee on Projection Room Layout and Planning. Chairman Rubin brought up the matter of variations in carbon cores, and after discussion it was agreed that a letter should be written to the manufacturers of carbons, drawing their attention to this condition.

Mr. Hopkins pointed out that in the matter of ventilation of the projection room there should be an individual fan for the ventilation of the lamp-house and an individual fan for the projection room proper, which would cause a positive pressure of air from the auditorium.

Chairman Rubin also suggested that the rewinding room be located near or directly behind the projector so that the projectionist would not have to pass by other equipment in order to obtain film, thereby reducing fire hazard.

INTER-SOCIETY COMMITTEE ON COLOR SPECIFICATION

At the request of the president of the Optical Society of America President Crabtree has nominated Dr. H. W. Moyse of the DuPont-Pathé Film Manufacturing Corp. and Mr. R. Evans of the Fox Film Corporation to act as delegates of the Society to the conferences on the organization of an inter-society committee on color specification sponsored by the Optical Society of America.

ABSTRACTS

"Economy Film" Ready. *Mot. Pict. Daily*, **29**, Feb. 5, 1931, p. 1. An announcement of a new panchromatic negative film requiring one-third to one-half the exposure necessary for the previous panchromatic negative stock. The red and green sensitiveness of the new emulsion adapts it particularly for use with incandescent illumination. Greater depth of focus is claimed for negatives exposed on the film than on previous emulsions, since lenses may be diaphragmed down more. The emulsion is especially adapted to natural color photography where lighting problems have always been difficult. G. E. M.

Development in Color Photography. G. Grote. *Phot. Kor.*, **66**, July, 1930, pp. 177–81. A résumé of color photography patents, mostly for the year 1929, classified as follows:

Mosaic and Line Screen Process.—Ruzicka, Brit. Pats. 326,780; 326,764; 326,779. Th. Baker, Brit. Pat. 324,043 (1929). Bialon, Brit. Pat. 326,287; French Pat. 668,382 (1929). Busch-Larsen, Brit. Pat. 316,277 (1929). Zellr, Haring, and Piller, D.R.P. 493,064. Zimmermann, U. S. Pat. 1,746,330. Pal, D.R.P. 224,701. Dufay, D.R.P. 487,365. Ruzicka, Brit. Pat. 326,781 (1929). Chapman, Brit. Pat. 327,200 (1929).

Lenticular Film Process.—Soc. Franç. Cinematographique, Swiss Pats. 135,767; 135,765; Brit. Pat. 307,351 (1929). D.R.P. 492,207; D.R.P. 497,560. Soc. Civ. pour l'Étude de la Phot. et de la Cin. en couleurs, French Pat. 667,332: Brit. Pat. 309,540 (1929). Soc. Franç. Keller-Dorian, Brit. Pat. 298,951 (1929).

Motion Picture Processes by Additive Projection.—Emil Busch A.-G., D.R.P. 493,644. Alstrup and Jensen, D.R.P. 495,686. Nordmann, French Pat. 666,854. Dornig, D.R.P. 494,753. Cox, *Kinotechnik*, 1930, p. 201; D.R.P. 498,709. Rilny, Brit. Pat. 323,760 (1929).

Subtractive Print Processes.—Becker, Oliver, and Colour Phot., Ltd., Brit. Pats. 317,909; 317,911; 323,800 (1929); French Pats. 673,816; 675,550. Martinez, Brit. Pat. 280,252 (1929); French Pat. 634,074. Lierg, Brit. Pat. 298,979 (1929).

Tri-Packs.—Th. Baker, Brit. Pat. 324,394 (1929).

Direct Subtractive Process.—Martinez, Brit. Pat. 310,533 (1929).

Three- and Four-Color Subtractive Motion Picture Processes.—O. and A. Pilny, Swiss Pat. 136,573. Kelley, U. S. P. 1,753,379. M. W. S.

U. S. Sound Installation Survey. *Mot. Pict. Herald*, **102**, Feb. 7, 1931, p. 13. Of the 28,826 theaters reported in text-books, 17,899, or only 62 per cent, were actually found to exist. There were 11,553 theaters, or 65 per cent, equipped for sound pictures. Fifty per cent of the 6346 silent houses were closed. The location of theaters having sound installations was reported as follows: Eastern U. S. (20 states, including D. of C.), 4605 installations; Central U. S. (17 states), 5409; Western U. S. (11 states), 1533. (Presumably the survey was completed about Jan. 1, 1931.—Abstractor.) G. E. M.

Schools Using Non-Theatrical Films. *Mot. Pict. Herald*, **102**, Feb. 7, 1931,

p. 45. Forty per cent of the 44,186 motion pictures screened during 1930 in 517 primary and secondary schools in the United States dealt with social science subjects. Sound equipment was unavailable in the majority of the schools. Natural science material was next in popularity and combined with social science represented 66 per cent of the showings. Twenty-five per cent of the remaining subjects were represented by physical education, manual and industrial arts, home economics, English, and commercial. The data were assembled by E. I. Way, Chief of the Industrial and Educational Section, U. S. Dept. of Commerce.

G. E. M.

A Revolutionary Illuminant. *Bioscope* (*Modern Cinema Technique*), **85,** Dec. 3, 1930, p. ix. A photoflash bulb fitted with a reflector provides the still cameraman with a convenient, smokeless, and silent flashlight for photographing sets and action in a studio during the progress of actual shooting. The bulb and reflector attached to a small battery are mounted on top of a press camera so that the shutter operates the flash as well. The flash lasts only $^1/_{75}$th of a second and is said to be unrecognizable by the eye. Where it is both difficult and expensive to transport and erect generating equipment, scenes may be illuminated by setting off one lamp per frame. This is stated, on test, to work out for one-third the cost of motor generator transportation. G. E. M.

Dynamic Reproducers in the Theater Sound System. H. G. CISIN. *Mot. Pict. Herald,* **102,** Sect. 2, Jan. 17, 1931, pp. 47–8. The dynamic coil type of speaker is considered to be most applicable to theater use. A detailed description is given of the two types of dynamic speakers: (1) cone-type; and (2) horn-type. Although it is usually conceded to be more difficult to install a cone-type speaker, the effort is well paid for by the superior results as high and low notes are stated to be reproduced better by this type of speaker. A horn is sometimes used in certain theaters in conjunction with a cone-type speaker. Tests are described for sound equipment installations in theaters. G. E. M.

Methods of Determining the Filter Factor. K. CHIBISSOFF AND A. MICHAILOWA. *Kinotechnik,* **12,** Nov. 20, 1930, pp. 595–601. A comparison is made of the sensitometric methods of determining filter factors from the shifting of three critical points of the H. & D. curves along the exposure axis:

(1) The threshold value;
(2) The point of least useful gradient;
(3) The inertia point.

Agfa orthochromatic and panchromatic emulsions were employed, and the factors of the following filters determined: Zeiss "Color a" and "Color b;" Wratten Nos. 6 (K_1), 8 (K_2), 9 (K_3), 21, and 26. A tungsten filament lamp was used as a light source through a filter converting the color temperature to 5000°K. The determinations of change in threshold value were made with an Eder-Hecht wedge, the other determinations with an H. & D. sensitometer with a shutter of 80 rpm. Development was at a constant temperature of 15°C. in trays by the brush method, and was carried to a gamma of unity. Both metol-hydroquinone and para-aminophenol developers were used. By comparison of the results of the three methods of determining factors, the following conclusions are drawn:

(1) In determining filter factors from the shift in threshold value, the results are affected only slightly by variation in the intensity of the light source.

(2) The ratio of the filter factors determined from the point of least useful

gradient and from the inertia point is practically constant for the different filters. This means that the useful portion of the underexposure region of the H. & D. curve is not very different in form for different spectral composition of the light source.

(3) Filter factors determined from the threshold value are lower than those determined from the point of least useful gradient, which are, in turn, lower than those determined from inertia point.

(4) The ratio of the filter factors determined from the point of least useful gradient and from the threshold value is not a constant for different filters. This means that the non-useful portion of the underexposure region varies with the wave-length. Changing from a yellow to a redder filter causes this portion to become longer.

(5) The rate of renewal of the developer at the surface of the emulsion influences the value of the filter factor determined from the point of least useful gradient and from the inertia point.

(6) Filter factors determined with para-aminophenol were greater than those determined with metol-hydroquinone.

(7) For photography and motion picture photography, the determination of the filter factor from the point of least useful gradient is the method of most practical importance. M. W. S.

An Investigation of the Need for Objectives of Large Diameter in Motion Picture Projectors. F. HAUSER AND L. MOHR. *Kinotechnik*, **12**, Sept. 5, 1930, pp. 463–8. The light beams of various optical systems of a motion picture projector have been photographed and light losses demonstrated. The beams were made visible by smoke. A mirror arc with a "Busch-Neospiegel" mirror of 250 mm. diameter and 140 mm. focus was used to illumine a model of the film aperture. The distance from the center of the mirror to the plane of the film was 650 mm. A 25 ampere current was used. The objective focused the aperture on a distant screen. The arc was adjusted to give as nearly a uniform screen as possible. (Presumably, the crater was focused approximately in the plane of the apertures.) The beam of light issuing from the aperture was fairly divergent. Using several "Neokino-Objectiv" lenses of different focal lengths and diameters, the author finds that to utilize all of this cone of light, an objective of 140 mm. focus must have a diameter of 82.5 mm., and an objective of 185 mm. focus must have diameters of 82.5 and 104 mm. for the rear and front elements, respectively. It is concluded that the relative aperture of the projector objective must be greater than that of the mirror, defined by the ratio of the diameter of the mirror to the distance of the center from the film aperture.

By means of a metal plate containing two 2 mm. holes, placed in the gate, the form of the beams through the center and the corner of the film aperture were photographed for different illuminating systems. With a condenser arc, a slender beam was found to emerge from the center of the aperture, but a divergent beam from the corner. With such illumination used with objectives not corrected for divergent beams, the author believes that the sharpness at the edges of the picture must suffer. With a 170 mm. spherical mirror, and a 250 mm. "Neospiegel," the beams from the center and corner were found to be about equally divergent.

M. W. S.

Arc Silencing Apparatus. *Kinotechnik*, **12**, Sept. 5, 1930, p. 484. Choke

coils for silencing arc lamps in taking sound pictures are supplied by a German firm in 25, 40, and 150 ampere models. The two smaller sizes, weighing 15 and 30 kilograms (about 33 and 66 pounds), respectively, are mounted on wood bases and fitted with handles for carrying, while the larger size, weighing 90 kilograms (about 198 pounds), is mounted on rubber tired wheels. M. W. S.

Cinema and Visual Fatigue. *Intern. Rev. Educational Cinemat.*, **2**, Dec., 1931, pp. 1379–94. The result of an inquiry by questionnaire among 25,000 Italian school children and also of one among eye specialists showed that 28.6 per cent of the children normally experience visual fatigue after a motion picture show, and 4.4 per cent occasionally do. The percentage of eye-strain is higher for children under twelve. Good projection conditions with unworn films should cause no undue strain for normal eyesight. The duration of a cinema show is too long for children's eyes. Schoolroom films are probably too short to be harmful. Titles are particularly bad if the lettering is different or the background too light. R. P. L.

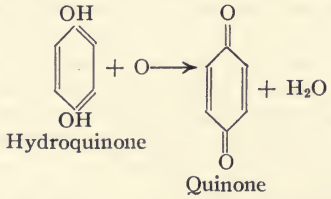
The Studios of France. FERNAND VINCENT. *Cinemat. Franç.*, **13**, Dec. 27, 1930, p. 141. A detailed account of eleven French studios together with the nature of the equipment employed. The number of studios using the various types of sound recording equipment are as follows:

RCA Photophone	3
Western Electric	2
Gaumont-Petersen-Poulsen	3
Tobis-Klang Film	2
Radio-Cinema	1

J. I. C.

The Role of Sulfite in Photographic Developers. J. RZYMKOWSKI. *Camera* (Luzerne), **9**, Nov., 1930, pp. 128–32; Dec., 1930, pp. 164–7. The preservative action of sulfite in photographic developers is due, not to a preferential oxidation of the sulfite by the oxygen of the air to the exclusion of the hydroquinone, but to a series of reactions in which both hydroquinone and sulfite take part. Upon the basis of evidence from the literature, and from original experimental work, the author constructs the theory that these reactions are the following:

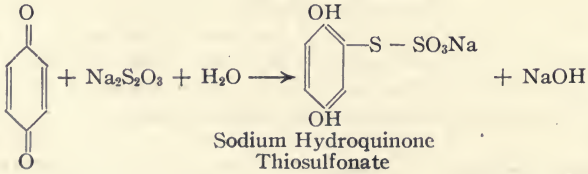
(1)



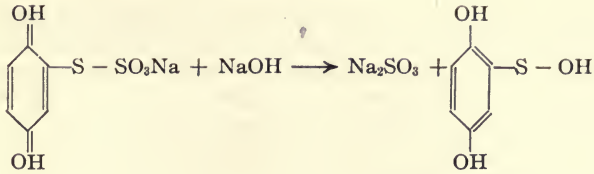
(2) $3Na_2SO_3 + H_2O \longrightarrow 2Na_2SO_4 + S + 2NaOH$

(3) $S + Na_2SO_3 \rightleftharpoons Na_2S_2O_3$

(4)

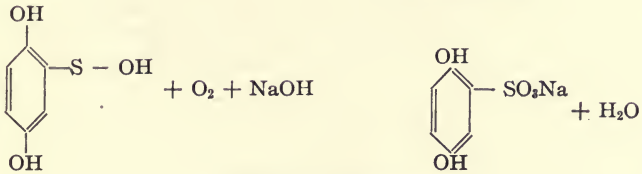


(5)



Hydroquinone
Thiohydroperoxide

(6)



Sodium Hydroquinone
Monosulfonate

The sodium hydroquinone thiosulfonate, formed in eq. (4), is believed to be the hydroquinone-sulfite complex previously assumed by Mees and Piper (*Brit. J. Phot.*, 1912, pp. 441–3) to explain the fogging action and minimal electrical conductivity of hydroquinone developers with a deficiency of sulfite. By assuming that the monosulfonate undergoes the above series of reactions like the hydroquinone itself, an explanation is advanced for the formation of sodium hydroquinone disulfonate, found in thoroughly oxidized developers. M. W. S.

The Reproduction of Negatives. PAUL HANNEKE. *Camera* (Luzerne), **9**, Dec., 1930, pp. 155–7. A novel method of making a duplicate negative consists in bathing a silver bromide film or plate in a 4 per cent solution of potassium bichromate by subdued light, drying, and exposing under the negative to be copied until a faint brown positive image is visible. The print is then washed and finally developed by ordinary light in a regular photographic developer. The portions unexposed in the printing process develop most fully. A duplicate negative is thus obtained. The contrast can be altered by varying the printing exposure or by giving a subsequent flash exposure. M. W. S.

Automatic Rewind. *Film Daily*, **55**, Feb. 1, 1931, p. 7. A motor-driven automatic rewind, designed for the efficient handling of sound film and said to accommodate up to 3000 feet of film and any make of reel, is described briefly. The inside circumference of the magazine is said to be lined with sound absorbing felt, which prevents noise and danger to film ends from abrasion and slapping. Adjustable friction for any desired tension is provided through accurately machined automobile type brakes, asbestos lined. C. H. S.

Projector Attachment Eliminates Distortion and Eyestrain. *Film. Daily*, **55**, Feb. 15, 1931, p. 9. An optical system which can be attached to an ordinary projector, and with which, it is claimed, eye-strain and distortion is eliminated, has been demonstrated in England. The attachment consists of a blue screen through which the picture is projected, while at the same time another image of the same picture is superimposed after it has been reflected from a gold mirror. C. H. S.

The Cataloging of Cinema Films. J. HANAUER. *Intern. Rev. Educational*

Cinemat., **2**, Nov., 1930, p. 1271. An international uniform system independent of language or alphabets should be established, with a complete file at international headquarters at Rome. Recommends and discusses the Dewey decimal system for the purpose and gives examples. R. P. L.

When Industry Calls on 16 Mm. R. FAWN MITCHELL AND M. W. LARUE. *International Photographer*, **3**, February, 1931, p. 32. An account of the practical uses found for 16 mm. cameras in industry. In time and motion studies of manufacturing operations a film record of the entire process, synchronized with the time element, is of value, both for study of the operation and for the training of employees. The use of the motion picture in research and for the standardization of methods in branch factories is also mentioned, and a table of data on artificial lighting is given. A. A. C.

Study Conducted on Use of Films for Advertising. *Proj. Eng.*, **3**, February, 1931, p. 14; *Amer. Cinematographer*, **11**, February, 1931, p. 36. The Motion Picture Division, Department of Commerce, is making a survey to determine the many uses to which the motion picture is being put in business and the value attending its employment. A questionnaire will be sent to the 2000 concerns in the United States who have used the motion picture for business purposes. From this experience record much helpful information is expected on the production, distribution, and effective use of films in different branches of business. A. A. C.

Testing Equipment for Sound Projection. E. W. D'ARCY. *Proj. Eng.*, **3**, February, 1931, p. 11. A testing set has been designed for making a rapid and complete check of theater sound systems. It has facilities for measuring vacuum tube characteristics, continuity of circuits, photoelectric cell operation, phasing of loud speakers, and to test the frequency response of the entire system. A general description of the method of measurement is given. A. A. C.

New Motion Picture Projection Optics. W. B. RAYTON. *Proj. Eng.*, **3**, February, 1931, p. 20. The introduction of sound created a demand for more light on the theater screen. To meet this condition new projection and condensing lenses have been developed by the Bausch & Lomb Optical Company. The projection lenses are anastigmats, and the first part of the paper is an explanation of what this means and why such correction is necessary to secure a sharp picture over the entire area of the screen. The condenser lenses, of patented construction, are also described in some detail. They are said to give 50 to 100 per cent more light than ordinary spherical condensers. A. A. C.

Pick-Up Possibilities. S. MCCLATCHIE. *Proj. Eng.*, **3**, March, 1931, p. 7. There has been little development in electromagnetic pick-up design since 1925, when the first commercial outfit appeared, based on the earlier work of Baldwin and Capps. The frequency characteristics of the present product in relation to the limits imposed by the record itself are discussed and comparison is made between American pick-ups and the types in use in England and Germany. The author concludes that armature resonance can be eliminated by locating the resonance peak beyond the musical range, thus eliminating the need for damping and making the characteristic curve a straight line throughout the musical range. A. A. C.

Surgery in Moving Pictures. RICHARD B. STOUT, M.D. *Proj. Eng.*, **3**, March, 1931, p. 9; *International Photographer*, **3**, February, 1931, p. 35. A

solution is offered for some of the problems of photography in the operating room. A 16 mm. camera was attached to the regular Operay light above the operating table, and remote control devices were used for actuating the release button and for rewinding. The surgeon or his assistant may act as cameraman and take only the important steps in the operation. Good results were obtained in black and white at $f/4.5$ with ordinary lights, but for Kodacolor pictures more light was needed and eight small automobile spotlights were fitted up as auxiliary illumination. A. A. C.

Camera Noise Silencing Blimps. GORDON S. MITCHELL. *Proj. Eng.*, **3**, March, 1931, p. 10. A story of camera silencing devices from the booths and blankets used in early days to the latest blimp made at the Pathé Studios by L. E. Clarke (see this JOURNAL, **15**, Aug., 1930, p. 165). The difficulties attending the use of the earlier make-shift devices led to the Pathé design, a description of which is given in some detail. The usefulness of this type of sound proofing is apparent and will continue until a noiseless camera appears on the market.

A. A. C.

Progress in Sound Recording. CARL DREHER. *Electronics*, March, 1931, p. 542. One of the most important improvements in the sound recording art during the past year has been the introduction of anti-ground noise recording. This was first accomplished with the variable area type of record by biasing the recording galvanometer in such a manner that weak signals are recorded near the edge of the track. The resultant reduction in the amount of transparent area produces a proportional decrease in the noise caused by dirt or scratches on the film. This method has the disadvantage that with low modulation the useful portion of the sound track is so close to the edge of the scanning beam that, if the scanning beam is incorrectly located, the signal may not come through at all. This method has been recently improved to permit the recording to be centrally located on the sound track, while the useless transparent portion of the track is masked by means of a movable shutter. The corresponding methods in the variable density type of record are likewise discussed. A decrease in ground noise of about 10 db. is claimed for the method and it is probable that greater reductions are possible.

The paper also discusses recent developments in the use of the microphone and auxiliary apparatus in the studio. It is pointed out that the present tendency is to bring the recordist into closer touch with the director, the first cameraman, and the sound assistants. A. C. H.

Impedance Matching Network. ARTHUR E. THIESSEN. *Electronics*, March, 1931, p. 552. A very simple resistance network called a "taper pad" is described for matching the impedance of two circuits. Although it is common practice to use an impedance-matching transformer for this purpose, the taper pad, which can usually be built up of two decade resistance boxes, is a very useful substitute.

A. C. H.

Reflecting Screens for Relief Picture Projection. *Jour. Opt. Soc. of America*, February, 1931, p. 109. A continuation of an earlier paper (*Jour. Opt. Soc. of America* and *Rev. Sci. Inter.*, **18**, 118, 1929) concerning a method of projecting pictures in relief which depends upon the simultaneous projection of a large number of views from a battery of juxtaposed projectors. In the previous paper, a translucent projection screen was described. In the present paper, a special type of projection screen is described that operates with reflected light. A. C. H.

An Analysis of the Literature concerning the Dependency of Visual Functions upon the Illumination Intensity. LEONARD T. TROLAND. *Trans. Illum. Eng. Soc.*, February, 1931, p. 107. This paper was prepared for the Committee on Industrial Lighting of the National Research Council. The literature concerning the visual functions occurs in such widely separated places that a paper of this type is of immense value. The scope of the eighty-five pages which this paper comprises can be indicated best by giving the table of contents prepared by the author, *viz.:* I. Preface. II. Method and scope of literature search. III. Abstract of the literature bearing on the dependency of visual functions upon intensity of the stimulus: (1) General survey of the problem. (2) Absolute sensitivity to light; references on absolute energy and brightness threshold; references on areal relations of the threshold; references on light and dark adaptation. (3) Fechner's law: discrimination of reflection coefficients of large areas; references on brightness discrimination threshold. (4) Dependency of visual acuity upon illumination intensity; references on visual acuity, general; references on visual acuity as a function of intensity; references on glare. (5) Speed of vision as determined by intensity; references on speed of vision. (6) The dependency of color vision upon intensity; references on color and intensity. (7) Oculomotor functions, eye-strain, fatigue, and injury; references on the pupil and other oculomotor functions; references on eye-strain and fatigue; references on injury to the eye due to light. (8) The influence of illumination intensity upon practical operations; references on illumination intensity and practical operations; miscellaneous references. (9) Summary and conclusion.

ABSTRACTS OF RECENT U. S. PATENTS

17,876 (Reissue). **Multiple Sound Records on Single Film.** F. H. Owens. November 18, 1930. Sound reproducing means employing a film having a multiplicity of sound records arranged side by side longitudinally of the film and a slit extending laterally of the film in a strip covering the entire width of all of the sound records on the film. The strip provides a mask for all of the sound records on the film except the sound record with which the slit is aligned. The strip may be shifted in order to render one sound channel effective to the exclusion of the other sound channels.

1,781,799. **Television System Employing Non-Visible Illumination.** John L. Baird. Assigned to Television, Limited. November 18, 1930. A system of television wherein rays of non-visible frequencies are directed against an object and a light-sensitive device sensitive to such rays arranged adjacent the object for producing a modulated electric current. A scanning disk is disposed between the object and the light-sensitive device. A source of illumination is coupled with the light-sensitive device and acts in response to the impulses transmitted by the light-sensitive device. There is an exploring means disposed adjacent the source of illumination and forms an integral part of the scanning disk. The system provides means for seeing an object in darkness, in which case the invention comprises the combination with an object from which non-visible radiation is emitted or reflected, of a device that is sensitive to such radiation and correspondingly therewith controls an electric current, an exploring mechanism whereby said device explores the object or an image thereof, and a receiving apparatus comprising a luminous source of light controlled by the said device whereby a visible image of the object is provided.

1,781,866. **Speed Indicator and Variable Synchronizer.** R. H. Bahney. Assigned one-half to Hurxthal F. Frease. November 18, 1930. A scanning disk having formed therein a set of scanning apertures and a set of one or more speed and synchronizing apertures. A television tube is arranged to be traversed by the scanning apertures and a periodically illuminated and extinguished light is arranged to be traversed by the set of signaling apertures. Separate circuits are controlled by the scanning device adjacent the signaling apertures and adjacent the synchronizing apertures.

1,784,858. **Sound System Employing Film Markings for Gain Control.** Edward C. Wente. Assigned to Bell Telephone Laboratories, Inc. December 16, 1930. Sound recording system in which a film record is moved with relation to a recording lamp and with respect to a series of marking lamps adapted to place predetermined marks upon the film. A pick-up device is located at a distance from the source of sound for translating the sound into variable current, operating a recording circuit. A second pick-up device is located near the source of sound

and connected with the recording circuit for varying the gain in the recording circuit and marking the film in accordance with the gain variation by energizing the marking lamps. In reproducing sound from the film, the reproducer is provided with a relay-operated potentiometer for introducing in the reproducer circuit proper amounts of gain to compensate for the losses occurring in the recording potentiometer. The relays of this potentiometer are controlled by contact devices operating through perforations in the film where the markings occur or by light-sensitive cells responsive to the variations of light beams caused by the film markings when the beams are projected through the film.

1,785,262. **Duplex Scanning Disk.** C. F. JENKINS. Assigned to Jenkins Laboratories. December 16, 1930. A spot scanning system employing a rotatable scanning disk common to both spot illumination and spot cell pick-up. Light is passed through the scanning disk, the disk having apertures in alignment with the scanning elements of the scanning disk. As the light passes through both scanning disks, the light is rendered effective upon a light-sensitive cell. Both the incident and the reflected light passes through the same scanning disk thereby improving the efficiency of illumination while keeping the moving spot centered on the light cell. In the apparatus employed by the patentee a large apertured scanning member is disposed between the light source and the object to be scanned and a small apertured scanning member is disposed between the first scanning member and the light-sensitive device.

1,786,652. **Dual Electro-Optical Scanning System for Television.** RALPH V. L. HARTLEY. Assigned to Bell Telephone Laboratories, Inc. December 30, 1930. A television system wherein an image is produced by successively scanning groups of elemental areas of a field of view, an image of which is to be reproduced. Each group comprises two separate elemental areas which are scanned simultaneously. A light-sensitive device is actuated by the dual scanning system for producing a single photoelectric current having a component corresponding to the tone values of each of the simultaneously scanned elemental areas.

1,787,824. **Tinting Picture Areas and Marking Sound Record of Motion Picture Film.** JOHN G. JONES. Assigned to Eastman Kodak Company. January 6, 1931. A motion picture film where the picture areas of the film are tinted while preserving the sound record area thereof untinted. The film is advanced over a tinting roller with a flexible stencil partially wrapped about the roller to mask the sound record area of the film. The tint is applied to the stencil as well as to the picture areas of the film but the position of the stencil between the tinting roller and the film precludes the tint from reaching the sound channel portion of the film.

1,787,825. **Motion Picture Film Marked to Designate Untinted Sound Record.** LOYD A. JONES. Assigned to Eastman Kodak Company. January 6, 1931. A photographic film which is provided with a series of motion picture exposure areas and an untinted sound record area. The photographic film is tinted over the picture areas but is untinted over the sound recording area as the tinting interferes with the sound record. The tinted film when used in a dark room illuminated with the usual orange and red light has such an appearance that it is difficult to determine the location of the untinted sound track on the film. A designating line is therefore provided adjacent that edge of the film

which bears the untinted sound record to enable the operator to immediately locate the untinted sound record on the film.

1,787,919. **Sound and Picture Recorded on Disk.** ARTHUR H. WATSON. January 6, 1931. Sound and picture impulses are recorded on the same disk record. The visual impressions are translated into a visible picture and the sound impressions are translated into sound. Synchronizing impulses are also provided on the record for producing a predetermined relationship between the picture and sound. The apparatus resembles a phonograph structure including the usual turntable for receiving a disk record. The synchronizing impulses are recorded in a peripheral groove while the sound impulses are recorded on the record concentrically within the picture impulses which are recorded between the peripheral synchronizing groove and the sound impulses adjacent the center of the record.

1,787,920. **Scanning Device for Television System.** ARTHUR H. WATSON. January 6, 1931. A scanning device for television systems where a plurality of reflecting surfaces are mounted upon a rotatable support, the surfaces representing a portion of a single sphere. The surfaces are shifted out of the sphere so that each surface is disposed at a different angle from the other surfaces. The reflecting surfaces are produced by simultaneously forming concave surfaces upon a plurality of reflecting elements, each comprising a sector of an annular portion of the spherical surface. The fundamental feature of the invention herein may be summarized as a structure comprising a scanning disk presenting a plurality of separate concave reflectors, each constituting a separate optical element which constitutes a single plate ground with uniform concave curvature throughout and sub-portions thereof moved out of their normal planes to comprise an operative scanning disk.

1,787,921. **Television Apparatus for Scanning Straight or Curved Lines.** ARTHUR H. WATSON. January 6, 1931. A scanning mechanism for a television system which is capable of producing both straight line and curved line pictures at will. The scanning mechanism may be changed in position for the transmission and reception of straight line or curved line pictures or vice versa. The scanning mechanism includes a rotatable drum carrying a plurality of focusing reflectors, where the reflectors are so arranged as to reflect and focus the concentrated light upon a screen along axes substantially radial to the axis of the drum, when the axis of the direct light beams from the light are perpendicular to the plane rotation of the drum. In the operation of this system a line described by the focused light upon the screen when the drum is rotated is substantially straight. The angular position of the rotatable member may be changed in modifying the system for scanning straight or curved lines at will.

1,788,010. **Combined Sound and Color Motion Picture Record.** FRED M. BISHOP. Assigned to Eastman Kodak Company. January 6, 1931. A film strip for the simultaneous reproduction of color motion pictures accompanied by sound where the film comprises a transparent support having upon one surface a photographic layer and having upon the other surface a smooth longitudinally extending area and a longitudinally extending lenticulated area, the lenticulations consisting of convex protuberances having a focal length of the same order of magnitude as the thickness of the film, the portion of the film opposite the smooth area constituting a sound record area and that opposite the lenticulated area con-

stituting a natural color motion picture record area. The protuberances or ridges are preferably of the order of twenty-two per lineal millimeter, but the exact size is dependent in part on the curvature of the protuberances, the thickness of the film and other constants of the optical system of which the film is a part, and the size may vary widely from that mentioned, say, between ten and forty per lineal millimeter; but in all events it is so minute that the focal length of an individual lens approximates, or is of the same order of size as, the thickness of the film. The patentee uses the word "lenticulated" to define such a surface comprising a large number of lens-like elements.

1,790,038. **Automatic Synchronism of Television Apparatus.** PHILIP CHALFIN AND BENJAMIN CHALFIN. January 27, 1931. A method of automatically synchronizing the moving parts of a television receiving apparatus with the moving parts of a television transmitting apparatus. The object is divided into a succession of points of light by means of oscillating elements and directed into a photoelectric cell to cause electric impulses to flow therefrom which vary in intensity in proportion to the lights and shadows of the subject. A synchronizing impulse flows from the photoelectric cell for each oscillation of each oscillating element; the images are transmitted and received and the energy amplified. A beam of light whose intensity is governed by the impulses received is directed into oscillating lenses whose oscillations are controlled by the synchronizing impulses. The light from the lenses is directed upon a screen where the likeness of the object at the transmitter is reassembled due to the oscillations of the lenses. The lenses are mounted in lens holders which oscillate under electromagnetic control for producing the required scanning of the object at the transmitter and the required sweeping of the light beam at the receiver. Synchronizing impulses control the movement of the lens holders thereby insuring synchronized movement of the scanning mechanism at both the transmitter and the receiver.

1,790,736. **Television Transmission Apparatus.** GEORGE WALD. February 3, 1931. A light-sensitive frame is provided that will convert images into amplified electric current impulses that may be transmitted to a receiver for reproduction, by direct reflection of the image on the frame which is equipped with light-sensitive cells, whereby the electric current impulses are controlled by the variation in resistance resulting from the varying degrees of light reflected from the image. The frame at the transmitter is composed of a series of conductors adapted to receive electrical impulses of varying frequency with a plurality of light-sensitive cells connected with the conductors. A second series of conductors is adapted to be excited by impulses of varying frequency. Grid rods are positioned intermediate to the respective light-sensitive cells and the second series of conductors. The circuits including both sets of conductors are brought into resonance for the transmission and reception of television energy.

1,790,898. **Electron Discharge Tube for Transmitting Pictures.** THEODORE W. CASE. Assigned to Case Research Laboratory, Inc. February 3, 1931. An electron discharge tube having a screen directly on the end thereof upon which the picture to be transmitted is focused. The portion of the electron discharge upon which the picture is focused is provided with a photoelectric coating over which the electron stream is adapted to sweep. The electron stream is directed upon the photoelectric coating and is oriented thereover by electro-static elec-

trodes angularly disposed around the path of the electron stream. The electron stream forms a moving pointer which explores every portion of the picture focused on the photoelectric material. The electrons constitute the return electrical connection between the filament and the photoelectric material. The units of this exploring electron finger alternately are rushing toward first an illuminated portion of the photoelectric material, and next toward an unilluminated portion of the photoelectric material. As a result different electrical phenomena will obtain in the completed circuit, due to the negative electrons approaching different potential points on the illuminated photoelectric electrode, and minute electric currents will flow in the complete circuit controlled by the illuminated potassium electrode.

1,791,039. **Film with Multiple Sound Records and Slit Carrier.** FREEMAN H. OWENS. Assigned to Owens Development Corporation. February 3, 1931. Sound reproducing apparatus in which a film having a plurality of sound records carried thereby is employed where the film is movable adjacent a movable slit carrier. The slit carrier is adapted to register a slit thereon with any one of the channels on the film. The slit carrier is automatically actuated to register a selected slit with a selected channel as the film is moved first in one direction and then in the reverse direction in order to provide for continuous sound reproduction.

1,792,259. **Multiple Transmission of Pictures.** WILLIAM A. TOLSON. Assigned to General Electric Company. February 10, 1931. Picture transmission system where a plurality of scanning devices are each arranged for transmitting a different picture with means for similarly framing the pictures. Scanning disks are aligned with optical systems and with separate photoelectric cells for optically scanning different pictures. The several photoelectric cells are connected in parallel and connected to control the modulation of the transmitter. The relationship of the scanning means for each of the different pictures is adjusted by individual control of each of the scanning disks.

1,792,323. **Pick-up Device for Sound Recording.** LEWIS ROBINSON. Assigned to General Electric Company. February 10, 1931. A sound pick-up for talking motion picture recording systems where a mirror is attached to a torsion member. A connection is made between a diaphragm and the torsion member at a point adapted to cause torsional vibration in the torsion member. The torsion member is centered to prevent bodily displacement thereof without restricting the torsional vibration thereof. A high degree of sensitivity is obtained by use of the torsional member in the pick-up device.

1,780,364. **Modified Braun Tube for Electroöptical Transmission.** F. W. REYNOLDS. Assigned to American Telephone and Telegraph Company. November 4, 1930. A Braun tube modified in two principal respects is used at the transmitter for scanning. One modification consists in substituting an auxiliary electrode of thin transparent film platinum or other suitable material for the usual fluorescent screen, thus forming an electrically conducting and light transmitting electrode. A second modification consists in positioning immediately in front of the auxiliary electrode, a specially constructed multiple unit photoelectric element, whose function is to control the density or power of the cathode rays or beam within the tube. A separate stream of photo-electrons is produced for each elementary area of the image. Each stream is confined to a definite path and varies in intensity to the corresponding area of the image.

1,780,572. **Optical Device for Radio Cinematographic Transmitters and Receivers.** LEON THURM. November 4, 1930. A rotatable shutter for controlling the passage of light with respect to a film where the shutter has a series of openings formed therein displaced in position with the rotation of the shutter. A screen is disposed between the shutter and the film and carries a rectangular aperture of a length equal to the double of the corresponding dimension of the aperture in the shutter. At the rear of the film there is placed a photoelectric cell or group of cells which serve to modulate a transmitter under control of the light which is passed through the film.

1,780,681. **Guide Cylinders for Motion Picture Film.** E. W. KELLOGG. Assigned to General Electric Company. November 4, 1930. A freely rotatable cylinder is provided to support the film at the recording or reproducing point. The rotatable cylinder is in turn supported by rotatable members engaging the periphery thereof. These rotatable members have fixed centers so that the rotatable cylinder revolves around the supporting rollers and forms a guiding surface for the film at the recording or reproducing point.

1,781,210. **System for Transmitting Oblong Pictures.** J. L. BAIRD. Assigned to Television, Limited. November 11, 1930. Pictures which are oblong in form may be transmitted and reproduced with either the longer side of the oblong horizontal or vertical. An exploring device is disposed adjacent an opaque screen. The screen is provided with oblong frames at spaced intervals thereon, one of which extends with its longer side in a horizontal direction and the other of which extends with its longer side in a vertical direction. The light-sensitive cell may be operatively related to either of the apertures in the screen for permitting reproduction of the image in a picture having a long side thereof extending in either direction.

1,781,550. **Multiple Sound Records of Restricted Frequency Range.** B. KWARTIN. November 11, 1930. A sound film having a multiplicity of separate sound channels in which music of different frequency characteristics is independently recorded. The separate sound channels having different frequency characteristics may operate loud speakers, each designed for the efficient reproduction of sound over a certain range of frequencies. Each sound channel is selective to different pitch frequency characteristics of particular musical instruments. This eliminates the necessity of attempting to record all frequencies in the same sound channel on the film.

1,781,800. **Light Concentration in Television System.** J. L. BAIRD. Assigned to Television, Limited. November 18, 1930. Light is concentrated upon light-sensitive cells by reflecting surfaces which extend on each side of the path of light from the object to the cells. The reflecting surfaces are disposed adjacent the path of light from the object to the cells and serve to concentrate the light upon the light-sensitive cells, which light might otherwise be scattered laterally from the object.

1,783,031. **Transmission of Pictures.** E. F. W. ALEXANDERSON AND RAY D. KELL. Assigned to General Electric Company. November 25, 1930. A Kerr cell is employed having polarized groups of transparent plates mounted on opposite sides of the cell, the planes of polarization of the two groups being arranged at right angles to each other. A lens scanning disk is located to project light through the plates of the cell. A perforated scanning disk is arranged to receive the light

through the cell and the plates therein for the transmission or reproduction of pictures of comparatively large size.

1,785,070. **Inductive Light Source.** THEODORE W. CASE. Assigned to Case Research Laboratory, Inc. December 16, 1930. A concentrated light source wherein an inductance is mounted within an evacuated bulb and high-frequency currents sustained in the inductance and modulated according to sound wave vibrations for producing changes in light intensity emitted by the inductance within the bulb. A vacuum tube oscillator is employed for impressing energy upon the inductance in the bulb. The bulb is filled with an inert gas such as helium, argon, neon, nitrogen, *etc.*

1,786,812. **Facsimile Transmission System.** V. K. ZWORYKIN. Assigned to Westinghouse Electric & Manufacturing Company. December 30, 1930. A motion picture film is moved past a transmitter at a fixed speed between an oscillating mirror and a photoelectric cell. Light from a fixed source is directed against the mirror and, after reflection therefrom, is focused to a fine point that moves from side to side of the moving film. Assuming that the film is moving vertically, the vertical component of the scanning motion is accordingly provided for by the motion of the film, while the horizontal component is taken care of by the mirror-oscillations.

At the receiving station a Braun tube having a plurality of cathode-ray controlling devices mounted therein is provided. One of the controlling devices functions in accordance with the output from the photoelectric cell at the sending station and serves to impose variations upon the amplitude of the ray; another of the controlling devices causes the ray to move horizontally in synchronism with the oscillating mirror at the sending station; while still another controlling device periodically deflects the ray vertically at a speed equal to the linear advance of the film at the sending station.

1,788,227. **System for Uniform Detail in Scanning.** J. O. BENTLEY. Assigned to General Electric Company. January 6, 1931. Scanning mechanism for picture transmission where the scanning disk is provided with laterally extending lines which move past a slot forming a light aperture for scanning the picture radially so that the details of the reproduced picture vary in fineness from the center to the perimeter. The ends of the slotted aperture are wider than the intermediate portion of the aperture and as the radially slotted disk rotates the size of the scanning beam increases near the ends of the radial slots in the disk, thereby enabling the detailed reproduction of the picture to be as accurate at the periphery as it is at the center.

1,790,491. **Television Scanning System.** T. A. SMITH. Assigned to Radio Corporation of America. January 27, 1931. A mirror disk having two portions, one of the portions being associated with a reflector system for scanning and reproducing a television subject along a parallel set of lines extending in one direction across the subject. A second reflector system coöperates with the second portion of the mirror disk for scanning and reproducing the same subject along a second set of parallel lines extending in an angular direction to the first-named set of scanning and reproducing lines. At each half revolution of the mirror disk, the scanning is cyclically changed from one to the other of the sets of scanning and reproducing lines at a rate commensurate with the persistency of vision.

1,790,687. **Combined Phonograph and Motion Picture Projectors.** S. S. A.

WATKINS. Assigned to Electrical Research Products, Inc. February 3, 1931. A home type talking motion picture machine in which a phonograph record may be driven by the usual phonograph motor or may be driven by a belt connection with a motion picture projecting machine for synchronizing the operation of the motion picture projector with the phonograph sound reproducer. The record table for the phonograph is provided with a pully around which a belt moves for imparting motion to the phonograph turntable in synchronism with the movement of the motion picture projector. The auxiliary disk which forms the turntable and which carries the pulley may be removed and the usual record table for the phonograph used independently of the motion picture projector.

1,791,481. **Television Scanning Device.** O. TERVO. February 3, 1931. A construction of scanning apparatus which eliminates the usual scanning disk. Two mirror polyhedrons are rotated in timed relationship in right angle planes. One mirror is not more than $^1/_4$ inch in width. A lens serves to focus a point of light on the peripheral edge of the mirror. An optical system is associated with the mirrors for effecting a scanning operation without the use of a scanning disk.

BOOK REVIEWS

Visual Aids in Education. J. J. Weber. *Valparaiso University*, Valparaiso, Indiana, 1930, 220 pp. In the preface, the author stresses the term "visual aids in education" instead of "visual education." The volume represents a summary of his previous publications with elaborations, and includes reports and a discussion of his experiments. Lists of words were handed to graduate students for introspective study. Statistical results indicated that the visual sense contributed about 31 per cent to experience and the auditory only 12 per cent. Films contribute to the realm of the specific rather than to generalizations. The experiments showed that the learning and retention of lessons were appreciably aided by using closely correlated films. The efficiency was greatest when accompanied by oral commentary and when used very early in the lesson period. The scatter of the scores was less after a visually aided lesson than after the unaided lesson. Therefore films either help the dull pupils more, or those inexperienced in the problem, or both. Films for schools should be divided into two very distinct types: (1) informational films; (2) instructional films. The first should be short-fact films with few or no titles. The second type, possibly sound films, act as visiting expert teachers. Standards for both types are discussed.

The discussions throughout are often made in positive statements and do not reflect a judicial attitude toward the situation; as, "the 16 mm. film is, in this writer's opinion, unsatisfactory for school use. Its image is yellow and grainy and its definition is poor."

The volume is a preliminary mimeographed edition. R. P. Loveland

Television. H. Horton Sheldon and E. N. Grisewood. *D. Van Nostrand Co.*, New York, N. Y., 1929, 194 pp. $2.75. A review of the development of television beginning with the elementary problem of picture transmission, tracing the significant steps which have led to the realization of television. The text is written in story form, and the authors have succeeded in presenting the subject matter in a manner easily understood by a reader of limited technical knowledge.

Beginning with the Bakewell picture transmission system in 1847, the work of the early inventors is described, showing how the art progressed as the development of the selenium cell, the photoelectric cell, and the vacuum tube amplifier removed the limitations controlling the speed and fidelity of reproduction. To assist the reader, chapters outlining the elementary theory of optical systems and electromagnetic wave propagation are given. The authors then describe the selenium cell, the photoelectric cell, glow lamps, oscillographs, scanning mechanisms, and synchronizing equipment.

This is followed by chapters showing how these units have been combined into complete systems: first, for telephotography and, finally, for television. The television systems of Baird, Bell Telephone Laboratories, Jenkins, and Alexanderson are briefly described. A chapter on amateur equipment is added for the

guidance of the experimenter who wishes to build his own equipment. The book is concluded by a chapter on the future of television. The authors, while frankly recognizing the technical difficulties yet to be overcome, quote predictions from various authorities and conclude that within ten years we shall receive television broadcasts as readily as we receive radio programs today. H. M. STOLLER

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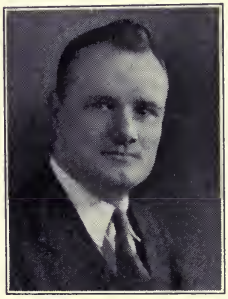

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COMMITTEE CHAIRMEN

Cowling, H. T.: Born August 20, 1890, at Suffolk, Va. George Washington University, 1909; chief photographer, U. S. Reclamation Service, 1910–17; chief cinematographer and technical director, Paramount-Burton Holmes Travel Pictures, 1917; Eastman Teaching Films, Inc., 1927 to date. Member of Board of Governors, 1928–30; treasurer, 1931; Chairman, Membership and Subscription Committee, 1929 to date.

Glunt, O. M.: See March, 1931, JOURNAL, page 389.

Gregory, C. L.: Born September 9, 1882, at Walnut, Kansas. Ohio State University, 1904; photographic research, U. S. Geodetic Survey and Thomas A. Edison, Inc.; director and cinematographer, Mutual, Thanhouser, Fox, Metro, 1906–14; color research, Technicolor Motion Picture Corp., 1914–15; research director, Corcar Chemical Co., 1916; chief instructor, U. S. Signal Corps School of Photography, 1918; instructor in cinematography, Columbia University, 1919; director, Orient & India Pictures, 1922–23; dean, New York Institute of Photography, 1923–27; producer, 1927–29; research director, Kislyn Corporation, 1929 to date. Chairman, Historical Committee, 1931.

Hardy, A. C.: See March, 1931, JOURNAL, page 389.

Kelley, W. V. D.: Born March 8, 1877, at Trenton, N. J. Technical work, American Mutoscope & Biograph Co., 1899–1902; technical director, Prizma, Inc., 1914–23; Du Chrome Film System, Ltd., 1924 to date. Member of Board of Governors, 1923–24; Chairman, Color Committee, 1930 to date.

Kunzmann, W. C.: Born August 11, 1885, at Sandusky, O. E.E., Akron College of Engineering, 1906; research engineer, National Carbon Co., 1908–15; sales engineer, National Carbon Co., 1915 to date. Member of Board of Governors, 1928 to date; Chairman, Convention Committee, 1925 to date.

Matthews, G. E.: See February, 1931, JOURNAL, page 259.

Palmer, M. W.: Born April 26, 1884, at Buffalo, N. Y. Stevens Institute of Technology, 1906; electrical engineer, Biograph Studio, 1912–18; electrical engineer, Paramount Publix Corp., 1918 to date. Vice-President, 1927; Chairman, New York Section, 1930 to date. Chairman, Studio Lighting Committee, 1931.

Rayton, W. B.: Born 1884, at Rochester, New York. B.A., Syracuse University, 1906; Bausch & Lomb Optical Co., 1908–26; director, scientific bureau, Bausch & Lomb Optical Co., 1926 to date. Chairman, Projection Theory Committee, 1931.

Ruben, H.: Born June 14, 1890, at New York, N. Y. Director of Projection, Paramount Publix Corp., and Publix Theaters Corp. Chairman, Projection Practice Committee, 1931.

Santee, H. B.: Born August 19, 1894, at Williamson, N. Y. B.E., Union College, 1916; supervisory engineer, Western Electric Co., 1916–25; supervisory engineer, Bell Telephone Laboratories, 1925–26; theater engineer, Vitaphone Corp., 1926–27; director of theater engineering, Electrical Research Products, Inc., 1927–30; director of commercial engineering, Electrical Research Products, Inc., 1930 to date. Chairman Sound Committee, 1931.

Whitmore, W.: Born August 12, 1902, at Lockhart, Tex. University of Texas, 1920–22; B.S. in Journalism, Northwestern University, 1926; publicity department, Western Electric Co., 1929 to date. Chairman, Publicity Committee, 1930 to date.

Wolf, S. K.: Born September 29, 1901, at Baton Rouge, La. M.S., Yale University; Westinghouse E. & M. Co., 1922–23; member of faculty, Sheffield Scientific School, Yale University, 1923–28; installation engineer, Electrical Research Products, Inc., 1928–29; acoustics engineer, Electrical Research Products, Inc., 1929–30; acoustic consulting manager, Electrical Research Products, Inc., 1930 to date. Chairman, Projection Screens Committee.

CONTRIBUTORS TO THIS ISSUE

Baer, C. E.: Born May 6, 1886, at Edenburg, Pa. A.B., Cornell University, 1908; M.A., Teachers College, Columbia University, 1926; teacher in science, public schools, New Castle, Pa., and Seattle, Wash., 1909–27; science editor, *High School Teacher*, 1925–27; supervisor of science, N. Y. State Department of Education, 1927–28; science editor, Eastman Teaching Films, Inc., 1928 to date.

Crabtree, J. I.: See January, 1931, issue of JOURNAL.

Krows, A. E.: Born June 22, 1892, at New York, N. Y. Engaged in publicity work, 1911–14; Triangle Film Corporation, 1915–16; Goldwyn Pictures, 1916; free-lance producer, 1927–29; Electrical Research Products, Inc., 1930; author of *Play Production in America* (1916), *Playwriting for Profit* (1928), *Equipment for Stage Production* (1928), and *The Talkies* (1930).

Lucas, F. F.: Born August 7, 1884, at Glens Falls, N. Y. Metallurgical materials engineer, Bell Telephone Laboratories, 1902 to date.

Matthews, G. E.: See February, 1931, issue of JOURNAL.

IMPORTANT NOTICE

It is very necessary that all members of the Society and subscribers to the JOURNAL immediately advise the General Office of the Society, when a change in mailing address is made. Otherwise, when literature is returned by the Post Office for this reason, the member's or subscriber's name is removed from the mailing list for the JOURNAL until the proper address is obtained. Future issues of the JOURNAL will contain, from time to time, lists of members or subscribers for whom no address is known. Anyone knowing the whereabouts of those members or subscribers is requested to advise the General Office promptly.

SOCIETY ANNOUNCEMENTS

THE SPRING MEETING

The Spring Meeting of the Society will be held in Hollywood, Calif., May 25th–29th, inclusive.

The chairman of the Papers Commitee, Mr. O. M. Glunt, is arranging an interesting technical program and Mr. W. C. Kunzmann, chairman of the Arrangements Committee, is making extensive preparations for the entertainment and comfort of the visiting members.

It will be noted that the convention period has been extended from the usual 4 day period to 5 days. This allows four afternoons for sightseeing and studio visits. Definite arrangements have already been made for visits to the Fox and Paramount Studios.

A feature of the meeting will be the exhibition of new equipment developed during the past year. This will not be of the nature of a trade exhibit nor will there be booths, but adequate space will be allotted each exhibitor free of charge. The exhibition rules specify that equipment be new or have been improved within the past twelve months. No pamphlets or advertising literature will be permitted. Each exhibitor will be allowed to display a small card giving the name of the manufacturing concern, and the equipment will be labelled with a plain label free from the name of the manufacturer. It is required that a technical expert be present during the exhibition to explain the technical features of the apparatus.

THE NEW YORK SECTION

At a meeting held at the Bell Telephone Laboratories on February 27, 1931, Mr. F. H. Richardson presented a paper entitled "The Projectionist and Sound" and Mr. T. E. Shea of the Bell Telephone Laboratories gave a demonstration and description of noiseless recording with the bias valve.

THE CHICAGO SECTION

At a meeting held at the headquarters of the Electrical Association on March 5, 1931, Mr. R. P. Burns presented a paper entitled "The Operation of the High Intensity Arc."

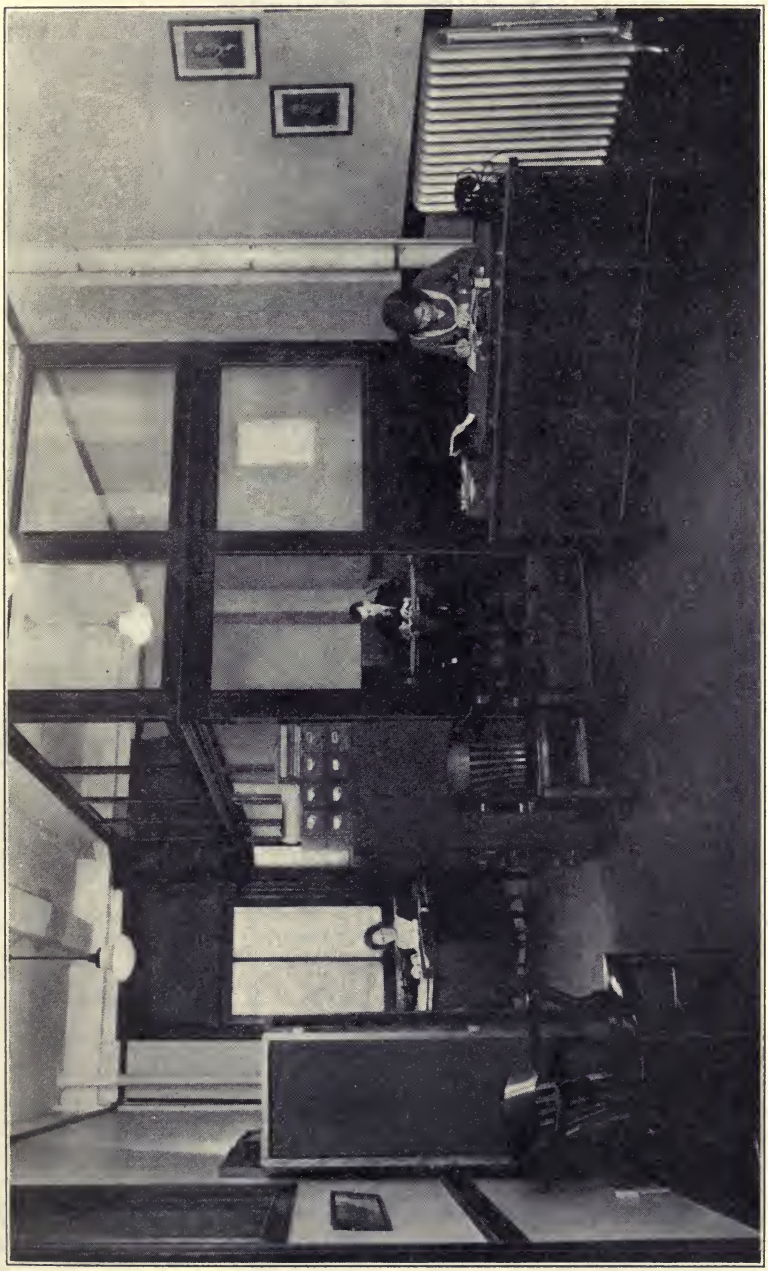
PACIFIC COAST SECTION

Chairman MacKenzie has appointed a number of committees to assist in arrangements for the Spring Convention. These include Apparatus Exhibits, Papers, and Arrangement Committees.

At a meeting held on February 19th in the Sound Theater of the Paramount Publix Studios, Dr. S. B. Nicholson of the Mt. Wilson Observatory, dealt with the use of photographic emulsions for measuring the heat from stars and Mr. J. B. Frayne reported on recent items of progress in motion picture engineering.

LAPEL BUTTONS

There is mailed to each newly elected member, upon his first payment of dues, a gold membership button which only members of the Society are entitled to wear. This button is shown twice actual diameter in the illustration. The letters are of gold on a white background. Replacements of this button may be obtained from the General Office of the Society at a charge of $1.00.



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BACK NUMBERS OF THE TRANSACTIONS AND JOURNALS

Prior to January, 1930, the *Transactions* of the Society were published quarterly. A limited number of these *Transactions* are still available and will be sold at the prices listed below. Those who wish to avail themselves of the opportunity of acquiring these back numbers should do so quickly, as the supply will soon be exhausted, especially of the earlier numbers. It will be impossible to secure them later on as they will not be reprinted. The cost of all the available *Transactions* totals $46.25.

	No.	Price		No.	Price		No.	Price
1917	3	$0.25	1924	18	$2.00	1927	29	$1.25
	4	0.25		19	1.25		30	1.25
1918	7	0.25		20	1.25		31	1.25
1920	10	1.00	1925	21	1.25		32	1.25
	11	1.00		22	1.25	1928	33	2.50
1921	12	1.00		23	1.25		34	2.50
	13	1.00		24	1.25		35	2.50
1922	14	1.00	1926	25	1.25		36	2.50
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1923	16	2.00		27	1.25		38	3.00
	17	2.00		28	1.25			

Beginning with the January, 1930, issue, the JOURNAL of the Society has been issued monthly, in two volumes per year, of six issues each. Back numbers of all issues are available at the price of $1.50 each, a complete yearly issue totalling $18.00. Single copies of the current issue may be obtained for $1.50 each. Orders for back numbers of *Transactions* and JOURNALS should be placed through the General Office of the Society, 33 West 42nd Street, New York, N.Y., and should be accompanied by check or money-order.

Statement of the Ownership, Management, Circulation, Etc., Required by the Act of Congress of August 24, 1912, of JOURNAL OF THE SOCIETY OF MOTION PICTURE ENGINEERS, published monthly at Easton, Pa., for April 1, 1931.

State of New York }
County of New York } ss.

Before me, a Notary Public in and for the State and County aforesaid, personally appeared Sylvan Harris, who, having been duly sworn according to law, deposes and says that he is the Editor-Manager of the Society of Motion Picture Engineers and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management (and if a daily paper, the circulation), etc., of the aforesaid publication for the date shown in the above caption, required by the Act of August 24, 1912, embodied in section 411, Postal Laws and Regulations, printed on the reverse of this form, to wit:

1. That the names and addresses of the publisher, editor, managing editor, and business managers are:

Name of— *Post Office Address—*

Publisher, Society of Motion Picture Engineers, 33 W. 42nd St., New York, N. Y.
Editor, Sylvan Harris, 33 W. 42nd St., New York, N. Y.
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SYLVAN HARRIS, Editor, Business Manager.

Sworn to and subscribed before me this 24th day of March, 1931.

(Seal) KENNETH L. JEFFERY.
Notary Public, Westchester County,
Certificate filed in New York County,
Clerk's No. 48, Reg. No. 2-J-37.

(My commission expires March 30, 1932)

EXHIBIT OF NEW APPARATUS AT THE SPRING CONVENTION

Hollywood, Calif., May 25–29, 1931, Incl.

Arrangements are being made for an exhibition of newly developed motion picture apparatus in order to better acquaint the motion picture engineer with the newly devised tools which may be of value to him.

This will not be of the same nature as the usual trade exhibit. There will be no booths although each exhibit will be allotted definite space by the Apparatus Exhibits Committee and all exhibits will be arranged in one large room. The following regulations will apply:

1. The apparatus to be exhibited must be new or have been developed or improved within the past 12 months.
2. No pamphlets or advertising literature will be permitted.
3. Each exhibitor will be permitted to display one small card giving the name of the manufacturing concern and each piece of equipment shall be labeled with a plain label free from the name of the manufacturer.
4. Exhibitors must provide their own tables or display stands. No shipments will be accepted collect unless previous arrangements have been made with the General Office.
5. If space in excess of 100 square feet is required, special arrangements must be made.
6. A technical expert capable of explaining the technical features of the apparatus exhibited must be present during the period of the exhibition.
7. The hours of the exhibition will be determined by the Apparatus Exhibits Committee and the exhibits will be closed during the papers sessions.
8. All exhibition space will be furnished *gratis*.
9. The apparatus to be exhibited will be censored by the Apparatus Exhibits Committee to insure that this is essentially new as described under item 1.

Please make requests for space to Mr. Kenneth Lambert, Chairman of the Exhibits Arrangement Committee, Metro-Goldwyn-Mayer Studios, Culver City, Calif., or to Mr. Sylvan Harris, Editor-Manager of the Society of Motion Picture Engineers, Room 701, 33 West 42nd Street, New York, N. Y., stating the number and nature of the items to be exhibited.

JOURNAL

OF THE SOCIETY OF

MOTION PICTURE ENGINEERS

SYLVAN HARRIS, EDITOR

Volume XVI | MAY, 1931 | Number 5

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JOURNAL
OF THE SOCIETY OF
MOTION PICTURE ENGINEERS

SYLVAN HARRIS, EDITOR

Published monthly at Easton, Pa., by the Society of Motion Picture Engineers

Publication Office, 20th & Northampton Sts., Easton, Pa.
General Office, 33 West 42nd St., New York, N. Y.

Subscription to non-members, $12.00 per annum; to members, $9.00 per annum, included in their annual membership dues; single copies, $1.50. A discount on subscriptions or single copies of 15 per cent is allowed to accredited agencies. Order from the Society of Motion Picture Engineers, Inc., 20th and Northampton Sts., Easton, Pa., or 33 W. 42nd St., New York, N. Y.

Entered as second class matter January 15, 1930. at the Post Office at Easton, Pa., under the Act of March 3, 1879.

A LOUD SPEAKER GOOD TO TWELVE THOUSAND CYCLES*

L. G. BOSTWICK**

Summary.—A loud speaker, designed for use as an adjunct to existing types of speakers to permit efficient sound radiation at the higher audible frequencies, is described. The structural and performance characteristics are indicated, and some of the advantages and limitations of such a loud speaker are discussed.

Twelve thousand cycles—over five octaves above middle C in the musical scale—of what advantage is a loud speaker that is capable of so greatly exceeding the pitch limit of any voice or musical instrument? Twelve thousand cycles is within the highest octave that can normally be perceived by the ear, but yet it has been found that certain musical instruments and voices, and many common sounds such as hand-clapping or the jingling of keys or coins, have overtones or harmonics that make such a loud speaker necessary for perfect reproduction. In some cases the change in the character of the sounds resulting from suppression of the high frequencies is not objectionable but in others it may be such as to cause the reproduced sound to bear but little resemblance to the original. Extension of the frequency range of a reproducing system to include the very high frequencies results in marked improvements in the reproduction of impulsive sounds and in the naturalness, color, and brilliance of reproduced speech and music.

Although it is possible for the high frequencies to be suppressed at many points in a reproducing system, the loud speaker is almost certain to be blamed, and often justly. Loud speakers are usually inefficient at very high frequencies because the mass of the diaphragm impedes the vibratory motion and thereby diminishes the acoustic output. Existing diaphragm shapes and materials do not permit a sufficiently light structure to avoid this effect.

The loss in acoustic output at high frequencies, however, may be diminished by using a horn. The horn improves the acoustical coupling between the diaphragm and the air, and thereby makes

* Received by the Editor February 28, 1931.

** Bell Telephone Laboratories, New York, N. Y.

possible greater sound radiation with smaller vibrational amplitudes. The effect of the mass of the diaphragm in cutting down the acoustic output is consequently reduced because the larger vibrational amplitudes are not required.

The use of a horn, however, involves another limiting factor, which is found in the air chamber between the diaphragm and the throat of the horn. The air in this chamber is compressible and, as a result, it tends to diminish the vibratory motion at the throat. At low frequencies this compressibility of the air chamber does not usually cause difficulty but at high frequencies it is quite important.

Fig. 1. An experimental loud speaker designed for high-frequency reproduction.

In the loud speaker shown in Fig. 1 and Fig. 2 these and other factors that usually cause the high frequencies to be suppressed, have been taken into consideration. The diaphragm is made of 0.002 inch duralumin and is a little over one inch in diameter. A spherically-embossed section at the center provides rigidity and causes the diaphragm to vibrate as a whole, like a piston. A moving coil of aluminum ribbon wound edgewise is attached to the diaphragm at the periphery of the embossed section and vibrates in a very strong magnetic field in the usual way. The diaphragm and moving

coil weigh together but 160 mg. A sufficiently incompressible air chamber is obtained by making the separation between the diaphragm and horn very small. The chamber stiffness (the reciprocal of the compressibility) is inversely proportional to the separation, and by making this about 0.010 inch the adverse influence of the chamber is substantially eliminated up to the very high frequencies. The throat end of the horn conforms to the contour of the diaphragm, as can be seen in Fig. 1. Since for equal radiation, the amplitude must be larger for low frequencies, this small chamber separation, in limiting the amplitude of the diaphragm, makes it impossible to radiate the low frequencies. Consequently only a small horn, suitable for the high frequencies, is required. The horn shown in Fig. 1 is of the exponential type and suitable for frequencies above 2000 cycles. Its mouth is a little over two inches in diameter, and its

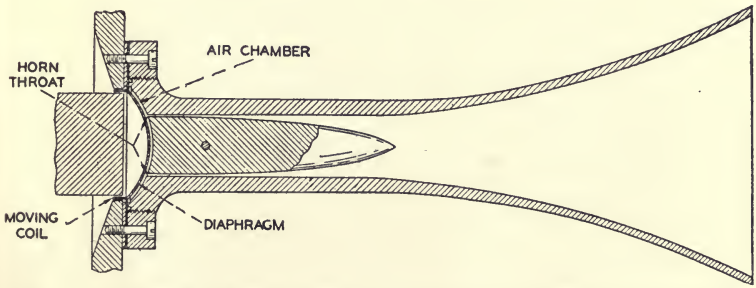

FIG. 2. Sectional diagram showing diaphragm, air chamber, and horn constructions.

throat is made in the form of an annular slit, for minimizing high-frequency interference effects within the air chamber.

Fig. 3 and Fig. 4 are curves obtained from measurements of the performance of this loud speaker at different frequencies. Fig. 3 shows measurements of the sound pressure on the horn axis at a distance of about three feet. A calibrated condenser microphone was used as the acoustic meter; the results are expressed in decibels. Fig. 4 shows the absolute efficiency of the speaker, determined from measurements of the electrical motional impedance. This efficiency represents the amount by which the output of this loud speaker is less than the maximum possible output obtainable from an ideal speaker. The average value for the absolute efficiency throughout the frequency range from 3000 to 12,000 cycles is about twenty per cent.

Since this loud speaker cannot radiate the low frequencies, it must be used in conjunction with a loud speaker designed for the low-frequency range. Either baffle- or horn-type speakers of existing design may be used with it. Fig. 5 shows a curve obtained by using the high-frequency loud speaker with a standard Western Electric theater speaker having a large 60-cycle cut-off exponential horn. The small speaker was suspended in the mouth of the large horn

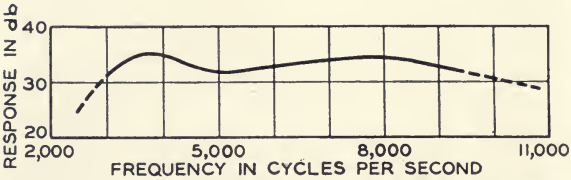

FIG. 3. Response-frequency characteristic of the high-frequency loud speaker, measured to 10,000 cycles, on the axis of the horn three feet from its mouth.

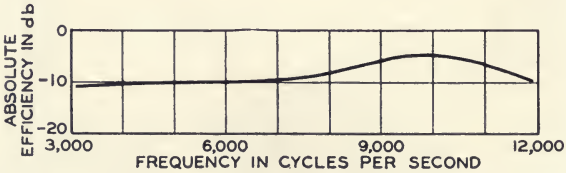

FIG. 4. Output characteristic of the high-frequency loud speaker, in decibels relative to the ideal.

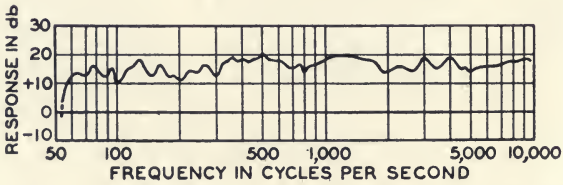

FIG. 5. Connected to the power supply, through the circuit shown in Fig. 7, the high-frequency loud speaker and a low-frequency speaker provide the above frequency characteristics.

(Fig. 6), and the two speakers were connected to the electrical supply through a simple electrical network (Fig. 7) which delivered most of the electrical power above 3000 cycles to the high-frequency loud speaker and most of that below 3000 cycles to the low-frequency speaker. This arrangement makes most effective use of the electrical supply and prevents possible damage to the more delicate high-fre-

quency speaker by large amounts of low-frequency power. The measurements were made in a large felt-lined room with a condenser microphone rotated in an inclined circle six feet in diameter

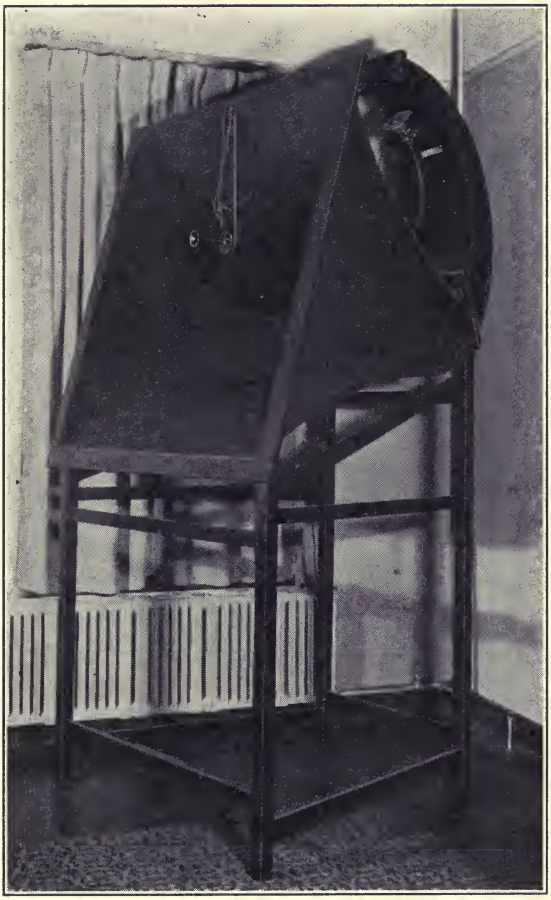

FIG. 6. In obtaining the combined frequency characteristic, the small speaker was suspended in the mouth of the large horn.

about a point on the large horn axis twelve feet from the mouth.

The use of such a loud speaker has several advantages aside from the improved frequency range. It permits a more favorable design of the associated low-frequency loud speaker because the

delicate parts and restricted dimensions necessary to radiate the high frequencies are not needed. This makes possible greater power capacity and in some cases better efficiency in the low-frequency speaker. Another advantage is that it affords more uniform sound-field distribution. The sound field of loud speakers of the dimensions necessary for low-frequency radiation often becomes too concentrated in one direction at high frequencies. This excessive concentration is due to the large dimensions of the radiating surface compared to the wave-length. By radiating the high frequen-

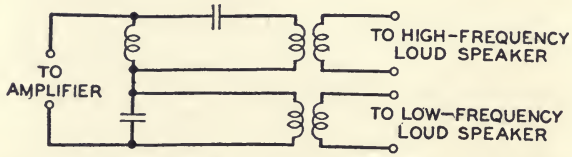

Fig. 7. Circuit used for supplying low- and high-frequency speakers from the same amplifier.

cies from a small loud speaker the restriction of the sound field is greatly diminished.

On the other hand, a loud speaker efficient at high frequencies introduces other difficulties that would not be encountered if the high frequencies were suppressed. For example, amplifier overloading becomes much more strident, and noise may increase to an objectionable extent. A loud speaker of the type described, therefore, cannot be used to full advantage in systems where these latter factors are not favorable.

TELEVISION IN COLOR FROM MOTION PICTURE FILM*

HERBERT E. IVES**

Summary.—*If a television scanning disk is placed close to the ridged film in a Kodacolor projector, and three photoelectric cells are placed side by side in front of the projection lens, three sets of photoelectric signals will be produced, each corresponding to one of the primary colors. It is not necessary to use the color filters ordinarily placed before the lens or color-sensitive photoelectric cells, since the black and white strip images on the film contain the complete record of the characteristics of each colored image. The three sets of signals are transmitted over three communication channels and actuate a three-color receiving apparatus previously described.*

In speculations on the possible uses for television, one project which receives considerable attention, partly because of its relative ease of accomplishment, is the transmission of images from motion picture film. It is true that the practical simultaneity of event and viewing, which is the unique offering of television, is lost when the time necessary for photographic development of the film intervenes. Nevertheless it is conceivable that if this delay is small, television from film may still possess such an advantage over the material transportation of film as to give it a real field. A further possibility, more remote, but within the range of legitimate speculation, is that television apparatus may sometime be used to receive, in the home, motion pictures of the sort now offered in the theaters or in home projection outfits. However distant these mergings of the two arts may be, the technical problems presented are pretty clearly defined, and offer interesting features for study.

Among these problems is the transmission of images in color from colored motion picture film. This paper describes a method of accomplishing this, using the receiving apparatus for television in color recently described, and special sending apparatus which utilizes the latest form of colored moving pictures—the ridged film now marketed under the name of Kodacolor.

As an introduction to the method of telecinematography in color

* Reprinted from *Jour. Opt. Soc. of America*, **21** (January, 1931), No. 1 p. 2.
** Bell Telephone Laboratories, New York, N. Y.

using ridged film, it is profitable to outline how the problem could be solved with film in which the colors are incorporated by dyes (*e. g.*, Technicolor), and the three-color transmitting and receiving system recently developed in the Bell Laboratories.[1] This may be done most easily by considering Fig. 1, where the three-color transmitting apparatus is shown in section, with the addition of film handling means. The photoelectric cell cabinet, containing three sets of color-sensitive cells with appropriate filters, is indicated at *C*, from which three communication channels, *R*, *G*, and *B*, carry the red, green, and blue signals to the receiving end. At *A* is the arc lamp,

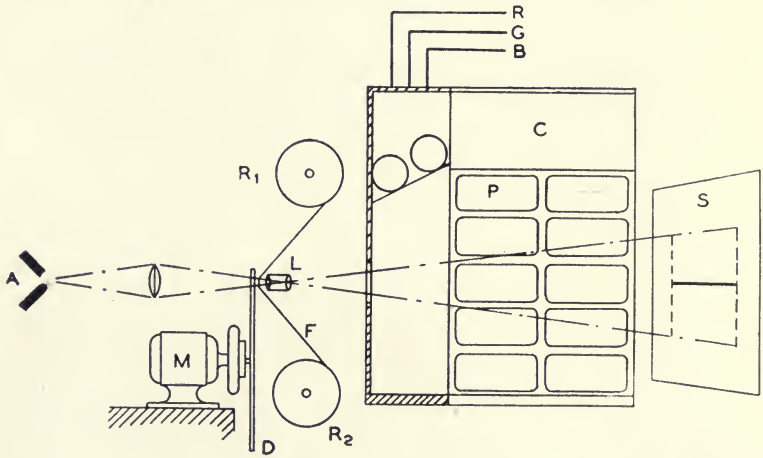

FIG. 1. Sectional view of television sending apparatus for transmitting from colored motion picture film. *A*, light source; *D*, scanning disk; *M*, synchronous motor; *C*, photoelectric cell cabinet containing three sets of color-sensitive cells with appropriate filters; *F*, motion picture film; *L*, projection lens; *S*, white screen.

whose light is condensed upon the perforated disk *D*, which is driven by the synchronous motor *M*. The lens *L* projects an image of the disk upon the matte white screen *S*, from which light is reflected back into the photoelectric cells. The film *F*, as it unwinds from the reel R_1 onto the reel R_2 passes in front of the disk *D*, and as closely as is practicable to it so that the film and the disk holes are in focus together on *S*.

If, with the apparatus as just described, the film stands still, with a picture frame exactly filling the field aperture in front of the disk, and the disk rotates at its normal speed for television, the screen *S* shows a projected image of the film, colored if the film is colored, and

capable of being picked up by the photoelectric cells and transmitted, to be received like the image of a colored object by the single disk, three-lamp receiving apparatus, as ordinarily used for this purpose. When the film is moved in order to give a motion picture, there are two alternative forms of scanning disk available, depending on whether the motion of the film is intermittent, as in most cameras and projectors, or continuous. In the first case, a scanning disk must be used with a blank sector corresponding to the period occupied by the shift of the film between frames, as shown at D_1, Fig. 2, and a similar disk must be used at the receiving end also. The use of intermittent exposures is, however, not only inefficient, because of the waste of line-time during the blank period, but is quite unnecessary when the image is analyzed by successive passages of a scanning aperture across the field. Instead of a disk provided with a spiral

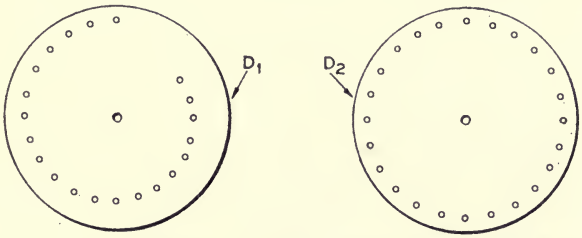

FIG. 2. Two forms of scanning disk for use with motion picture film. D_1, disk with holes in spiral arrangement, with a blank sector corresponding to the interval between frames in intermittent projection. D_2, disk with holes in circular arrangement for use with film in continuous uniform motion.

of holes it is simpler and better to use a disk with the scanning holes arranged in a circle, as shown at D_2, Fig. 2, and to give the film a uniform and continuous motion along the vertical diameter of the disk. When this is done the screen S shows merely a horizontal strip of light (indicated in Fig. 1 by the solid line) but the usual spirally-perforated disk at the receiving end spreads this out into a complete picture.

This method of transmitting colored images from motion picture film, while completely practical, suffers under the disadvantage that it requires an original colored film of a sort which is both expensive and time-consuming to produce. Should television transmission from film become popular it is probable that the chief demand would be for films which would be shown but once, and for showings within

a few hours, at most, of the event. Some form of colored film would then be called for which could be prepared quickly and cheaply, and the film process need not be one adapted for making numerous copies.

A form of colored motion picture which very completely meets these requirements is produced by the Kodacolor process.[2] In this the image is black and white, but is distributed into a triple linear mosaic by lenticular ridges on the film. Exposure is made through

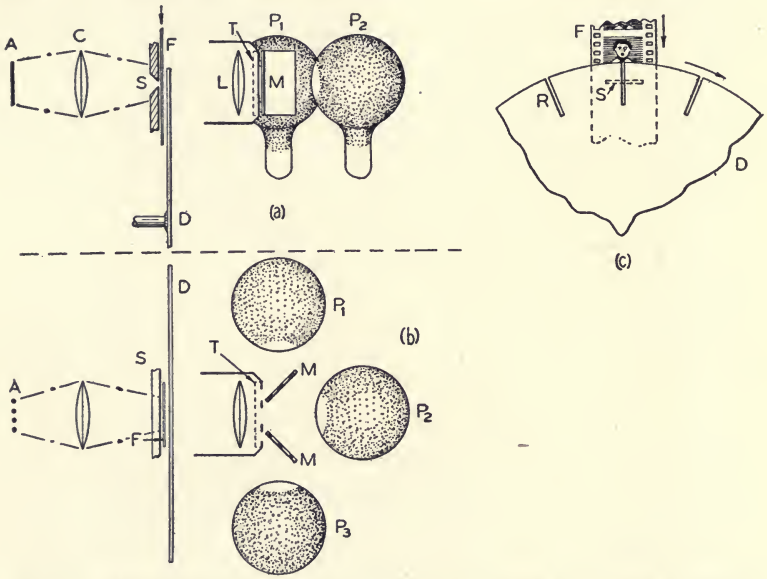

FIG. 3. Television scanning apparatus for use with Kodacolor (colorless) ridged film. *A*, light source; *C*, condensing lens; *F*, film; *S*, slot, transverse to direction of film motion; *D*, scanning disk, provided with radial slots *R*; *L*, projection lens; *T*, position of color filters used for screen projection; P_1, P_2, P_3, three photoelectric cells; *M*, mirrors.

a lens with three apertures, and projection is accomplished through a lens similarly equipped with three apertures, covered with red, green, and blue filters. The original negative, made into a positive by a process of photographic reversal, is used for projection. There is but one film available, but this is all that is necessary for the use in television which we are considering. The film is cheap as compared to a film in which the color is added by a dyeing process, and the time required to prepare it for projection is a matter of hours instead of days.

The method of using Kodacolor film may be most comprehensively described by saying that the film is to be projected as though for display upon a screen, but that the three beams of light issuing from the projection lens are directed each into a separate photoelectric cell for television transmission. With the details of the apparatus shown in Fig. 1 in mind, the Kodacolor film arrangement is readily grasped from Fig. 3, where the upper view (*a*) shows the elevation, the middle view (*b*) the plan, and (*c*) shows a detail of the scanning disk and film. Starting with the light source A, the light is condensed by the condenser system C on the film F which moves continuously

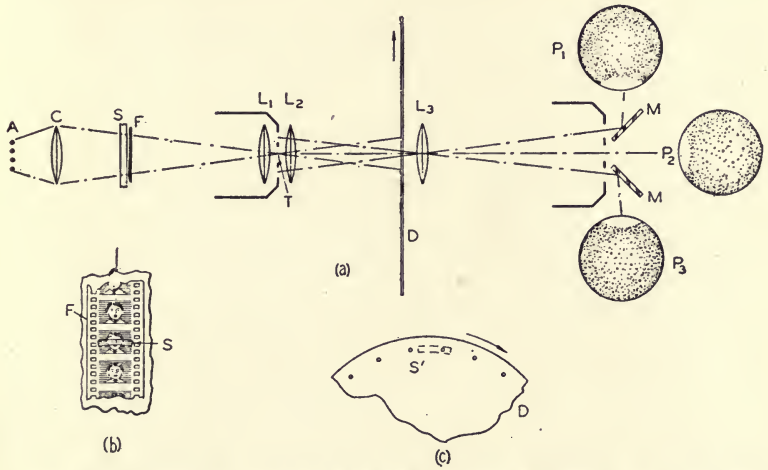

FIG. 4. Alternative arrangement of scanning apparatus for use with Kodacolor film. The elements are the same as in Fig. 3, except that the film is imaged on the disk D by the lens system L_1, L_2, and an additional lens L_3 beyond the disk images the three apertures of the projection system onto the photoelectric cells.

past the slot S and directly behind the disk D. The disk is shown as provided with radial slots R, these together with the fixed slot S forming the scanning holes. After passing through the film and disk the light is projected as if to a screen by the lens L, in front of which is placed, in the regular projector, the set of red, green, and blue filters T. For our purpose both the screen and the filters are dispensed with. After passing through the lens, the light is diverted into three photoelectric cells, P_1, P_2, and P_3, by the mirrors M. These cells are all similar, and need not be color-sensitive. The filters are omitted as obviously unnecessary—color is not needed until the sig-

nals are received and recombined at the receiving disk where the same apparatus is used as for the reception of signals from original colored objects.

The arrangement of apparatus shown in Fig. 3 calls for the slot, film, and disk being practically in contact. This condition, which must be met if color fringes are to be avoided, is likely to offer some difficulty, since both are moving at high speed. An alternative arrangement, by which the disk and film are separated, is shown in Fig. 4. Here the symbols are as in Fig. 3, and the apparatus is the same from the lamp A to the film F. The disk is, however, removed to a new position beyond the projection lens L_1, which is supplemented by a short-focus lens L_2 so that an image of the film F, where it lies over the slot S, is projected onto the disk. A third lens L_3, close to the disk, images the three apertures T onto mirrors M and photoelectric cells P as before. By this means the film image may be placed accurately in the plane of the disk and color fringes avoided.[3] Additional advantages are that the disk may be made of any convenient size, and that the radial slots to which one is practically driven by constructional difficulties in the very small disk may be replaced by holes as shown at (c).

In describing the apparatus for achieving television in colors by a beam-scanning method[1] emphasis was placed on the fact that the same single scanning disk was used at each end as for monochrome work. A similar characteristic holds for the film apparatus here described. Either color or monochrome film can be used interchangeably, the latter requiring but one transmission channel. If monochrome receiving apparatus only is available when multichrome film is used, it may be received as monochrome, preferably selecting the green channel as giving nearly orthochromatic effects. If three-color receiving apparatus is available of the form previously described,[1] images from monochrome film may be received on all three (red, green, and blue) lamps together, adjusting their relative intensities to give white or any other desired color for the resulting monochrome image.

REFERENCES

[1] IVES, H. E.: "Television in Color by a Beam-Scanning Method," *Jour. Opt. Soc. of America*, **20** (January, 1930), No. 1, p. 11.

[2] *Photographic Journal* (September, 1929), p. 402.

[3] The disk and film could be similarly separated in the form of apparaus shown in Fig. 1 although the necessity is not so apparent.

A NOVEL PROJECTOR*

Summary.—*The principal features of the projectors described are primarily intended to avoid wear and injury to the film which occurs in non-continuous projectors. The wear is principally due to the tension applied to the perforation edges as the film is either forced down upon the sprocket teeth or pulled away from them. In one type of projector, the action of the feed and take-up sprockets is supplemented by that of driven friction rollers, which are designed to limit the pull on the perforation edges to a negligible fraction of its normal value. A more recent type of projector utilizes no sprockets at all, friction rollers with automatically regulated slippage taking their place. Loops in the film automatically regulate its pressure against the friction rollers, the size of these loops, and consequently the pressure, regulating the slippage.*

In this paper "Codus" describes two motion picture projectors designed and marketed in Europe by M. Oemichen. The characteristic features of their design are intended to reduce the effects of wear and injury to the film as much as is possible in a non-continuous projector. Worn and torn sprocket holes, after a few hundred projections in the conventional type of projector, result in the screen image becoming too "jumpy" for continued use of the film. The designer attributes this mainly to the excessive pull exerted upon the edges of the film perforations by the sprocket drive. The pull is exerted at two places: First, the feed sprocket pulls the film out of the supply reel, against the heavy friction applied to prevent uncontrolled unwinding of this reel, and the strain of this pull is exerted upon the perforation edges at the feed sprocket. Second, the friction drive of the take-up reel exerts a similar pull upon the film which is resisted by the take-up sprockets, and the strain of this pull is similarly exerted upon the perforation edges at the take-up sprocket. The tension applied results in both cases in a tearing effect upon the perforation edges when the film is either forced down upon the sprocket teeth or pulled away from them.

The action of the pull-down claws is similarly exerted upon the perforation edges. However, "Codus" indicates that the designer of the Oehmichen projectors does not consider the action of the pull-

* *Le Cinéopse*, **XII** (November, 1930), p. 438. Translated and abridged by A. G. Denis, Eastman Kodak Co., Rochester, N. Y.

down claws as one of the primary causes of wear and, if his theory may be considered as correct, the action of the pull-down claws is not resisted by a heavy pull like that of the driving sprockets but is resisted only by the friction applied at the gate. Furthermore, although the Oehmichen machines embody every feature calculated to reduce to a minimum any wear of the film which may be due to the action of the pull-down claws—multiple claws, a special gate of patented design, independent pressure pads, and a very low pressure of 3 ounces —the Oehmichen gate and pull-down mechanism present no feature constituting a radical departure in design, as do the feed and take-up sprockets.

On one type of the Oehmichen projector (Type GC4) there are provided feed and take-up sprockets of conventional design whose action is supplemented by that of driven friction rollers. The function of

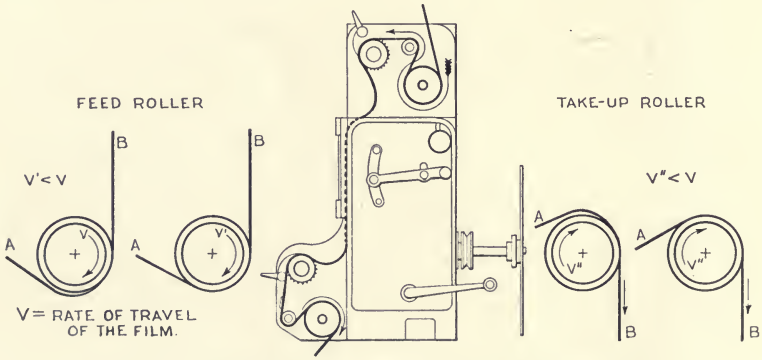

FIG. 1. Schematic arrangement of Type GC4 projector.

these rollers is not to drive the film positively but solely to take up, in a manner which cannot result in injury to the film, the strains required to pull the film from the supply reel and to resist the pull of the take-up reel. This avoids putting heavy strains upon the perforation edges at the sprockets themselves and the film enters and leaves the sprockets without appreciable injury.

The friction rollers are cylindrical drums of the same width as the film, covered with rubber on their edges. The perforated edges of the film are in contact with a rubber surface on both sides and the picture area of the film does not come into contact with the surface of the rollers. It will be seen by referring to Fig. 1, which illustrates in schematic manner the Oehmichen Type GC4 projector, that no

pressure rollers are used to maintain the edges of the film in contact with the friction rollers, but that the film is merely looped around the greater part of the periphery of the friction rollers by means of standard guiding rollers. As a matter of fact, no continuous positive contact such as would allow no slippage is sought between the film and the friction roller. The friction roller intended to supplement the action of the feed sprocket revolves at a peripheral speed slightly higher than that of the feed sprocket itself, and the friction roller used in conjunction with the take-up sprocket revolves at a peripheral speed slightly lower than that of the latter. It will be obvious that if continuous positive contact were established between the friction rollers and the film, loops would at once form between the friction rollers and the sprockets with which they are associated. However, since there is no mechanism provided to maintain continuous positive contact between film and friction rollers, and since a heavy pull is exerted by the film in the case of both friction rollers on the side away from their associated driving sprockets, no such loops can actually be formed. This is due to the fact that any slackness of the film between the driving sprocket and the friction roller must manifestly, long before a loop can be formed, cause the loss of positive contact between film and friction roller and must result in slippage. The greater or lesser degree of slackness of the film between friction roller and driving sprocket must provide a continuous and instantaneous regulation of slippage on the friction roller. This slippage decreases, and a positive contact may even be established momentarily whenever an appreciable tension of the film happens to develop between the friction roller and the driving sprocket. The slippage increases rapidly as soon as a certain degree of slackness of the film between friction roller and driving sprocket has been exceeded.

That the friction roller can effectively be made to assume the pulling strains exerted by the film and relieve the driving sprockets of all but a negligible fraction of this strain, will become apparent when it is realized that the mechanism constitutes an ingenious and simple application of a familiar principle in the operation of the capstan. It is well known that if a belt be looped around a rotating shaft, the continuous pull which it is required to maintain on the outgoing side of the belt in order to prevent slippage and maintain positive contact between the belt and the shaft is only a fraction of the pull which it is desired to exert on the ingoing side of the belt. This fraction,

which is a function of the area of contact, the ratio of the latter to total peripheric area of the shaft, and the coefficient of friction may easily be made small. Moreover, the ratio of the pull transmitted by the shaft to the pull applied to maintain contact of the belt increases rapidly with the latter. In the case of film which is looped around a well-designed friction roller, a pull of a small fraction of an ounce exerted on the film on the outgoing side of the friction roller is sufficient to permit the latter to transmit a pull of several pounds to the film on the other side of the friction roller.

The friction roller thus does not relieve the driving sprocket—and the perforation edges—of all pulling strain, but limits the pull on the perforation edges to the tension required to maintain slipping contact between film and friction roller. In other words, it limits the pull to a negligible fraction of its normal value.

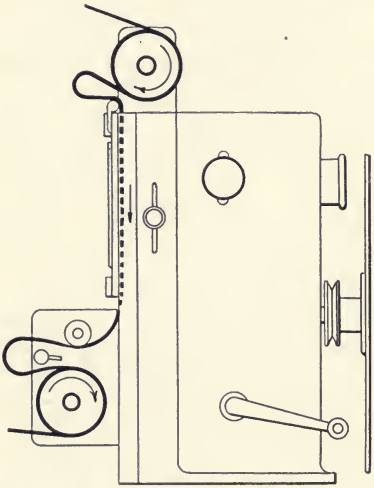

FIG. 2. Schematic arrangement of Type BAG projector.

The same explanation applies as well to the action of the friction roller associated with the take-up sprocket, which revolves more slowly than the latter and resists a pull instead of applying one, as to the action of the friction roller associated with the feed sprocket.

On a more recent type of Oehmichen projector, Type BAG, a much more radical departure from conventional design is attempted. The BAG projector appears to have been designed primarily for use in schools or by amateurs, and it would seem legitimate to claim for it the advantages of great simplicity and cheapness of construction as well as those of the reduction of film wear. It has a pull-down mechanism with self-engaging claws which presumably does not differ much from that of its predecessor. It contains no sprocket at all, and has no positive drive. Friction rollers with automatically-regulated slippage take the place of both feed and take-up sprockets. As in the case of the GC4 projector, the speed of rotation of the feed friction roller is so adjusted that it tends to pull the film out of the supply reel and feed it to the pull-down mechanism faster than

the latter requires. The take-up friction roller revolves at such a speed that, allowing no slippage, it would feed film to the take-up reel more slowly than it receives it from the pull-down mechanism. A certain amount of slippage is thus necessary to prevent the formation of loops of unreasonable size. Since there are no driving sprockets of which the positive drive can be used, as in the case of the GC4 machine, their regulated pull cannot be used to control the degree of contact between film and friction roller and thus regulate their slippage. Moreover, the pull exerted by the pull-down mechanism is obviously too abrupt to permit its use to regulate slippage directly. As a matter of fact, loops of a certain size must be maintained both above and below the pull-down mechanism to permit the smooth operation of the latter.

Fig. 2 shows schematically how the problem of maintaining these necessary loops and simultaneously utilizing the pull of the pull-down mechanism to control slippage has been ingeniously solved. Between the pull-down mechanism and both the feed and take-up rollers, the film is passed back and forth between the friction roller and a guide roller placed in close proximity to the friction roller. On both sides of the pull-down mechanism loops are thus formed which permit smooth and effortless operation. It would seem, however, that since no pull is applied on the film at the points where it leaves the friction rollers to form these loops, there would be nothing to check slippage once the projector is put in operation and that these loops could not be maintained. Such, however, is not the case. In order that the loop should be lost, it would have to be reduced to a very small size in order to slip out between the friction roller and the guiding roller. A very simple experiment, illustrated in Fig. 3, which consists of attempting to slip a loop of film from between two fingers held almost in contact, will show at once that this cannot be done easily. The film resists

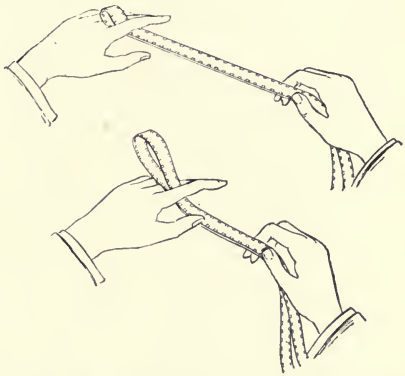

FIG. 3. Illustrating the principle by means of which the loop is maintained in the projector; due to the pressure exerted by the loop it is difficult to pull it through the fingers.

bending at a sharp angle, and the two sides of the loop begin to exert a very appreciable pressure on the fingers as soon as the radius of curvature of the loop falls to certain limits.

In the same way, as soon as the action of the pull-down mechanism, or that of the take-up reel, have reduced the size of the upper and lower loops to a certain radius of curvature which is a function of the thickness and elasticity of the film, but apparently never falls below safe limits, an appreciable pressure is exerted by the film against the friction roller. This pressure, increasing the adherence of the film to the friction roller, is identical in its effects to the steady pull of the driving sprockets in the GC4 projector. It permits the friction roller to transmit to the film a steady pull which is out of proportion to the pressure exerted by the loop. In other words, the loop adjusts its own size by controlling the slippage

It is asserted that this automatic regulation of the size of the loop is a further great advantage of this projector and greatly tends to make its threading fool-proof and increase the reliablity of its performance. No care whatever need be taken to adjust the size of the loops before starting since they automatically adjust themselves within a few revolutions of the machine. Many irregularities and faults in the film, the occurrence of which would result in disastrous damage to the film in the ordinary projector, cause in the sprocketless projector only a momentary disturbance followed instantaneously by a return to normal operation.

It is claimed for both the GC4 and the BAG projectors that they may safely be run at speeds as high as 180 feet per minute, and that, by renewing splices after every thousand projections, it is possible to project the same film 30,000 or 40,000 consecutive times without producing more than a normal amount of wear on the film.

TIME-LAPSE CINEMATOGRAPHY IN RESEARCH*

RAYMOND EVANS**

Summary.—*Supplementing a previous paper by Howard Greene published in 1926, the present paper describes further some of the applications of the time-lapse camera. The great value of this camera in conducting research of various kinds is pointed out, particularly with regard to work which is done in the laboratories of the United States Department of Agriculture.*

Accelerated-action cinematography, otherwise known as time-lapse cinematography, hitherto has been thought of, in general, as a species of trick photography, and the product of the art as being diverting, perhaps amusing, rather than informative. The average person who knows anything at all about this art thinks of time-lapse work almost altogether in terms of accelerated growth of plants—mention time-lapse photography and we instinctively think of flowers opening as by magic. The United States Department of Agriculture, however, has come to take an entirely different view of this branch of the cinematographic art. The time-lapse camera has come to be looked upon as an instrument for scientific research rather than as a motion picture camera in the accepted sense.

The mechanism used was described in detail by the late Howard Greene, in a paper read before the Society and published in 1926.[1] Briefly, it is a Universal camera, with clock movement, motor, and associated automatic switches, which enable one to make exposures at intervals ranging from a fraction of a second to one hour, making film that, with normal projection, gives an action which is accelerated in proportion to the length of time between exposures.

This machine was projected more than ten years ago by Mr. George R. Goergens, cinematographer in charge of the department's motion picture laboratory, and a crude working model was built according to his plans. These plans, however, though fundamentally sound, were not carried out successfully in certain details and the machine did not function satisfactorily. When Howard Greene joined the

* Received by the Editor March 27, 1931.

** Office of Motion Pictures, U. S. Department of Agriculture.

staff of the office of Motion Pictures in August, 1923, he was assigned the job of rebuilding this mechanism. He undertook to do this work with his own hands, and the success with which the apparatus now functions is attributable largely to the ingenuity he displayed in devising the various controls that automatically operate the lights, the

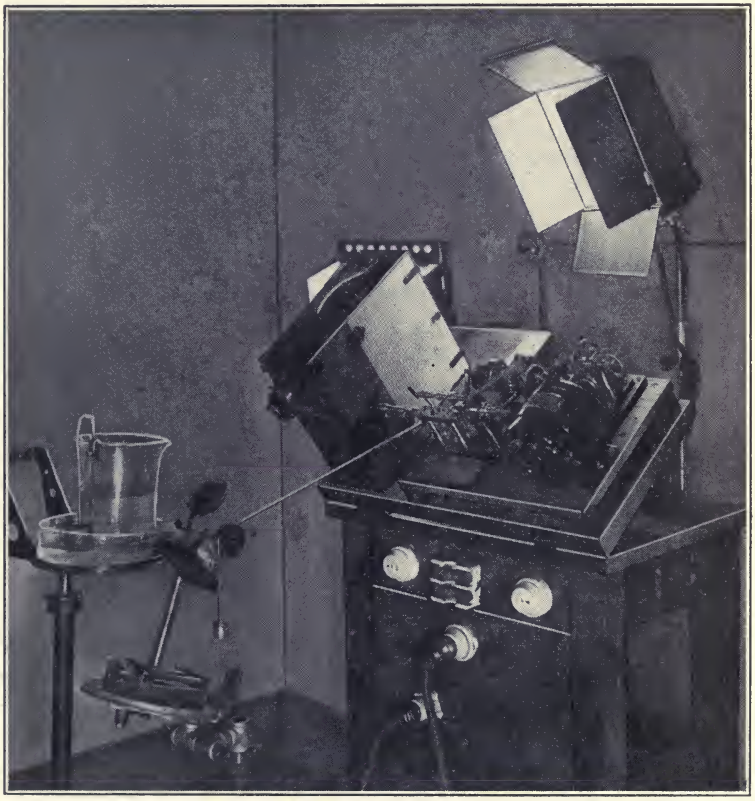

FIG. 1. General view of the mechanism of the time-lapse camera (1931).

shutters, and even the moisture-conserving lid of the box in which the germination tests are run (Fig. 1). Mr. Greene's sudden death last summer deprived the Department of the services of an engineer endowed with inventive genius of a high order.

Shortly before his death Mr. Greene rebuilt the shutter mechanism of the time-lapse camera so as to effect a sharper cut-off than before.

This change has considerably increased the efficiency of the camera. The shutter mechanism is illustrated in Fig. 2, which is a photograph of Mr. Greene's original model. Fig. 3 shows the mechanism in detail as built into the time-lapse camera assembly. Those who are familiar with steam engine cut-off devices, as exemplified by the "duck bills" that are such a noticeable feature of steamboat engines of the walking-beam type, will readily see how Mr. Greene has used the same principle to speed up the shutter at the time of exposure.

Prior to 1928 the time-lapse camera had not been considered seriously as an instrument for research, though there was a vague feeling that it ought to lend itself to some such use. Then, however, while

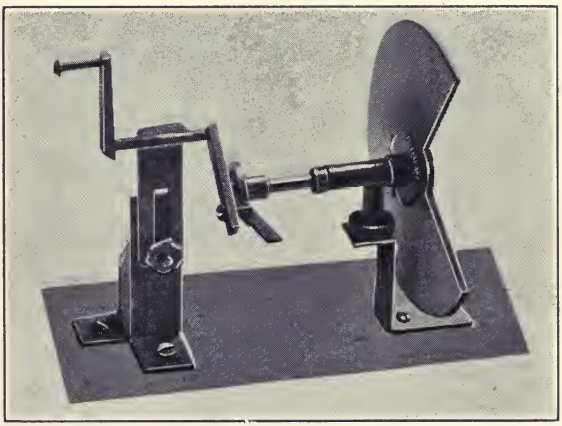

FIG. 2. Model of shutter mechanism.

running some time-lapse shots of germination tests for the Seed Testing Laboratory of the Department, something developed that started the scientists of that laboratory off on a new track, and furnished the new conception of the time-lapse camera as an instrument for research. The work had been planned to show the progress of a germination test as a minor feature of a general film on seed testing, but the behavior of certain seedlings that germinated but which failed to grow proved so unexpected and interesting that an entirely new set of tests was started solely for the purpose of observing the peculiarities of these abnormal seedlings. The time-lapse camera was run for many weeks on these tests and the result was so enlightening to those who conducted the experiment that they took the

film to Rome on the occasion of the Fifth Congress of the International Seed Testing Association and showed it before that body. Dr. Edgar Brown, in charge of the Seed-Testing Laboratory, relates that it was necessary to run the film many times in succession in order that the audience might have an opportunity to observe carefully the action of the abnormal seedlings in question.

During the winter of 1929–30 the research laboratories of the Bureau of Dairy Industry used the time-lapse camera for studying the growth of bacterial cultures. For this purpose a Pyrex glass tube 7 mm. in diameter and 30 meters long, coiled in a flat spiral and filled with an infusion broth, was used as a track along which the progres-

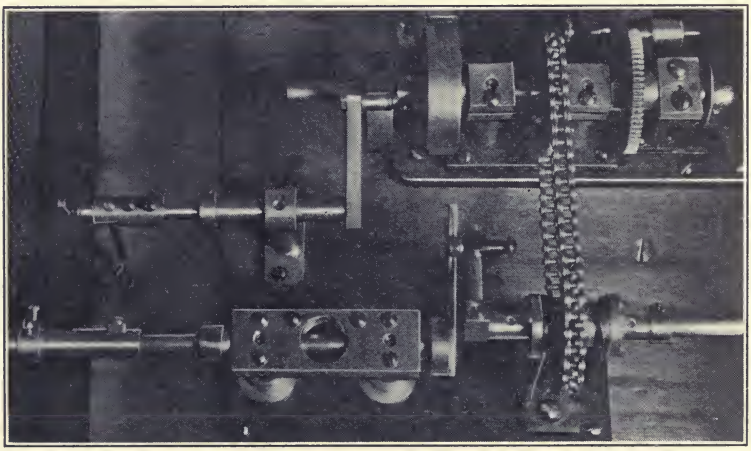

FIG. 3. Shutter mechanism in position.

sion of the bacterial growth was to be photographed. The culture was started at the center of the coil, and as it worked outward through the coil its progress was marked by a decided change in color of the liquid in the tube. The coil was so mounted as to fill the field of the camera. The room in which the work was done was held at an even temperature by automatic controls and exposures were made at five-minute intervals. A watch, placed in one corner of the field, provided a check on the timing mechanism of the camera. About eight days were required for the culture to traverse the 30-meter length of the coil, and during that time about 140 feet of film was exposed.

This film was then projected with a film-strip projector to the full

size of the coil itself, and working on this projected picture, one frame at a time, a series of measurements was made and tabulated. These measurements, disclosing the progress of the culture in millimeters per hour, were plotted against the total hours of growth, and the resultant graph indicated beyond question the fact that the growth of the bacteria was intermittent and that the recurring periods of growth and rest were fairly rhythmical. These facts were of profound interest to the investigators who conducted the experiment. The paper on the subject, by L. A. Rogers and G. R. Greenbank published in the *Journal of Bacteriology*, aroused keen interest among bacteriolo-

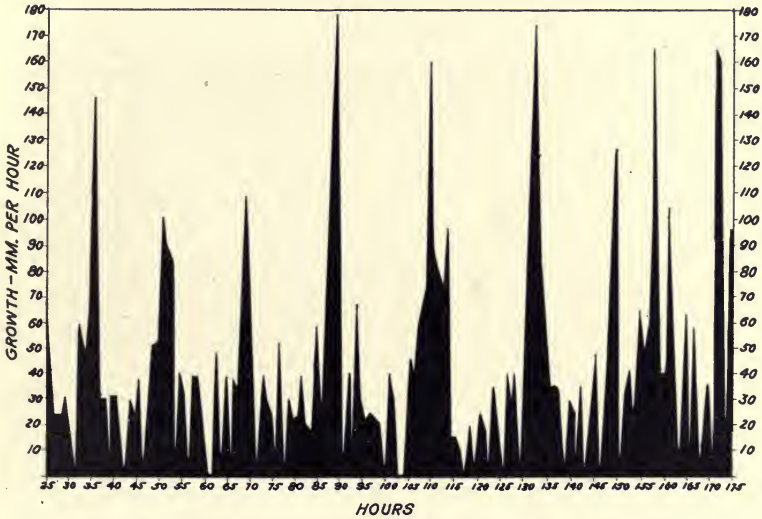

FIG. 4. Curve illustrating intermittent growth of bacteria.

gists in general, since the time-lapse cinematography in question served to establish facts that had been suggested by the growth of cultures on agar plates, but which could not positively be proved by that method. As to the ultimate scientific significance of this fact, one can only conjecture; it may or may not have a bearing on intermittent fevers. In any event it provides further evidence of the value of time-lapse cinematography in research.

It should be noted that neither in the case of the germination test, nor in that of the culture test was the resultant film used as a motion picture in the sense in which we are accustomed to think of motion pictures. In the first instance the film was projected over and over,

to enable the observers to make careful note of minute movements of the roots and stems of the seedlings; in the second instance the film was not used on a motion picture projector at all but on a slide projector.

In this connection, then, the time-lapse camera should be considered as an instrument in the same category as the microscope; it makes visible to the eye *action* that is normally invisible, as the microscope makes visible to the eye *objects* that are normally invisible. The microscope exaggerates space; the time-lapse camera epitomizes time with reference to movement, and shows motions and rhythms which are hidden by the normal lapse of the hours.

REFERENCE

[1] GREENE, HOWARD: "Apparatus for Time-Lapse Motion Picture Photography," *Trans. Soc. Mot. Pict. Eng.*, No. 26 (November, 1926,) p. 147.

THE LIFE OF SOUND FILMS IN HUNGARY*

ALEXANDER SZEKELY**

Summary.—*The causes of deterioration of film prints in use are pointed out and briefly discussed. Deterioration results largely from the drying out of the film, due to its protracted exposure to heat in the projectors. Various defects in the design of American projectors and their consequent contribution toward film deterioration are pointed out.*

The problem of dealing with damaged sound films has, up to the present, received rather one-sided consideration. The sound technician is interested only in preventing damage to the sound track, or, in the case of film with sound disks, he is only concerned with the suitable replacement of those parts which have to be cut out because they are mutilated. These matters are unquestionably of the greatest importance for good sound reproduction and uninterrupted synchronism. There are, however, other points to be considered in this connection.

Premature deterioration of film prints is a vital problem, particularly from the standpoint of the film agent in the smaller states, because the consumption of a large number of prints means a considerable increase in operating costs.

Projectors have been improved to such a degree that the film passes through them with the greatest ease. As a result of this improvement, however, the speed at which the projectors were operated increased correspondingly. The public demanded more and more, and the cinemas lengthened their programs accordingly. Gradually it came about that the projection machines were operated at speeds of 40 to 50 pictures per second. It is obvious that the improvement in equipment was thus counteracted by the increased speed of projection.

Film technicians therefore hoped that the introduction of synchronized sound would improve this condition, since sound films may be projected only at a speed of 24 pictures per second. Since modern

* *Filmtechnik*, **6**, No. 25, Dec. 13, 1930. Translated by G. Jung, Kodak Aktiengesellschaft, Berlin, Germany.

** Associated Hungarian Ciné Industries.

projection machines are capable of giving reliable service at even greater speeds it was logical to assume that the lower projection speed would result in a longer life for the print.

Experience has, however, proved this assumption to be incorrect. The films are mutilated just as quickly, if not more quickly, than silent films projected at a speed of 50 pictures per second. Since the modern projection machines are at least as well constructed as those used for the projection of silent films, the cause of the damage to the films must be looked for elsewhere.

In order to save time or for reasons of convenience, projectionists have long made it a practice to splice two, or even three, reels of film together so as to make rolls of 2000 to 3000 feet. They could then project 6000 feet without re-threading by switching over from one machine to the other. This same practice has been followed with film sound records but had to be modified for films with disk records.

When operating with disks it is not possible to place three consecutive acts on one machine, and it is therefore necessary to switch over from one machine to another after each act. The film is spliced together in the following manner: The first act with the third or perhaps with the fifth, and the second act with the fourth or sixth. When the first act is nearing the end, of which fact the operator is warned by a punch mark which he has put in the disk, he switches over to the second machine for the second act. When this act is nearing the end, the punch mark in the disk causes a noise which is easily noticed, even by the audience, and the operator switches back to the first machine and begins to project the third act, which has been spliced to the first act. The fifth act, for example, remains in the machine from the beginning of the first act until the ending of the fifth act. If the machine is operated at a speed of 24 pictures per second this corresponds to a period of 40 minutes. This means that for the duration of 40 minutes this film is subjected first of all to fire hazard and, secondly, to drying out at a room temperature of from 95° to 105°F. This is the reason why sound films show a tendency to dry out more quickly than silent films, which never remain in the projection machine for more than 15 minutes, even if the roll is 2000 feet long. The greater deterioration of sound films is therefore due to increased drying out of the film with consequent brittleness.

What may be regarded as an even greater evil, however, is the fact

that the mechanism of the sound reproducing apparatus is of faulty design. Apparently, in designing this part of the machine the manufacturers had only one object in mind, *viz.*, that the sound track should pass exactly over that portion of the sound reproducing device where the illuminated slit is located and at a uniform speed. Smooth passage of the film and uniform contact with the guide tracks as well as more uniform motion of the sprockets was sought and attained.

Correct positioning of the film is assured by using the bow-shaped guide track against which the film is held while it passes the slit. The film is subjected to greater friction because of the large additional surface of contact in the sound track guides and consequently there is a greater strain on the film loop. Extra sprockets located beneath the reproducer unit also increase the wear.

It did not occur to the designers, however, to arrange these sprockets in such a manner that the film loop does not form too sharp a curve. As it is, the film which has already become too dry, is liable to jump off the teeth of the sprocket where it turns sharply, especially at poorly-made splices. In this way both the picture and sound record are frequently damaged by the sprocket teeth. On some of the American machines ordinary pressed sprocket wheels have been used for this purpose, the teeth of which do not even conform to the international standards, and so cause continual damage to the film.

It is also a mistake to provide an additional guide roller in the lower magazine since even those films which have a disk sound record have to pass over five sprocket wheels, instead of over three as formerly, increasing the risk of damaging the perforations.

The friction drive on the take-up spindles of some American machines is also wrongly designed, putting such a strain on the film as to cause the perforations to break as they pass over the hold-back sprocket. On some machines equipped with film sound reproducers, however, the sprocket wheels are provided with 32 teeth instead of 16, permitting the film to be engaged by 20 teeth. The purpose of this kind of sprocket is to insure smooth motion at the sound aperture and is another indication of the prevailing tendency to improve the sound reproduction at the cost of extra wear on the film. The fact that the film is engaged by 20 teeth can, however, cause such considerable damage as to reduce the life of the film by half, and for this reason it is essential that these mechanisms be redesigned.

Designers of sound film apparatus should not consider the problem of protecting the film against undue wear and tear as being only of secondary importance.

Some American firms have reported that the life of a colored print is estimated in America at 30 days. If, in Hungary, it should be necessary to replace each print after a run of 30 days it would be more profitable for the producer not to produce the film at all. Within 30 days it is not possible to earn even the $1200 necessary to cover the material cost of such a copy.

It is necessary, therefore, to call to the attention of those responsible for the design of this equipment the facts related above, and urge them to concentrate their efforts on the elimination of the defects described.

TEACHING HEALTH WITH PICTURES*

C. E. TURNER**

Summary.—*The various subjects and types of subject matter included in educational films for classroom use together with the relation between these subjects and the value of films as aids to instruction are discussed. A series of films is being produced with the coöperation of the Department of Biology and Public Health of the Massachusetts Institute of Technology, and includes, in general, material dealing with hygiene and physiology, and the relation between these and disease prevention. The value of the films lies in the fact that a visual appreciation of a particular subject is generally much more vivid and lasting among children in the lower grades of school than the same material simply presented in words, especially when the visual presentation is supplemented by an oral presentation and discussion of the subject.*

What is perhaps the most extensive series of educational films for health teaching ever undertaken by a single organization is now in process of production by Eastman Teaching Films, Inc. The series is being produced with the coöperation of the Department of Biology and Public Health of the Massachusetts Institute of Technology. Prior to the development of this set of films there were some three hundred health films available in the United States. Most of these had been produced for general audiences, the producers having the general adult audience in mind rather than the pupil or school audience. Some are useful auditorium films. The great majority of these films give relatively little information and are designed primarily to produce a particular attitude on the part of the person who sees the film. Most of them carry a story, and any film which is essentially dramatic in its nature must compete or suffer comparison with the films which children see at the theaters—films upon which hundreds of thousands of dollars are spent in production.

The Eastman Classroom Films represent essentially a new type of health film. Those which have been made in this series so far are primarily on informational subjects. The importance of habit

* Received by the Editor March 6, 1931.

** Professor of Biology and Public Health, Massachusetts Institute of Technology.

training and motivation toward proper health behavior is recognized and a few films have been made for primary schools which contribute primarily to habit and attitude formation. The films already completed, however, are nearly all subject-matter pictures for pupils more than ten years of age. The films now on the market include *Bacteria, Circulation, Circulatory Control, Blood, Breathing, Digestion, Diphtheria, How Teeth Grow, The Living Cell, Mold and Yeast, Posture, Sewage Disposal, The Skin, Tuberculosis, Muscles, Feet, Body Framework, Good Foods—Milk, Fruits and Vegetables, Bread and Cereals,*

FIG. 1. The giving of toxin-antitoxin from the film *Diphtheria*.

A Drink of Water, Food and Growth (A Rat Feeding Experiment), Care of the Teeth.

To some extent these films carry motivation; for instance, *Posture* illustrates the fact that the athlete who is putting a strain upon the body is likely to use the body in its proper mechanical position. An internationally known tennis player and other athletes are seen in action, to illustrate the strength and grace of the straight back in activities of which the child is fond and to which he looks forward. The body of the film consists of teaching material which shows good posture and how it is attained, the nature of poor posture and how it

is corrected. Scientifically-prepared animation of the body framework and important muscles shows just what takes place in the body during the change from poor posture to good posture.

Similarly in other subjects desirable practices are shown. *Tuberculosis* shows the nature of the turbercle in the lung, the nature and importance of the early detection of tuberculosis and the day's schedule in the preventorium. This institution is presented not as a hospital but as a place to which the child who may be subject to tuberculosis, predisposed to it, or threatened with it, can enjoy a happy period of a few months under an ideal health program. The habits which the children in the preventorium are following are those which teachers are urging upon all children; thus classroom discussion concerns basic hygienic practices.

The film, *Skin*, shows in some detail, by microscopic photography and by scientific animated drawing, both structure and function. The definite visual impression is superior to any knowledge which the child can obtain from the text-book or general discussion concerning such cellular organs. A greatly enlarged view of the skin of the hand shows the creases of the skin and the pores. Views of the hand are shown when both clean and dirty. Shots of this type provide a new conception of cleanliness and make it more to be desired.

In some of the films it is obvious that the subject lends itself to the presentation of scientific information almost exclusively. There is always some element of health training, however, which is suggested either in the film or in the carefully prepared teacher's guide which goes with it. The teacher is relied upon to supplement the film in any needed respect with classroom discussions.

Four films have been made on the subject of *Good Foods* for little children in the first three grades. These pictures seek to make good foods more attractive to the children by showing different animals eating the foods and by showing children enjoying them. The films furnish valuable material, too, for correlation with nature study, oral English, reading, composition, penmanship, spelling, and art. The teachers' guides which accompany the films indicate ways of conducting such correlations and suggest many interesting pupil activities which may be developed out of the pictures.

There are certain facts which are worthy of note in connection with this entire series. In the first place, each film is planned to teach a definite piece of material. It is designed for a particular age-level, but, like a working model, it may be used advantageously for groups

varying several years in age. The scenario is laid out with the same care and the same scientific accuracy as would be a series of model lessons or a text-book. Each picture is produced by an established commercial film-producing organization and undergoes careful editorial revision before it is put into production.

A teacher's guide of some ten to twenty pages is prepared in connection with each film. It describes the film scene by scene, giving in addition the primary teaching objectives, suggested correlations, and questions for review. Each film is divided into teaching units and these units are indicated in the film by titles printed in large capitals. They are also indicated in the teacher's guide. For example, *Tuberculosis* presents, first, a unit dealing with the tubercle

FIG. 2. The film on *Digestion* shows what takes place in a villus of the small intestine.

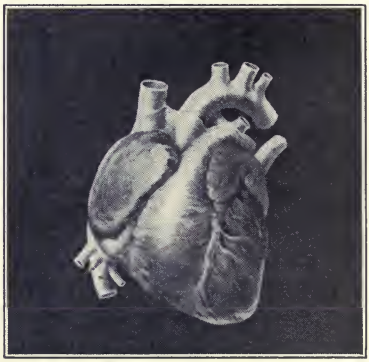

FIG. 3. The film on *Circulation* shows the action of the heart.

bacillus, second, a unit dealing with examination for early signs of tuberculosis, and, third, a unit which depicts the ideal mode of living for preventing the development of tuberculosis. These films are packed full of information. In most cases not more than one unit could be used at a lesson.

There are few titles; film footage is too valuable to fill with words. Some of the health films which were prepared several years ago contain one-third to one-half of the footage in the form of printed materials. It would seem to be less expensive and more satisfactory to do necessary reading elsewhere. The ideal is to present to the child or sell to the school a maximum of picture and a minimum of title in every film.

The pictures are printed on 16 millimeter safety stock and the picture can be stopped at any time on the screen. In the ordinary film there are nearly 16,000 separate frames or pictures, each of which may be considered a potential still picture. The wise teacher will stop the picture frequently and develop class discussion of the material. In fact, instead of supplanting the teacher the film is a new instrument in his hands. It enables him to do things he had been unable to do previously, but requires real professional ability on his part.

These films cannot be used advantageously without advance teacher preparation. The teacher who shows the film without discussion or comment and dismisses the class is not a professional person. Little learning will have been achieved in such a case by the children. Much of the material needs discussion and explanation at the time when the film is shown.

It is felt that these films contribute to the training of the child's power of observation. In teaching the natural sciences teachers stress the development of this power. Pictures as well as specimens may be studied for detail. One of the chief values of the film is its power to present to the child anything which can be seen directly, microscopically, or telescopically, or which can be imagined and reproduced in drawing. A few weeks ago the writer showed some of these films to a group of university men, including doctors of medicine. At the end of the showing a physician said, "These films should be shown in medical schools."

When asked if he meant that the films were too difficult for high school children, he replied, "No, I mean that here, through photography and animated diagrammatic drawing, visual concepts of physiological processes are presented more clearly than we, who are physicians, have been able to imagine them from our readings and dissections."

Any person at any age-level will learn new facts concerning operations of the body from seeing those processes depicted on the screen, devoid of all gruesomeness and the confusing elements involved in the examination of the human body itself.

Pictures permit considerable freedom from those problems which involve vocabulary. The child knows what is happening. He may not be able to describe it perfectly, certainly not in the vocabulary of the physician, but he can draw pictures of the sort of thing he has seen and he can tell you in his own words what has taken place. As

a matter of fact, it is one of the best methods of developing vocabulary. Teachers know that it is much more valuable to have the child in the position of seeking words with which to express an idea than it is to have him in possession of words which are not associated with a definite concept. Here is a splendid opportunity for vocabulary development and an association of words with structures and functions.

The films are made with the same accuracy which would be needed if they were to be shown to physicians, although they were prepared for public-school pupils. Teachers should think of these subject-matter films, not as entertainment "movies" but as source material—in fact, each film brings to the teacher an entire series of models, charts, and classroom demonstrations. Instead of spending many hours getting the demonstration ready, the teacher merely goes to the cupboard and gets the particular film desired. Obviously, talking pictures cannot be used to advantage for films of this type which demand repeated, sectional study. The films are bought out-right by the schools, since it is less expensive and much more satisfactory to buy than to rent them.

INDUSTRY ADOPTS THE MOTION PICTURE CAMERA*

ALLAN H. MOGENSEN**

Summary.—Although the study of motion is not new, the application of the motion picture camera to this study provides an important tool by means of which the study is today being widely applied in industry. The purpose of motion study is to first record the actual motions involved in any particular industrial operation; second, to furnish a means for analyzing these motions; and third, to furnish an opportunity for eliminating or revising the motions so as to develop the one best way of accomplishing the desired results. The value to industry of such a study is pointed out, together with the fact that the application of the motion picture camera to such work may be quite an important by-product of motion picture engineering activities.

To the person not directly connected with manufacturing, the terms time and motion study usually imply some sort of "speed-up" or "stretch-out." In other words, something done by an efficiency expert to make people work harder. Nothing could be further from the truth. Motion study is not a speeding-up process. By its use, the one best way of doing a job is sought and, when found, it is usually the easiest way of doing it.

Neither is motion study new. Frank B. Gilbreth in his quest for the one best way many years ago laid so firm a foundation and did the work so thoroughly that much time will yet elapse before industry will make full use of it. Starting with progress photographs taken at weekly intervals, Mr. Gilbreth developed the technic of micro-motion analysis with the motion picture camera as it is known today.

In making such a study, the first step is to record the present conditions and method. A motion picture is made of the worker, including in the field a micro-chronometer. This is a fast moving clock that gives a time record in units of 0.0005 minute. Thus there is on the film an exact record of the motions performed together with the time at which each occurred. The film is then projected one frame at a time, and the data transferred to cross-section paper. This is known as a simultaneous motion-cycle chart, or "simo-chart." Two columns are used—one for each hand. Each column is divided so

* Received by the Editor March 25, 1931.

** McGraw-Hill Publishing Co., New York, N. Y.

that there is a parallel space for each finger, and by using colors and symbols for each element of motion, the whole cycle is plotted. The elements of motion are called "therbligs," and it has been found that seventeen of these can be used to represent all the elements of hand motions. Thus by taking the data from the film and recording it in this form, it is possible to see the exact therblig used and the time consumed. One method can be compared with another, the best sequence of the fewest therbligs set up synthetically, and the one best way established.

Naturally, the motion picture alone will not reveal any facts to the

FIG. 1. Making the motion-study film.

person who is not familiar with the fundamentals of motion economy, and in many instances operations may be studied and new methods suggested without using the camera. These principles are nothing more than common sense, and can be readily grasped. A few might be mentioned, in order to indicate their nature.

All of the work is based on the strong human tendency to form habits. Materials and tools are located at definite places and at the proper height, so that for these locations there will be a minimum of effort, a minimum of distance traveled, a better distribution of

motions of the right and left hands, and both hands may be used simultaneously and preferably in opposite directions. One always encounters resistance in attempting to overcome strongly formed habits, and, as will be shown later, the motion picture is of considerable value in aiding the forming of the new habits. Gilbreth used a simple example to bring out his point when a worker would claim that the new method was more difficult and took more time than the old. He would time the person writing his name, and then would tell him to write it, omitting alternate letters. At first this would take longer, but on repeating it a number of times, the person would finally be able to write the name in about half the time.

The introduction of sixteen millimeter equipment did much to make motion study possible for the average manufacturing plant. For short cycles, the ordinary spring-wound camera may be used, while, where longer studies are necessary, either a hand-cranked model or motor-driven camera is used. At present, one of the manufacturers of these cameras is working on a constant-speed camera which will eliminate the clock. Meanwhile, improvements in the micro-chronometers have eliminated many of the difficulties formerly encountered. Faster lenses and film make the problem of lighting a simple one; in fact, many excellent industrial sixteen millimeter films have been made with no artificial light at all. Critical focusing has made composition of the work-place easier, and insures the inclusion of all parts of the operation. Analysis of the film is simplified by the introduction of small projectors that do not burn or buckle the film when it is studied for long periods of time. While the cost of studies made with professional equipment could in most cases be justified by the savings effected, the lower cost of the sixteen millimeter film and equipment makes possible analyses and improvements in many instances where these savings might not be so evident at the start.

The camera is of great benefit in studying operations where the machine or tool plays an important part. Motion studies of these operations often indicate a complete revision, whereas ordinarily one might merely attempt to make the best possible use of whatever equipment was available. As a result, in plants where principles of motion economy are followed, one finds the tool and machine designers and builders supplying equipment that often makes possible a several hundred per cent increase in production without greater effort on the part of the man who is to use this equipment, and often the effort required is even less than it was before.

The camera is of inestimable value in training the men who make time and motion studies. They learn to think in terms of motions, and can recognize poor motion practice on the part of even the apparently fast worker. They realize that skill and speed are not one and the same. Attention is directed to all phases of the problems, and often changes will be suggested that completely revolutionize methods and practice, where without this training, only minor improvements would have been suggested.

For setting up the standard method to be followed, two applications are seen. One is to use the film to train new operators in the proper sequence of motions and to possibly revise the methods of older operators who may get away from the method as set up. The other use is to establish a method in one plant and then to use the film to set up the method and train new workers in other plants. Several concerns are using this means of getting uniformly good practice in their various plants, both here and abroad. A complicated operation that formerly required considerable time before a new worker could attain performance even approaching the best workers can now be taught more thoroughly and with much less effort and time. The skill of the best worker can be made available to all the workers, and certain parts of an operation can be selected from the methods employed by various workers, as the one best way is seldom found in the sequence of any one worker.

For group work, the motion study affords the best means of finding what each worker is doing simultaneously. The simo-charts for each worker can then be plotted on a single sheet of paper, the work of the group can be simplified, and the one best way set up.

This paper has not attempted to cover the industrial field of uses of the motion picture. While interest in motion study has passed the development stage, and many industrial concerns are using it to their advantage, numerous other uses are being discovered. Instruction of employees in safety principles, setting up standard practice for inter-plant usage, and many others are being applied by industry daily.

As stated at an earlier point, motion study does not always require the motion picture camera. Certain operations can be improved merely by application of the principles of motion economy. Certain operations would not justify the time and expense of study by this method. But where there is sufficient activity, where the savings in time, money, and fatigue seem to indicate that the motion picture

study can be used, it is one of the most valuable tools for research into manufacturing methods. The plant in which no attention is being given to these methods may find itself lost in our ever-present search for better methods and lower costs.

ON THE THEORY OF TONE REPRODUCTION, WITH A GRAPHIC METHOD FOR THE SOLUTION OF PROBLEMS*

LOYD A. JONES**

Summary.—*The problem dealt with in this paper is that of finding how closely it is possible by the photographic process to produce a reproduction which will, when viewed, excite in the mind of the observer the same sensation as that resulting from the observation of the original. The treatment is divided into the main parts: the first dealing with the possibility of reproducing exactly the objective factors of the visual stimulus, and the second dealing with the subjective phase of the problem. A fairly complete system of terminology and symbols is developed in order to present more clearly the discussion, which necessarily deals with a large number of different factors. A graphic solution of the problem is given by means of which it is possible to determine quantitatively the departures from exact reproduction of both brightness and contrast in the finished print. This graphic solution is then extended to include the subjective phase and a final curve is obtained which indicates the extent to which reproduction of the subjective sensation is obtained. A practical application of the method is given, illustrating the results obtainable by the use of photographic materials, the sensitometric contrasts of which have been previously measured.*

The problem of ascertaining the exact extent to which it is possible by the photographic process to produce a pictorial representation of an object which will, when viewed, excite in the mind of the observer the same subjective impression as that produced by the image formed on the retina when the object itself is observed has engaged the attention of workers in the field of photography for many years. There are many phases of the subject to be considered, and a complete treatment requires a careful analysis of the various factors upon which depend the operation of our visual perception of space and spatial relations. A complete analysis, therefore, leads not only into the realm of physical science, but also into those of psychology and philosophy. It is not the purpose of this paper to

* Published: *Abridged Scientific Publications* from the Research Laboratory of the Eastman Kodak Company, **IV** (1919–1920) p. 99. Published in full: *J. Franklin Institute*, **190** (1920) p. 39; *J. Opt. Soc. Amer.*, **4** (1920), p. 420.

** Research Laboratories, Eastman Kodak Co., Rochester, N. Y.

present such a complete treatment, but to deal with a single phase of the subject.

A careful consideration of the various factors upon which depend our visual perception of space leads to the conclusion that brightness and brightness differences (*i. e.*, contrast) are by far the most important factors which are reproducible by the photographic process. The form factor (including size, shape, position, definition, *etc.*) to which so much importance is usually attached and which is conditioned by the performance of the image forming system, depends for its effectiveness upon the proper rendition of brightness differences. The proper reproduction of brightness and brightness differences, therefore, is of preëminent importance, and it is with this brightness factor and the possibility of its correct reproduction by the photographic process that this paper will deal.

This problem of tone reproduction, as it is commonly called, has frequently been regarded as requiring only the correct reproduction in the picture of the actual physical brightness of the original, and of the actual contrast relations existing between various areas of the object. When we consider, however, that a given brightness or contrast may produce an entirely different subjective impression, depending upon the state of adaptation of the observer's eye, it is obvious that such a treatment of the subject cannot afford a complete solution of the problem. The problem may, in fact, be divided into two general parts: the one, which we may term the objective phase, dealing with the reproduction of the actual physical brightnesses and capable of being completely solved by purely physical methods; the other, the subjective phase, including a consideration of those factors which determine the nature of the subjective impressions produced by the action of given physical stimuli under various conditions, and requiring the use of psycho-physical methods and data for its adequate treatment.

SIMPLIFYING ASSUMPTIONS

In order to simplify the subject and bring it within the limits of a single paper, it will be necessary to make certain simplifying assumptions. Since the sensivitity of the photographic plate to radiation of different wave-lengths is in general radically different from that of the eye, objects in which color is present have not in general the same brightness when considered from the visual standpoint as when the evaluation is in terms of the photographic plate.

Let us, therefore, assume that all areas of the object considered are both visually and photographically non-selective (*i. e.*, colorless). Under such conditions values of visual brightness are directly proportional to photographic brightness. Thus, this treatment will deal with brightness relations uncomplicated by any consideration of selectivity. Let us assume further that all photographic deposits considered are also non-selective in order that visual and photographic density values may also be considered identical.

TERMINOLOGY AND SYMBOLS

The problem to be treated involves so many operations, materials, and inter-relations that it is of considerable importance to adopt at the outset a logical system of terminology and symbols. The factors involved are:

		Symbol
1.	Object	O
2.	Negative sensitive material	X
3.	Negative	N
4.	Positive sensitive material	Y
5.	Positive	P
6.	Material reproduction	MR
7.	Subjective reproduction	SR
8.	Subjective object	SO

The first six of these are objective or physical in nature, the last two subjective or perceptual. An evaluation of O in terms of MR gives a function which defines the extent to which actual objective reproduction of brightness is obtained under the limiting conditions assumed, while an evaluation of SO in terms of SR gives the function required to determine the reproduction of the subjective impression.

The symbols as indicated will be used as subscript letters attached to the symbol for the various physical factors applying to them.

The physical factors are:

	Symbol
Radiant flux	F
Illumination	I
Brightness	B
Reflection coefficient	R
Transmission coefficient	T
Exposure	E
Time	t
Density	D

In Table I is given a schematic outline showing the various steps

in the computation of the final result of a given tone reproduction problem. It will be noted that the process is divided into ten distinct steps, represented by the Roman numerals I to X. The necessary factors required at each step are designated by the corresponding arabic numerals. In the parentheses, designated by the letters *A*, *B*, *C*, *etc.*, are statements either verbal or symbolic of the transformation factors which convert the factor of one step into that of the next succeeding step. At the starting point, I, it will be noted that the "subjective object" is taken, by which is meant the subjective impression of brightness and brightness difference excited in the mind of the observer. This impression, it is obvious, is that which it is desirable to reproduce rather than the actual physical brightness values which are measured by the usual physical methods. In practice, however, it is more convenient to take as the actual starting point of the operation the measured brightness values, B_o, of the object and to evaluate the subjective relation between B_o (II) and B_{so} (I) relative to that between B_{mr} (IX) and B_{sr} (X) after having obtained the necessary values of B_{mr}.

TABLE I

I. The Subjective object (*SO*).
  1. Subjective brightness of object (B_{so}).
    A. (Adaptation level of observer when viewing object, A_o, $B_{so} = f(A_o)$.)

II. Object (*O*).
  2. Brightness (B_o).
    B. (The constant of the image forming system, K_x.)

III. Image on the *X* (negative) material.
  3. Illumination (I_x) $= B_o . K_x$.
    C. (Exposure time, t_x.)

IV. Exposure on the *X* (negative) material.
  4. Exposure $E_x = (I_x . t_x)$.
    D. (Development, fixing, washing, drying, intensification, reduction, *etc.* Specified by $D_n = f(E_x)$.)

V. Negative (*N*).
  5. Density, D_n, or transmission, T_n.
    E. (Illumination, I_n.)

VI. Image on the Y (positive) material.
  6. Illumination, $I = (T_n . I_n)$.
    F. (Exposure (printing) time, t_y.)

VII. Exposure on the *Y* (positive) material.
  7. Exposure $E_y = (I_y . t_y)$.
    G. (Development, washing, fixing, toning, *etc.* Specified by $D_p = f(E_y)$.)

VIII. Positive (P).
8. Reflecting power, R_p.
H. (Incident illumination, I_p.)
IX. The material reproduction (MR).
9. Brightness (B_{mr}) = ($R_p . I_p$).
I. (Adaptation level of observer, $A_{mr} . B = f(A_{mr})$.)
X. The subjective reproduction (SR).
10. Subjective brightness (B_{sr}).
J. (The relation between B_{sr} and B_{so} determines the extent to which the desired subjective impression of tone is accomplished. $B_{so} = f(B_{so})$.)

THE NECESSARY DATA

Before considering the method of obtaining the tone reproduction solution, it will be well to consider briefly the individual groups of data which must be utilized. These may be summarized as follows:

1. Relative to the observer: A_o, adaptation level of eye when observing the object.
2. Relative to the object: B_o, brightness values for various areas of the object.
3. Relative to image forming system: K_x, factor converting B_o to I_x.
4. Relative to negative material: $D = f(E)$, the H and D curve of the material.
5. Relative to printing system: I_n, illumination incident on negative during printing.
6. Relative to positive material: $D = f(E)$, the H and D curve of the material.
7. Relative to material (objective) reproduction: I_{mr}, illumination on the print during observation.
8. Relative to the observer: A_{mr}, adaptation level of the eye while observing the reproduction.

A GRAPHIC SOLUTION

The graphic solution is presented in Fig. 1, the necessary curves being plotted in the four quadrants designated for reference as I, II, III, and IV. For convenience in plotting a double scale along the OX' axis, a separation between the upper and lower quadrants is made, the two points designated by O being, in fact, identical.

Along the line OX is established a suitable logarithmic scale upon which may be plotted the logarithms of the brightness values for the various areas of the object. Let the points a_o, b_o, and c_o represent three typical object-brightness (B_o) values, a being the lowest and c the highest which exist in the object considered. After having located on this scale (log B_o) the various points representing the

brightness values of the object which it is desired to reproduce, the curve A is plotted directly under the log B_o scale, and properly placed in the horizontal direction relative to the points on the log B_o scale. This curve A is the characteristic H and D curve of the sensitive material on which the negative is made. It must be deter-

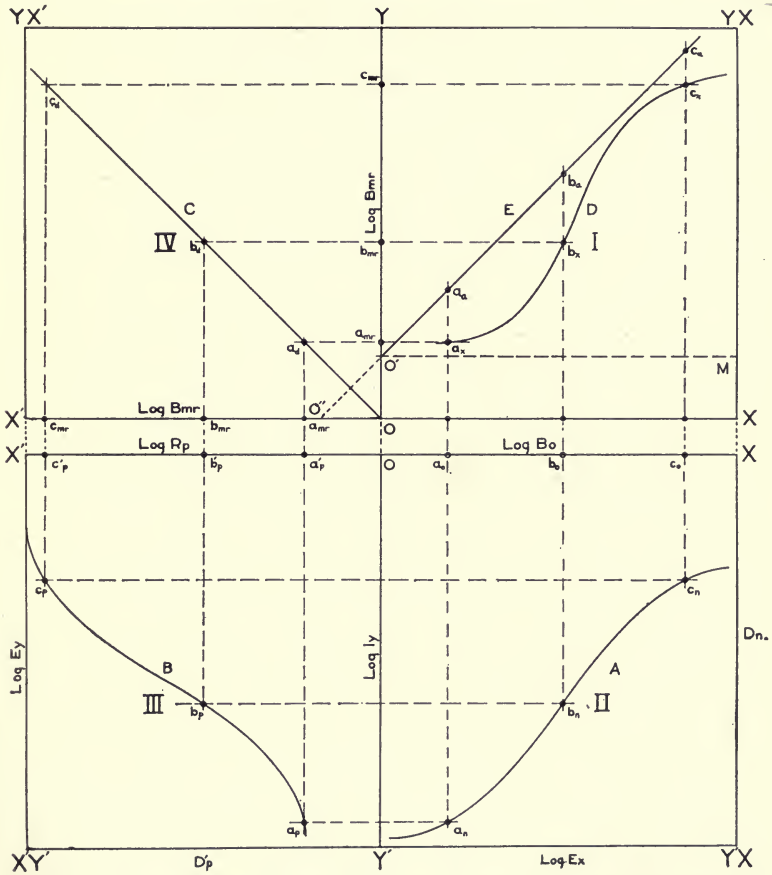

FIG. 1. Graphic solution for the objective phase of tone reproduction.

mined by sensitometric methods such that it is a true representation of the characteristic of the negative material when used under the conditions existing in the making of the negative, such conditions including those factors operative in transforming the latent into a real image as well as the necessary physical condition relative to

quality and intensity of the exposing radiation. Curve A is plotted with values of log exposure as abscissas and densities as ordinates, the log E_x scale being laid off on the line Y', $Y'X$, and the density scale on the $Y'X$, X.

The density values for the negative include the density of both fog and supporting material as well as of the silver deposit due to the exposure, thus being values of total density. Since the assumption has been made that the deposits are non-selective, it follows that the color-coefficient is unity. It was assumed that the density values are determined under such conditions of illumination (diffuse or specular) that they are true values for the printing process used, contact, or projection as the case may be. The unit interval on the log E_x scale must be equal to the unit used in establishing the log B_o and equal also to the unit interval of all log-scales used throughout the solution. The adjustment of the scale of log E_x along the line Y', $Y'X$, depends upon the choice of the negative density value (D_n) by which it is desired to render a given object brightness. For instance, if it be desired to render point a_o, the lowest brightness in the object by a negative density of 0.20, the scale of log E_x is so adjusted that when curve A is plotted the perpendicular dropped from point A will cut the curve at a density value of 0.20.

The relation between the log B_o and the log E_x scale will now determine the exposure that must be given to the sensitive material on which the negative is to be made in order to obtain the rendition of the chosen brightness value by the desired negative density. In order to compute the exposure time t_x, however, certain constants of the image forming system used in imaging the object on the sensitive material must be known.

Let the constant K_x be defined as that value by which a given value of object brightness B_o must be multiplied in order to obtain the value of the illumination I_x incident on the negative material at the point where that particular area of object is imaged. K_x is, therefore, the value which satisfies the equation.

$$B_o . K_x = I_x$$

$$\frac{E_x}{I_x} = t_x$$

$$\therefore\ t_x = \frac{E_x}{B_o . K_x}, \text{ or}$$

$$\log t_x = \log E_x - (\log B_o + \log K_x)$$

In order to compute t_x (K_x being known), it is necessary only

to read the values of log B_o and log E_x at the points where any line parallel to OY cuts the two scales, and substitute in the equation.

The value of the constant K_x depends on several factors such as diameter of stop, object and image distances, spectral transmission of the lens material, *etc.* The evaluation of K_x in terms of these various factors is somewhat complex, and will not be considered at this time.

It is convenient to regard the negative produced by the development of the exposed sensitive material (X) as a means of impressing a series of various exposures upon this sensitive material (Y) upon which the positive or print is to be made. The D_n scale must, therefore, be transformed into an inverse scale giving the relative values of the various illuminations which the negative will allow to act upon the material Y during the printing operation. Let I_n be the illumination incident upon the negative during printing and I_y the illumination transmitted by the negative and therefore incident upon the positive material Y. Let T_n be the transmission coefficient of the negative. T is related to D (density) by the equation:

$$D = \log \frac{1}{T}$$

and T is defined by the equation,

$$T = \frac{I_1}{I_0}$$

where I_0 = the incident illumination; I_1 = the transmitted illumination.

Hence:

$$\begin{aligned} I_y &= I_n . T_n \\ \log I_y &= \log I_n + \log T_n \\ &= \log I_n - D_n \end{aligned}$$

Since I_n is a constant, differentiation gives $d \log I_y = -d\ D_n$. Hence, any interval on the log I_y scale is numerically equal to the corresponding interval on the D_n scale but of opposite sign. Now along the line OY' establish a log scale on which the value of I_y computed from the known values of D_n and some suitably chosen value of I_n may be plotted.

In quadrant *III*, plot curve B, the characteristic curve of the positive material (Y). This also must be determined under conditions which give the true characteristics of the material as used in making the print from the negative. The abscissa values of

this curve are the densities D'_p while the ordinates are the corresponding exposure values plotted on the scale of log E_y established in a suitable position on the line X', $X'Y'$. The scale of log E_y must be so adjusted along the line X', $X'Y'$ that the curve B, when plotted, will occupy the proper position in the vertical direction relative to the position of curve A. The proper position of curve B is determined by deciding by what value of D'_p it is desired to render some chosen value of D_n. For instance, let it be required to render the highest brightness, c_o, of the object by a just perceptible density on the positive. Assuming that the resulting print is to be viewed with an illumination such that the eye is operating in the region of maximum sensitiveness to brightness difference, a deposit differing in brightness by 2 per cent from the background will be just perceptible. This is equivalent to a transmission or reflection coefficient of 98 per cent, which corresponds to a density of approximately 0.008. In order to fulfill the requirement it will be necessary to adjust the scale of log E so that when the curve B is plotted, a horizontal line drawn through the point where $D'_p = 0.008$ will cut curve A at c_n, which is also the point where a perpendicular dropped from c_o cuts curve A_y. The relation between the values of log E_y and log I_y at the points where any line parallel to $X'O$ cuts the two scales determines the exposure necessary to obtain the desired result. Thus:

$$\frac{E_y}{I_y} = t_y$$

$$\text{or } \log t_y = \log E_y - \log I_y$$

Substituting in this equation the values of I_y and E_y, the value of t_y, the exposure time necessary, may be determined.

It will be remembered that in order to establish the scale of log I_y, a value of I_n was assumed. Since an arbitrary choice of this value without previous knowledge of the speed of the positive material Y may lead to inconvenient or absurd values of t_y, it may be more logical to omit the establishment of the I_y scale and take the relative value of log E_y and D_n at the points where any horizontal line cuts the respective scales as a means of determining the exposure necessary in making the positive.

Thus:

$$\log t_y = \log E_y - \log I_y,$$

but,

$$\log I_y = \log I_n - D_n,$$

therefore,

$$\log t_y = \log E_y - \log I_n + D_n$$

The corresponding values of log E_y and D_n having been determined, two variables, I_n and t_y, remain, and by choosing a convenient value of t_y the value of I_n (the illumination incident on the negative during printing) necessary to satisfy the equation may be found.

Now let the points a_p, b_p, and c_p be located on curve B at the points where horizontal lines passing through the points a_n, b_n, and c_n intersect curve B, the points a_n, b_n, and c_n having been located at the intersections of curve A with perpendiculars dropped from points a_o, b_o, and c_o.

Along the line OX' lay off a log scale opposite in direction to the scale of log B_o. The scale OX' is that from which the reflection coefficient (R_p) (or transmission coefficient T_p) of the various areas of the positive are determined. The position of this scale along the line OX' is determined by consideration of the values on the D'_p scale and the reflection or transmission coefficient of an area of the positive which has received no exposure. Let R_b (or T_b) be the reflection coefficient of such an area.

The values of D'_p are derived from the measurement of the reflection or transmission coefficient of the various areas of the positive relative to the reflection or transmission coefficients of an unexposed area of the positive material which has received, of course, the same development treatment as the other areas of the positive. These values, therefore, are of relative reflection (or transmission) coefficients. This method of measuring and specifying positive densities is preferable (especially in the case of positives to be viewed by reflected light) from the standpoint of practice, and is the usual procedure in the sensitometry of positive materials. But in order to find the brightness of the various areas of the positive, when observed under a given condition of illumination, it is necessary to know their absolute reflection coefficients. It is necessary, therefore, in order that the values of R_p (or T_p) read from the log R_p scale may be in absolute terms and suitable for the computation of resulting brightness values (B_{mr}) to lay off the values of this scale (log R_p) so as to include the factor R_b (or T_b). The relation between the relative and absolute reflection (or transmission) coefficients is given by

$$R'_p . R_b = R_p$$

or

$$\log R'_p + \log R_b = \log R_p$$

Where R'_p is defined by the equation

$$\log R'_p = -D'_p$$
$$\therefore \log R_p = +\log R_b - D'_p$$

The scale on OX' must therefore be so constructed that at corresponding points on the $\log R_p$ and $\log D'_p$ scales the relation between the values of R_p and D'_p shall be as indicated in this equation.

This equation for the case of a positive material on a transparent base and intended to be observed by transmitted light becomes

$$\log T_p = +\log T_b - D'_p$$

In such cases it is sometimes more convenient to measure the values of D'_p in absolute terms, that is, they already include density of the unexposed area. The term T_b, therefore, becomes unity, making $\log T_b$ zero and the relation is expressed simply as

$$\log T_p = -D'_p$$

Now the points a'_p, b'_p, and c'_p are located on the $\log R_p$ scale at the intersections of the perpendiculars through the points a_p, b_p, and c_p, with the line OX'.

The values read from the scale at these points (a'_p, b'_p, and c'_p) are the reflection (or transmission) coefficients of the areas on the positive by which the areas of the object represented by the points a_o, b_o, and c_o are rendered.

The brightness (B) of a surface in terms of its reflection coefficient (R) and the incident illumination (I) is given by the relation

$$B = I.R$$
$$\log B = \log I + \log R$$

Assuming then that the illumination on the positive during observation is I_p, the brightness of any given area of the material (objective) reproduction is obtained by the relation

$$\log B_{mr} = \log R_p + \log I_p$$

The brightness of the areas a'_p, b'_p, and c'_p can, therefore, be computed for any assumed value of the illumination under which the positive is observed or the value of I_p can be computed for any assumed brightness for a given area. On the line OX' establish a log scale such that for corresponding points on this and the $\log R_p$ scale (b'_p and b_{mr}, for instance) the values of $\log B_{mr}$ and $\log R_p$ will with the assumed value of I_p satisfy the equation

$$\log B_{mr} = \log R_p + \log I_p$$

Or, if it is desired that any given area of the positive be of the same

brightness as the corresponding area of the object, the value of I_p necessary can be computed by the relation

$$\log B_o = \log B_{mr} = \log R_p + \log I_p$$
$$\log I_p = \log B_o - \log R_p$$

where $\log B_o$ and $\log R_p$ are the values for corresponding points of object and positive, such as, for instance, b_o and b'_p. Since the relation between the reflection coefficients of the various areas of the positive may be entirely different from the relation between the brightness values of the corresponding areas of the object, it is in general possible to realize this equality of brightness condition for only one point on the positive. In practice, however, it is found that by proper adjustment of conditions it can be realized throughout a finite range, which in some cases is a considerable proportion of the entire tonal range of the object.

Now in considering the extent to which a given positive observed under given illumination reproduces the subjective impression caused by observation of the object itself, it is necessary to take into account the state of adaptation of the observer's eye not only while viewing the reproduction, but also when looking at the object. The curve which determines the relation between what we shall term the material reproduction and the subjective reproduction is, in the complete graphic solution, plotted in quadrant IV, and is referred to as the subjective relative-contrast function. In order to avoid confusion, it will be well for the present to omit consideration of this step in the problem and to complete the first solution for material reproduction, after which a more comprehensible exposition of the subjective phase will be possible.

In order to obtain the reproduction curve, it is necessary to transfer the points a_{mr}, b_{mr}, and c_{mr} to the OY axis. This can be done by rotating the $\log B_r$ scale about the point O until it coincides with the line OY, but, since later a curve (the subjective relative-contrast function) will occupy quadrant IV, it will be better to make use of what may be termed a "dummy" curve (C) in IV, this being simply a line making an angle of 45° with the line OX' and passing through O. Vertical lines through the points a_{mr}, b_{mr}, and c_{mr} intersecting curve D locate the points a_d, b_d, and c_d on this curve and horizontal lines through these intersections locate, by their intersection with the line OY, the position of the points a_{mr}, b_{mr}, and c_{mr} on this scale. Now the intersections of the horizontal lines through a_{mr}, b_{mr}, and

c_{mr} (on line OY) with the vertical lines through a_o, b_o, and c_o determine the points a_x, b_x, and c_x which, when connected as shown, established the shape and position of the reproduction curve D (in I). This affords a graphic representation of the relation between the brightness factors of the object and those of the material reproduction (the illuminated positive). Now, through the point on the log B_{mr} scale (on line OY) where log B_{mr} is equal to the value of log B_o read at the point O (on line OX) draw a line parallel to OX. In the figure this is represented by the broken line $O'M$. This line is the absolute x axis of the reproduction curve D while the line $O'Y$ is the corresponding y axis, O' being the absolute origin. The line OX can be retained as the absolute axis by displacing the point of intersection of the dummy curve C (IV) in the proper direction along the X axis (line X', O, X) by a distance equal to OO'. (In the case shown in Fig. 1 this point would be to the left of O at O''.) In practice, however, such procedure usually results in the displacement of the reproduction curve D in the vertical direction by an inconvenient amount, and location of the new position of the absolute axis as indicated is usually more convenient. In some cases this method may result in the point O' falling outside the limits of the available coördinates, in which case its location is best indicated by a dimension line carrying a numerical indication of its position relative to the apparent axis OX.

Now a straight line drawn through O' and making an angle of 45° to the line of $O'M$ is the curve E, of absolute reproduction, this term being used to denote an exact reproduction in the material reproduction of both the brightness and contrast of the object. For any point on the reproduction curve D the magnitude of the departure from an exact reproduction of brightness is given by the length of the perpendicular line limited by the two curves D and E and drawn through the point considered; while the relation of the slopes (first derivatives) of the curves at corresponding points (B_a and B_x, for instance) determines the magnitude of the departure from exact reproduction of the contrast in the object at the point (b) considered.

The fact that the curve E is the curve for the exact reproduction of brightness follows from the construction, which is such that for any point on this curve log B_o is equal to log B_{mr}, thus satisfying the necessary condition that $B_o = B_{mr}$. The fact that a given brightness interval of the object is represented by the same brightness interval on the curve E indicates that the contrast of the object has been

exactly reproduced. A straight line at 45° to the axis is the necessary condition for exact contrast reproduction, while for exact reproduction of brightness this line must pass througha certain specified point on the log B_{mr} scale.

From the position of the curve E relative to D (the reproduction curve), it is possible to determine quantitatively the magnitude of the departure from the condition of exact brightness reproduction. The most convenient method of expressing the magnitude of this departure is by use of the ratio of the brightness of the object to

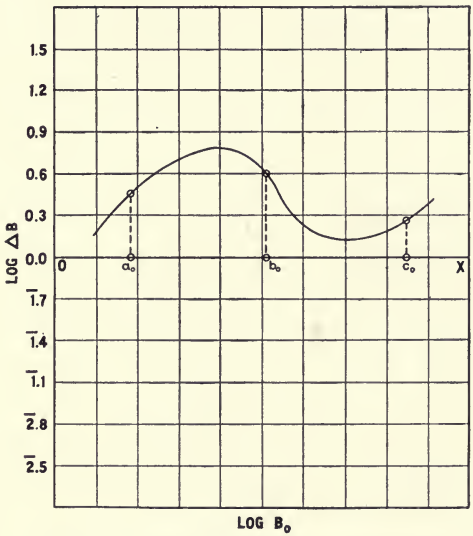

FIG. 2. Curve of brightness deviations.

the corresponding brightness of the reproduction, which ratio will be designated by the symbol ΔB.

$$\Delta B = \frac{B_o}{B_{mr}}, \text{ or}$$

$$\log \Delta B = \log B_o - \log B_{mr}$$

It can be shown that log ΔB for any particular value of log D_o is equal to the intercept between the curves E and D on the perpendicular line through that value of log B_o. In Fig. 2 the values of log ΔB are plotted as a function of log B_o, the resultant curve representing the departures from absolute reproduction of brightness.

ANALYTICAL CONSIDERATIONS

Let us now apply the method of the differential calculus to the functions plotted in Fig 1. Such treatment is especially useful in a determination of the contrast relations existing between the various elements. If at any point the ratio of some small increment ΔY (in the direction of the Y coördinate) to the corresponding increment ΔX (in the direction of the X coördinate) be computed, the value obtained is a measure of the average slope of the curve over the distance (ΔX) considered. When these increments are reduced to the infinitesimal dy and dx the ratio gives the value of the slope at a point on the curve. Hence, if the slope or gradient be designated by the symbol G, it is defined by the expression $G = \frac{dy}{dx}$. Applying this to the curves of Fig. 1, the following expressions are obtained.

The density gradient of curve A, the characteristic of the negative materials (X), is given by

$$G_n = \frac{dD_n}{d \log E_x}$$

Since $d \log E_x = d \log B_o$ this becomes

$$G_n = \frac{dD_n}{d \log B_o}$$

likewise for B, the characteristic of the positive material (Y), the density gradient is,

$$G_p = \frac{D'_p}{d \log E_y}$$

While for the reproduction curve D

$$G_{mr} = \frac{d \log B_{mr}}{d \log B_o}$$

From the construction of the diagram (Fig. 1), it will be seen that

$$d \log E_y = -d\, D_n$$

and

$$d \log B_{mr} = -dD'_p = d \log R_p$$

$$\therefore G_n = -\frac{d \log E_y}{d \log B_o}$$

and
$$G_p = -\frac{d \log B_{mr}}{d \log E_y}$$

$$G_n \times G_p = -\frac{d \log E_y}{d \log B_o} \cdot -\frac{d \log B_{mr}}{d \log E_y} = \frac{d \log B_{mr}}{d \log B_o} = G_{mr}$$

$$\therefore G_n . G_p = G_{mr}$$

Now for exact reproduction of contrast, it is necessary that $G_{mr} = 1.0$. The condition fulfilling this requirement is that the product of the gradient (or slope) of the negative characteristic by the gradient of the positive characteristic shall be equal to unity. If $G_n.G_p$ is greater than unity, a given brightness difference in the object ($d \log B_o$) is rendered in the positive by a brightness difference ($d \log B_{mr}$) greater than that existing in the object and hence the contrast is increased or the contrast scale is expanded. On the other hand, if $G_n.G_p$ is less than unity it indicates that the brightness difference in the positive is less than the corresponding difference in the object ($d \log B_{mr} < d \log B_o$) and it follows that the contrast is decreased, that is, the contrast scale is compressed. Turning now to a consideration of the most convenient method of showing graphically the departure from exact reproduction of contrast, it is found that a curve showing the relation between B_o and the slope (G_{mr}) of the reproduction curve D fulfills all the requirements.

$$G_e \text{ (curve } E) = 1.0 \text{ by construction}$$

$$G_{mx} = \frac{d \log B_{mr}}{d \log B_o} \text{ (curve } D)$$

$$\therefore \frac{G_{mx}}{G_e} = \frac{d \log B_{mr}}{d \log B_o} \text{ (curve } D)$$

The value of the first derivative of curve D at any point is, therefore, numerically equal to the ratio of the gradient of curve D to that of E, and hence is a measure of the departure from exact contrast reproduction. In Fig. 3 is plotted the value of $\frac{d \log B_{mr}}{d \log B_o}$ (for curve D) as a function of B_o. The log B_o scale is again a duplicate of that in Fig. 1, and the ordinates are gradient values. The condition that $G_{mr} = 1.0$ is that for exact contrast reproduction, and hence the line OX ($G_{mr} = 1.0$) is the curve of exact contrast reproduction. Points lying above this line ($G_{mr} > 1.0$) indicate an increased contrast in the positive while points below ($G_{mr} < 1.0$) correspond to a diminished contrast. In case a given difference of brightness ΔB_o in the object is rendered by a greater brightness difference ΔB_{mr} in the

reproduction, the contrast scale is said to be expanded while the opposite condition is expressed as a compression of the contrast scale. These conditions may be expressed mathematically, thus,

1. Increased contrast (expansion of contrast scale);
$$G_{mr} > 1.0$$
2. Exact contrast reproduction (normal contrast);
$$G_{mr} = 1.0$$
3. Diminished contrast (compression of contrast scale).
$$G_{mr} < 1.0$$

In dealing with the straight line portion the gradient values are constant, and hence are direct measures of the contrast reproduction in such regions.

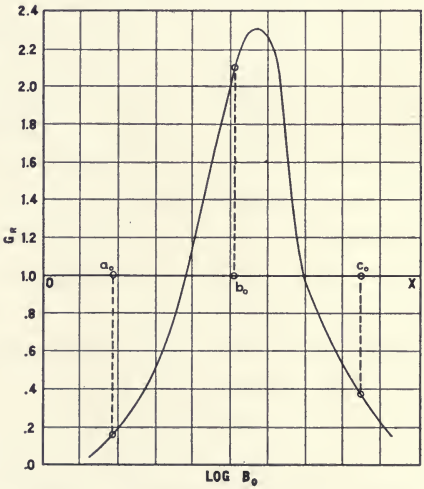

FIG. 3. Curve of contrast deviations.

Thus far, no assumption has been made relative to the shape of the curves A and B, the treatment having been of a general nature. In practice it is found that both of these curves may, within the limits of observation, be straight lines over a considerable portion of their lengths. The tangent of the angle which such straight portion makes with the log E axis is designated by the symbol γ, and is equal to the gradient $\left(\frac{d\,D}{d \log E}\right)$ at any point on the straight line portion. The gradient being constant throughout such straight portions, it is convenient when dealing with tone reproduction by such

portions alone to replace the values of gradient by those of gamma. The relation thus obtained is

$$\gamma_n \cdot \gamma_p = \gamma_{mr}$$

This it may be noted is the relation deduced by Porter and Slade, which is a special case of the more general relation between the gradient values. The special case is, of course, simpler to deal with and is applicable when the entire reproduction can be obtained by use of the straight line portions, which frequently occurs when the positive is made to be viewed by transmitted light (transparencies, *etc.*). In the case of a positive to be viewed by reflected light, it is usually necessary to utilize the entire scale of the positive material, including the curved portions as well as the straight line, and in such cases the special relation ($\gamma_p \cdot \gamma_n = 1.0$, for exact contrast reproduction) is practically useless, it being necessary to employ the more general form, $G_p \,.\, G_n = 1.0$.

For that brightness range of the object which can be rendered by the use of deposits in the negative and positive situated on the straight line portion of the characteristic curves of both materials, the above relation may be used. Stating this relation in words, for the most general case, where the gradient is variable from point to point, the product of the gradient of the negative by the gradient of the positive is equal to the gradient of the reproduction curve. This applies only, of course, to the gradient values determined at the corresponding points on the three curves, corresponding points being defined as any three points related to each other as the point b_n, b_p, and b_x (Fig. 1). Or, for the straight line portions where gradient is constant and replaceable by gamma, the product of the gamma of the negative by that of the positive is equal to that of the reproduction curve. It may be of interest to note at this point that this is precisely the same relation as that derived by the author in collaboration with Mr. Wilsey when applying this general method to the problem of measuring the color coefficient of photographic deposits. And, since, for exact contrast reproduction, the slope (γ) of the reproduction curve must be unity, the necessary condition is expressed by

$$\gamma_n \cdot \gamma_p = 1.0$$

or

$$\gamma_n = \frac{l}{\gamma_p}$$

It should be borne in mind, however, that this relation holds

only for the straight line portion of the curves, while the relation between the values of the differentials G_n, G_p, and G_{mr} is general and valid for any point regardless of the shape of the curves.

From a complete knowledge of the characteristics of the negative and positive materials, it is now possible to compute the quality of reproduction obtainable. It is also evident from the construction of Fig. 1 that if only one of these functions is known, that of the other can be obtained either graphically or by analytical methods provided an assumption as to the shape of the reproduction curve D be made.

In the original article several graphic examples are shown in which the shape of the negative and positive characteristics are determined as required to give correct reproduction under certain specified conditions. By the application of analytical methods many interesting relations between the characteristics of the negative and positive materials and the brightness contrast of the object are derived. For instance, it is pointed out that if the negative and the printing paper be such that the "density scale" of the negative is equal to the "exposure scale" of the positive material all the density differences in the negative would be rendered as density differences in the print, and further that the maximum negative density will be rendered as the minimum useful density of the printing material, while the minimum negative density will result in the maximum useful density in the print. Such procedure, of course, results in diminished contrast in extreme shadows and highlights, due to the shape of the characteristic curve of the printing paper, even though (as is usually possible) all of the object brightnesses are rendered on the straight line portion of the negative curve. While in some special cases better results may be obtained by some other procedure it is undoubtedly true that in general the most favorable relation between negative and printing paper is that the density scale (DS_n) of the former should be as nearly as possible equal to the exposure scale (DS_y) of the latter.

The fulfillment of this condition, as was pointed out in a previous paper on this subject, makes the correct development time for a negative a function of the contrast in the object. Thus in order to utilize the available density scale of a printing paper, it is necessary to give greater development times to negatives of subjects in which the contrast is low than to those in which the contrast is high.

The applications of the methods outlined to practical problems are

too numerous to mention in detail at this time. However, a specific example, Fig. 4, is shown. This illustrates the reproduction resulting from the use of negative and positive materials, the characteristic curves of which have been carefully determined by sensitometric measurements in this laboratory. The data, essential to this discussion, relative to the materials are as follows:

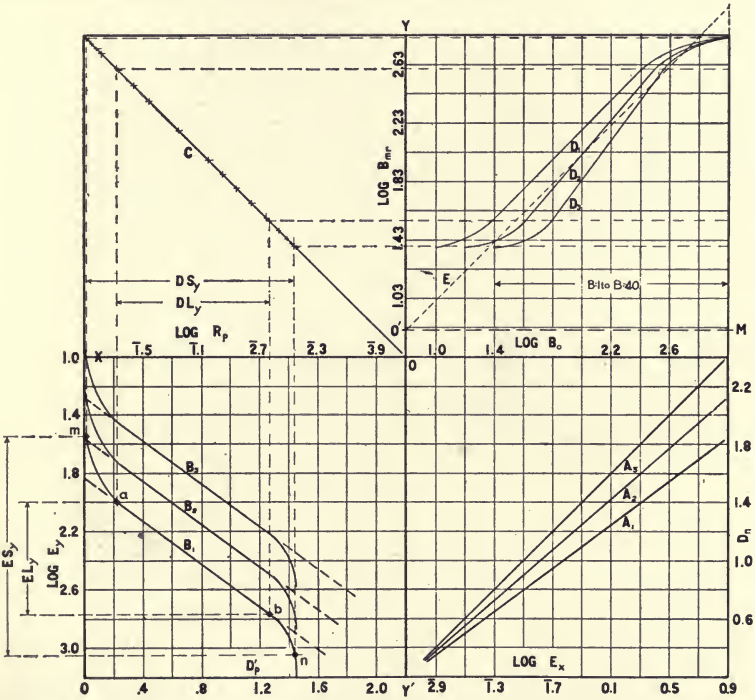

FIG. 4. Objective reproduction obtainable with specified materials and conditions.

The negative material:

$$EL_x \text{ (Exposure latitude)} > 2.0 \text{ (in log } E)$$

$$\log i = \bar{2}.5$$

$$\gamma_\infty > 1.00$$

The positive material (a developing-out paper):

E_s	(Standard exposure)	= 100,000 (m.c.s.)
γ_∞		= 1.34
EL_y	(Exposure latitude)	= 0.77 (in log E)
ES_y	(Exposure scale)	= 1.50 (in log E)

DL_y	(Density latitude)	= 1.06
DS_y	(Density scale)	= 1.43
D_{max}	(Maximum density)	= 1.45
R_b	(Reflecting power of fog strip)	= 0.80

Let it be assumed that the highest object brightness is 1000 (apparent meter candles), and that this brightness is to be rendered in the positive by a just perceptible density [$D = 0.01$ (approximately), $R_p' = 0.02$].

In order to illustrate the effect of contrast to which the negative is developed on the quality of the resulting reproduction, three different negative characteristics are plotted, differing only in the value of gamma. The resultant reproduction in the three cases is given by the curves D_1, D_2, and D_3. Applying the equations, it is shown that T_x (exposure time in making the negative) is 0.0126 second, that the exposure times in making the three prints are 71,

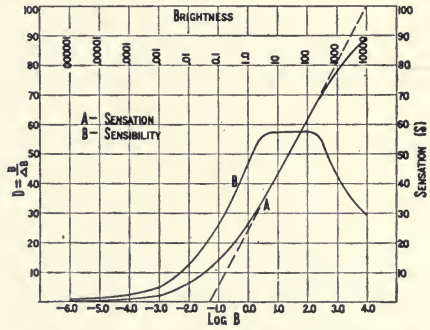

FIG. 5. Contrast sensitivity curves of the eye.

135, and 250 seconds for the three cases. The results are analyzed by plotting the departure curves, and it is shown that curve D_2 gives the least average departure from exact reproduction for the subject having a brightness contrast of from 1 to 40.

THE SUBJECTIVE PHASE

Turning now to a consideration of the subjective phase, it will be well to discuss the significance of the curves shown in Fig. 5. These contain the data relative to the visual sensitivities necessary for the evaluation of the subjective relative contrast function. Curve A gives the relation of the sensation to the stimulating brightness. Equal increments on the Y axis correspond to equal increments in the sensation, and the brightness intervals which give rise

to these sensation steps can be determined from this curve. The shape of this function could be established by direct experiments, but since such a process is extremely laborious, it is customary to arrive at the same end by other means. The curve B, the contrast sensibility, is the first derivative of the sensation curve, hence, if the sensibility be measured and the curve B plotted, the sensation curve may be obtained by integration. The sensibility at a given adaptation level is determined by measuring the least difference in brightness perceptible under the specified conditions. The least perceptible difference, ΔB, expressed as a fraction of the brightness at which it is determined, is a direct measure of the sensibility of the eye to contrast or brightness difference. The ordinate of curve B at any point is therefore equal to the slope of the curve A at the same value of B. Thus, if S be the sensation, $\frac{dS}{d\log B} = \frac{B}{\Delta B}$. The values of the ordinates of the sensation curve are in terms of sensation units, and the construction of such a sensation scale is based on the assumption that a just perceptible difference at any point on the sensation scale is equal to a just perceptible difference at any other point. The basic unit upon which this scale is established is therefore the least perceptible brightness difference.

The range of brightness over which the eye operates is enormous, from $B = 0.000001$ to $B = 10{,}000$ millilamberts, a range of 1 to 10,000,000,000, while for the photographic plate the corresponding range is but 1 to 2000 (approximately). This extreme range in case of the eye is due largely to the fact that the retina changes in sensibility with the intensity of the incident radiation. This property of variable sensibility has been likened to that of an ammeter equipped with a shunt whose resistance decreases as the current increases. The diameter of the pupil is but a very small factor in the sensibility change since it varies in area over a range of but 1 to 64. It should be pointed out that the curves in Fig. 5 are similar in shape to those given by Renwick, but that the absolute values of log brightness are very different. This is undoubtedly due to the uncertainty in the value of the unit used by König, from whose data the curves in question were plotted. Blanchard has discussed the question and has computed the probable value of König's unit as being 0.004 ml. (approximately). The millilambert is the c.g.s. unit of brightness, and is equivalent to a brightness of ten meter-candles or 0.93

foot-candles. The region of maximum sensibility is therefore from 3 to 250 foot-candles (approximately), instead of from 20,000 to 400,000 as indicated by the curves published by Renwick. Since the function of use in relating subjective reproduction to the objective contrast is obtained by using the ratio of the gradients at two points on the sensation curve, the units in which the curve is plotted are not of importance. However, in order to determine the sensibility for a given adaptation level, it is important that the correct abscissa value be used.

Now, if we consider a specified brightness difference in the object viewed with the eye adapted to some brightness level A_o, it is possible from curve A (Fig. 5) to find the corresponding sensation difference; and if the brightness difference between the corresponding areas of the material reproduction be known, together with the adaptation level (A_{mr}) of the observer viewing this material reproduction, it is possible to determine also the magnitude of the resulting subjective contrast. A comparison of the magnitudes of these two contrast values, namely: (*a*) the subjective contrast resulting from observation of the object at a given adaptation level, which subjective evaluation it is convenient to refer to as the subjective object; and (*b*) the subjective contrast due to the observation of the material reproduction at a specified adaptation level, which subjective evaluation will be termed the subjective reproduction, determines the exactness with which the subjective sensation resulting from the observation of the object is reproduced by observation of the material reproduction (the illuminated positive) under the conditions specified. It is also possible by similar methods to determine the magnitude of the contrast necessary, at any point in the tonal scale of the material reproduction, for the exact reproduction of the subjective contrast of the object, assuming, of course, that the values of A_o and A_{mr} are known,

A_o = Adaptation level while observing object
A_{mr} = Adaptation level while observing material reproduction.

For instance, in Fig. 6 consider an increment of brightness, $\Delta \log B_1 = \log B_1 - \log B_1'$, for which the corresponding increment in the sensation is $\Delta S_1 = (S_1 - S_1')$. At any other point take a second increment in sensation $\Delta S_2 = (S_2 - S_2')$ such that $\Delta S_1 = \Delta S_2$. Let the increment in $\log B$, corresponding to ΔS_2 be represented by $\Delta \log B_2 = (\log B_2 - \log B_2')$. Assume that the increment $\Delta \log B_2$

applies to some point in the object, and that the value of log B fixes the adaptation level of the observer looking at that object, while for the material reproduction the adaptation is conditioned by the value of B_1.

$$A_o = B_2$$
$$A_{mr} = B_1$$

Now the average slope of the curve (Fig. 6) over the range Δ log B_2 is given by

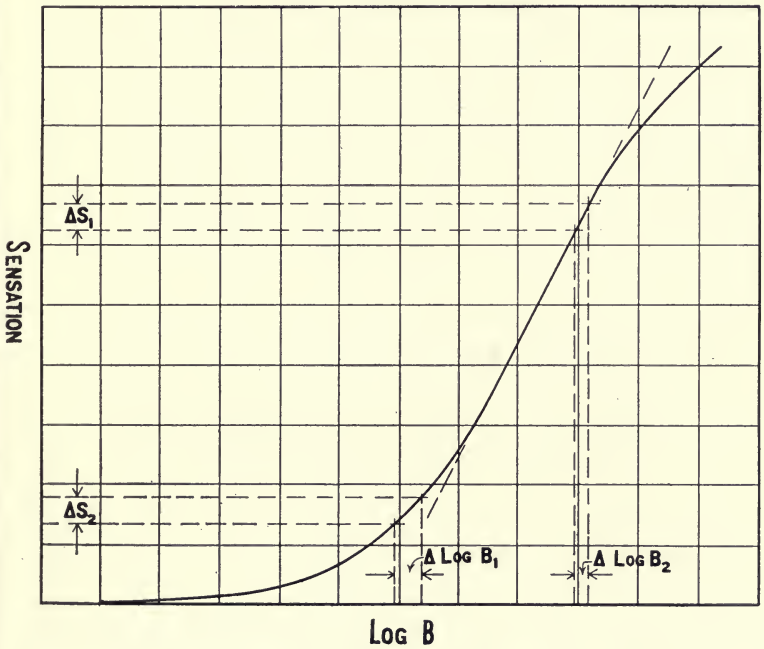

FIG. 6. The relation between sensation and stimulus.

$$\text{Slope (2)} = \frac{\Delta S_2}{\Delta \log B_2}.$$

And the average slope over the interval Δ log B_1 is likewise

$$\text{Slope (1)} = \frac{\Delta S_1}{\Delta \log B_1}$$

Since $\Delta S_1 = \Delta S_2$ it follows that

$$\frac{\text{Slope (2)}}{\text{Slope (1)}} = \frac{\Delta \log B_1}{\Delta \log B_2}$$

But the average slope of the sensation curve over any given interval is given by the average value of the ordinate D of the contrast sensibility curve (curve B, Fig. 5) over the same interval. Hence, we may express the values of the slope by the corresponding values of D, and equation becomes

$$\frac{\text{Average } D_2}{\text{Average } D_1} = \frac{\Delta \log B_1}{\Delta \log B_2}$$

or

$$\Delta \log B_2 = \Delta \log B_1 \cdot \frac{\text{Average } D_1}{\text{Average } D_2}$$

It is evident, therefore, if $\Delta \log B_2$ be the objective brightness difference at some point in the object, that the equation will give the value of the $\Delta \log B_1$, the objective brightness difference necessary in the photographic reproduction for the exact reproduction of subjective contrast. In the case illustrated, the interval $\Delta \log B_2$ is less than the interval $\Delta \log B_1$, thus indicating that a greater objective contrast in the reproduction will be required to reproduce the subjective contrast due to the smaller objective contrast in the object.

It is well known that other factors than the brightness of the area upon which the attention is fixed (foveal image) influence to some extent the adaptation level of the eye at any instant. Such factors include the brightness of the surrounding objects (*i. e.*, the peripheral images), and the length of time during which the attention has been fixed on the area considered. In practice, however, the picture being observed occupies a very considerable portion of the field of vision, and, further, in the great majority of such pictures the actual range of brightness is relatively limited. This is especially true of surfaces viewed by reflected light. Further, under the majority of conditions, the field of vision not filled by the reproduction being considered does not contain any area contrasting extremely with the brightness of the reproduction. It seems reasonable, therefore, to assume that the adaptation level will be fixed in practice by the brightness of the reproduction itself, and likewise that the level when viewing the object will be conditioned by the object considered.

The question then arises as to what particular brightness in object and reproduction will determine the adaptation level in each case. Considering the reproduction as a reflecting surface, the average range of brightness may be taken as 1 to 40 (1.6 in log B_{mr}), which,

even at the steepest part of the sensibility curve (Fig. 5) does not correspond to an excessive change in value of D. The change in adaptation as attention travels from highlight to shadow probably is not so great as that indicated by the brightness range, being limited to some extent by the stabilizing effect of the peripheral images as well as to the time lag of adaptation behind the changing foveal stimulus. It seems logical, therefore, to assume that A_o and A_{mr} are conditioned by the average brightness of object and material reproduction, and this assumption will undoubtedly hold for a large percentage of the normal cases, although it may be necessary, under extreme conditions, to take into account the change in adaptation (and consequently in the value of D) which occurs as attention shifts from an area of one brightness to that of another.

As a simplifying condition, let us, therefore, assume that the adaptation level is conditioned by a brightness of the object and reproduction, respectively, half-way between (on the log B scale) the highest and lowest brightness considered.

Let the values of the various factors be designated by:

For the object:

$$A_o = \text{Adaptation level for average } B_o$$
$$D_o = \text{Sensibility}$$

For the reproduction:

$$A_{mr} = \text{Adaptation level for average } B_{mr}$$
$$D_{mr} = \text{Sensibility}$$

Now in the equation previously given,

$$\frac{\text{Average } D_2}{\text{Average } D_1} = \frac{\Delta \log B_1}{\Delta \log B_2}$$

let the numerical subscripts be replaced by the subscript letters indicating the application of the terms to particular values, thus,

$$\frac{\text{Average } D_o}{\text{Average } D_{mr}} = \frac{\Delta \log B_{mr}}{\Delta \log B_o}$$

By allowing these finite increments to approach zero as a limit, we may replace the average values of D by values of the slope of the contrast sensibility curve at a point and obtain the expression

$$\frac{D_o}{D_{mr}} = \frac{d \log B_{mr}}{d \log B_o}$$

Since an assumption of equality of subjective contrast (sensation increment) has been made, this equation is a statement of the con-

ditions necessary for the exact reproduction of the subjective contrast.

Now the value of $\frac{D_o}{D_{mr}}$ gives the slope of a curve which if plotted in quadrant I, Fig. 1, would be the line of exact subjective reproduction of objective contrast. In the graphic solution, however, it is more convenient in plotting the reproduction curve D, and also in the later interpretation of the results, to retain the line E (of which the gradient is unity) as the line of exact contrast reproduction, and to alter the position of the points on the scale on the line O so that the reproduction curve plotted therefrom will be the curve of actual subjective reproduction, this alteration of position being an expansion or compression of the points on the scale in the case of constant values for the adaptation levels (A_o and A_{mr}), or a distortion of their distribution in case such values are variable. It is quite possible to obtain the final evaluation of the exactness of reproduction as a comparison between the contrast values of the subjective object and the subjective reproduction (see Table I, Items I and X), but in view of the fact that the starting point in any tone reproduction problem must be the objective brightness values of the object, it seems more logical to make these values the primary base of the computation and to express finally the departures from exact reproduction in terms of these physically measured values of object brightness. This necessitates the evaluation of the subjective contrast of the reproduction in terms of the subjective contrast of the object, and a final expression of this complex relation as a function of the object brightness B_o. The final comparison must therefore be made between the actual measured (objective) contrast values of the object and the corresponding contrast values of the subjective reproduction evaluated in terms of the subjective object. The scale on which the points representing the various areas of the reproduction, as evaluated in terms of this relative subjective contrast function, must occupy the line OY in order that the curve representing the final reproduction may be graphically constructed with values of B_o as abscissas. The required scale constructed on line OY will be termed the log B_z scale, and the relative subjective contrast function which is used to determine the distribution of the points on the log B_z scale will be referred to as the Z function, and its gradient will be designated by G_z.

Now in order that the line E (in quadrant I), having a slope of unity, shall be the line of exact subjective contrast reproduction, it is necessary that its slope or gradient be given by the expression $G_e = \frac{\triangle \log B_z}{\triangle \log B_o}$, where $\Delta \log B_o$ is some increment on the $\log B_o$ scale for which the corresponding interval in the subjective reproduction is $\Delta \log B_z$. Let the scale of $\log B_{mr}$ on line OY (Fig. 1) be replaced

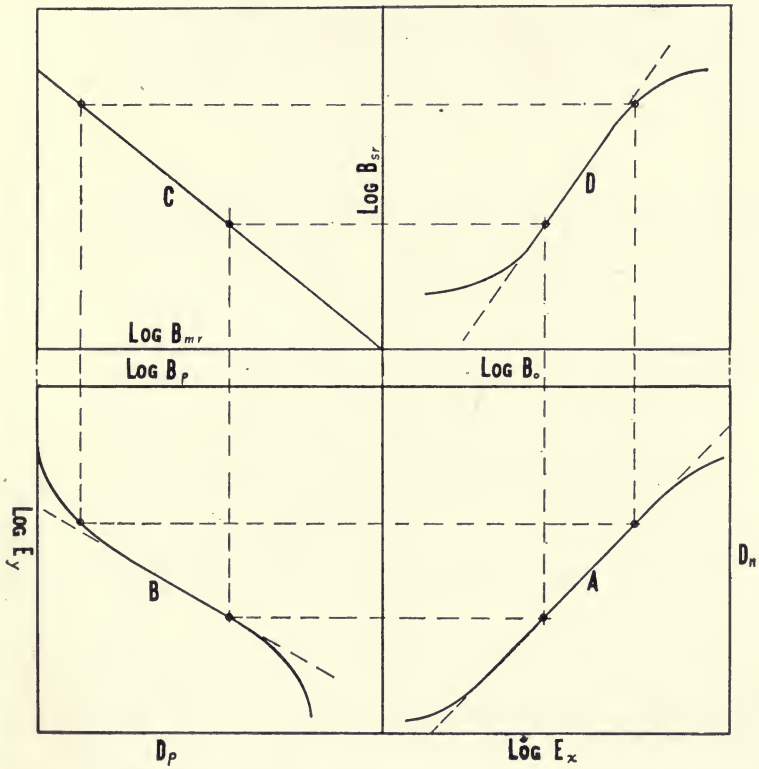

FIG. 7. Special case of the complete solution including subjective phase.

by a scale of $\log B_z$ (Fig. 7). This can be accomplished by replacing the dummy curve C (Fig. 1) by the new function which gives the relation between the material (objective) reproduction and the subjective reproduction. This subjective reproduction is itself a complex function containing the relation between the subjective evaluation on the object and subjective evaluation of the material re-

production. These evaluations are conditioned by the sensibility of the eye to brightness differences (contrast) at the time of observing the object and when viewing the reproduction. This relation, the relative subjective contrast function, can be constructed graphically, but the consideration of this will be omitted. It is sufficient for the present purpose to state that the gradient of this curve, which must be substituted for the dummy curve thus far used, is equal to the reciprocal of the ratio of the values of D_o to D_{mr}. Let G_z indicate the gradient of the relative subjective contrast function which from this point on will be used instead of the dummy curve, having an arbitrary gradient equal to unity. Then

$$G_z = \frac{D_{mr}}{D_o}$$

This procedure also makes it possible to establish on the line OY the scale log B_z (Fig. 7), for which the points located by the usual construction methods will represent the relative subjective brightnesses corresponding to the various areas of the object considered.

Now if

$$D_o = D_{mr}$$
$$G_z = 1.0 = G_d$$

This is the gradient thus far used in the construction of the curve C. It is evident, therefore, if average B_o and average B_{mr} are such that they fall between the limits (Fig. 5), log $B = 0.5$ ($B = 3.2$ ml.) and log $B = 2.2$ ($B = 166$ ml.), that the subjective reproduction of contrast will be identical with the material reproduction curves already discussed.

If, however, the brightness B_o of the object and the consequent adaptation level A_o of the observer viewing that object is relatively high, while the brightness of the material reproduction, B_{mr} (the illuminated positive), and the corresponding adaptation level A_{mr} is low, the subjective reproduction will be different from the objective reproduction. In this case the contrast sensibility D_o is greater than D_{mr} and hence the gradient, G_z, of the relative subjective contrast curve is less than unity.

$$G_z = \frac{D_{mr}}{D_o}$$

The reproduction curve D constructed in the usual way will also have a decreased gradient. This indicates that under such condi-

tions a loss of contrast occurs due to the subjective factors, and in order to obtain exact subjective reproduction it will be necessary to enhance the objective contrast in material reproduction, in order to compensate for the loss due to the subjective effect. It is evident from these considerations that a picture of a brilliantly lighted scene, which is to be viewed under relatively low illuminations, such as exist in interiors at night, should be somewhat more contrasty than the scene itself. That is, best subjective reproduction will be obtained by a positive in which the actual objective contrast is somewhat enhanced. This condition may be stated symbolically thus:

If D_o is greater than D_{mr}
G_z is less than 1.0

When G_z is less than unity there will be a loss of contrast due to the subjective factors.

On the other hand, if

D_o is less than D_{mr}
G_z is greater than 1.0

and there will be an enhancement of contrast due to the subjective factors. When G_z is greater than unity the slope of the relative subjective contrast function (curve C is quadrant IV) is greater than unity, and the gradient of the resulting reproduction curve D (quadrant I) is increased accordingly.

Now from a consideration of Fig. 7 it will be seen that for the straight line portions of the curves, if such exist,

$$\gamma_n \cdot \gamma_p \cdot \gamma_z = \gamma_r$$

Therefore if any three of these four functions involved be known or are assumed, the fourth may be determined. The line E is, as before, the curve of exact reproduction of contrast, and the curve D is the reproduction obtained under the specified conditions. Deviations may be determined as in case of the solution for the objective phase, and the results will indicate the departure from the exact reproduction of subjective contrast. It should be noted that this construction gives direct comparison between the objective values of brightness and the relative subjective equivalent in the reproduction. That is, the comparison is not between the subjective impression of the object and the subjective impression due to the reproduction, although this comparison can easily be made if such seems

desirable. The procedure adopted is such that all of the subjective factors are introduced by use of the curve C, the relative subjective contrast function. Such procedure is in effect the evaluation of the subjective reproduction in terms of the subjective contrast in the object itself.

Now in case it is considered necessary, by reason of the existing conditions, to take into account the change of adaptation with shift

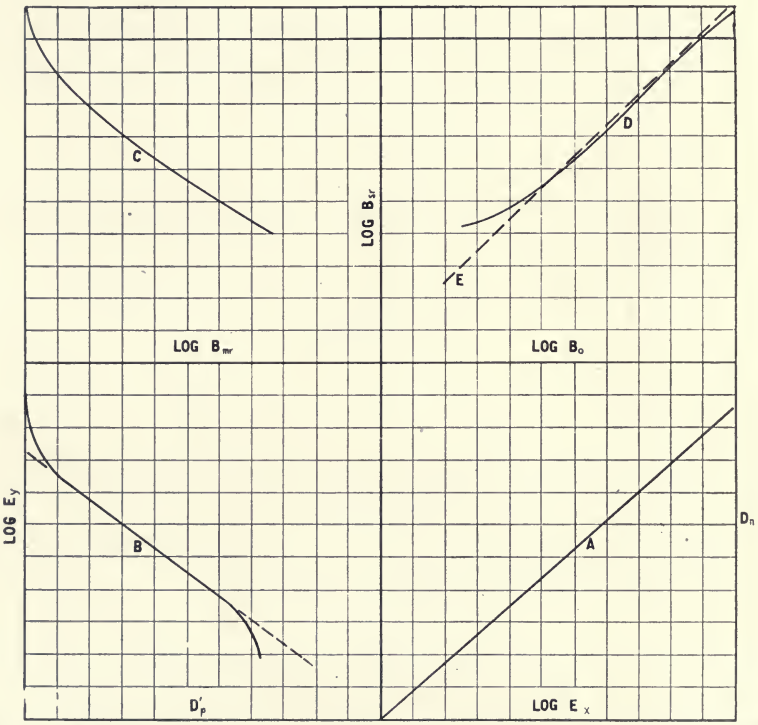

FIG. 8. A general case of the complete solution including the subjective phase.

of attention from highlight to shadow, this can be accomplished by computing for each pair of object and reproduction brightnesses the value of the ratio $\frac{D_{mr}}{D_o}$, and from the values thus obtained plotting a curve which is then used as the relative subjective contrast function. The curve C may not, under such circumstances, be a straight line, but will vary in slope as indicated by the computed values of $\frac{D_{mr}}{D_o}$. As a typical example of such a case computed from actual

values of a practical case, curve C in Fig. 8 is given. This is for an object in which the brightness range is from 15 ml. to 1000 ml., while the intensity of the illumination on the positive during observation is such that the brightness range is from 0.35 ml. to 10 ml.

Fig. 8, therefore, represents the complete general graphic solution giving the reproduction curve D, which is a graphic representation of the reproduction of the subjective impression obtainable under any set of specified conditions, the line E being the curve of exact reproduction of subjective contrast. It should be noted that with the particular values assumed in this case, the reproduction curve D is somewhat straighter in the highlight region than when a straight line was used as the relative subjective contrast function. It is probable in practice that the change in adaptation level is not so great as is indicated by the assumptions made in this case, and that the improvement in contrast reproduction is not so great as indicated by the curve shown.

Many interesting relations between the various factors may be derived and applied to practical problems, but the discussion of such details will not be taken up at this time. One point deserving mention, however, is relative to the values of adaptation of the eye, upon which depend the sensibility values from which the slope of the subjective relative-contrast function is computed. Few data are available at present as to adaptation levels when the visual field is filled by areas of different brightnesses, such as exist under practical conditions. Experimental work is in progress in this laboratory, from the results of which it is hoped more reliable evaluations of A_o and A_{mr} may be obtained for certain specified practical conditions. When these data are available it will be possible by the application of the general principles outlined in this paper to arrive at more certain conclusions relative to the exactness of reproduction in any particular case.

SOME EXPERIENCES IN ADAPTING THEATERS FOR SOUND REPRODUCTION*

LEWIS M. TOWNSEND**

Summary.—*In adapting existing theaters for sound reproduction, many factors have to be considered which it is the purpose of this paper to discuss. Among these factors are: the equipment which is chosen must be adequate for the particular theater involved; this equipment should be purchased from a reliable concern and properly installed, according to specifications; it is often better to completely rebuild a projection room than to crowd new and additional equipment into it; tests on fader settings for both film and disk records should be made at the time of installation, and periodically thereafter; a considerable amount of attention should be given to determining the acoustical characteristics of auditoriums prior to installing sound equipment, rather than at any time after it has been installed.*

Since the introduction of the first commercial sound-reproducing apparatus for motion picture theaters a few years ago, remarkable changes have taken place. Taking all factors into consideration, these changes have come about in a more or less orderly manner. Nevertheless, many difficulties had to be overcome and doubtless many more will present themselves before excellent sound reproduction becomes the rule rather than the exception. The experiences herein described are intended to show, in some measure, what procedure is required in order to be sure that, when a theater is equipped for sound reproduction, it will be pleasing to the audience.

Experience has shown that it is important that the company furnishing the equipment be of sound financial standing and shall have been in the business long enough to have gained the experience necessary to produce good results. A reliable firm will advise the installation of adequate equipment for each particular theater, and will be in a position to furnish competent engineers to see that this equipment is installed properly.

The actual installation should be in the hands of the most competent electrical contractor available, preferably one who has had previous experience in this particular work. He must follow im-

* Received by the Editor March 2, 1931.

** Paramount Publix Corporation, New York, N. Y.

plicitly the directions of the installation engineer. Some of the most common causes of extraneous noises and poor quality of reproduction are directly traceable to broken or twisted wires, poor connections, poor soldering, *etc.*

It is unwise to attempt to crowd additional equipment into the average projection room. If there is not sufficient space, it is better to rebuild the entire structure. Crowding of equipment causes many inconveniences in projecting the picture and sound, and is often the cause of poor performance. If the line voltage does not come within the limits specified by the manufacturer of the sound equipment, it is unwise to operate without a line-voltage regulator, which can be secured at relatively small cost. Its cost will be saved many times by the saving of tubes and condensers and other apparatus which are likely to break down at any moment under excess voltage.

When the installation is complete, tests should be made on all the phases of reproduction. Two disk records exactly alike should be used to determine whether the volumes are equal at identical fader settings on the projectors. The same procedure should be followed with photographic sound records. The film reproduction should be equalized with the disk reproduction in order that a certain fader setting will be normal with both film and disk on each projector. Weekly checks should be made to see that this equality is maintained.

The theater should now be checked to make sure that the acoustic distribution is equal in all sections. To do this, it is best to choose a talking record in which the volume is known to be of the same level throughout. It is impossible to determine whether the same volume of sound is obtained in all parts of the house if the recorded intensity changes. If it is not possible to obtain equal distribution to all sections of the house with the number of horns supplied, additional horns should be used. When the distribution is correct, it should not be difficult to control the volume required throughout the theater from any given point. This point, however, should be somewhere in the audience and not at the rear of the theater. If it is at the rear, the reproduction will more than likely be too loud. It is necessary to regularly ascertain whether all the speakers are in operation; this should be a daily duty of the projectionists prior to the opening of the show.

It has been shown time and again that poor reproduction can

often be attributed to too high a volume level. In a theater which is too reverberant or in which echoes occur, these faults will increase with each point of rise in the fader setting. The best procedure is to start with a low fader setting and to raise it until the volume is sufficient to enable speech to be thoroughly understood.

Before opening to the public a theater which is newly equipped with sound apparatus, rehearsals should be conducted in order to enable each projectionist who will handle the equipment to become thoroughly acquainted with the apparatus. This helps to avoid stops in the show due to unfamiliarity with new apparatus, locations of switches, *etc.*, and will also help to point out improper adjustments of the apparatus which might have occurred during installation.

While increasing attention is now being paid to acoustics, it seems to be current practice to make an acoustical survey at the time of installation of the sound apparatus or even later. While this survey may have some value, it is made at too late a date to enable the exhibitor to make any corrections that may be necessary before opening the show. The reaction of a first-night audience to poor reproduction due to poor initial acoustic conditions, may be felt by the theater for a long time after the required corrections have been made. The acoustical survey should be made at the time the equipment is ordered; the correcting material required, if any, should be installed in time for the opening date.

In the early days of sound, it was considered almost impossible to estimate the acoustical qualities of an auditorium from the architect's specifications. This idea has been entirely disproved and it is now well known that the reverberation period and the production of echoes are functions of the size and shape of the house and its fittings. It is, therefore, quite possible and practical to determine to a sufficient degree of accuracy, just what the acoustic properties of any given auditorium will be when constructed of specified material and containing a given amount of absorbent material at given points.

CINEMATOGRAPHIC ANALYSIS OF MECHANICAL ENERGY EXPENDITURE IN THE SPRINTER*

C. A. MORRISON** AND W. O. FENN†

Summary.—*An investigation into the work involved in sprint running is made by a method of cinematographic analysis. The runners are photographed as they pass behind a lattice which serves as a system of coördinance, the timing being accomplished by means of a series of dropping balls. As a result of this analysis, it has been possible to determine the amount of power required to accomplish the various component motions of the runner, and to separate these from the energy required to overcome gravity, wind resistance, and frictional contact with the ground.*

Some investigations[1] into the work involved in sprint running have led to the development of a method of cinematographic analysis of sprinters which may lend itself to adaptation to other cases wherein there is a complex cyclic motion of articulated components of a moving system. Since the experiments of Marey and Demeney[2] no elaborate development of the analytical possibilities of such methods has been attained. There were serious errors in the early experiments pertaining to human locomotion: (1) the entire limb was considered as a rigid, non-flexing member of the system; (2) the velocity was considered to be uniform throughout the cycle; and (3) the back swing was neglected.[3] These assumptions gave values of the kinetic energy of the moving components which are only about one-eighth of the actual amount.

Fundamentally our method is that of Marey and Demeney. The runners are allowed to pass immediately behind a white, wooden lattice (Fig. 1) whose openings are exactly one meter square. The lattice is wide enough to include the average stride of the runners. A lens of long equivalent focal length (140 mm.) is used in order to reduce the parallax between the runner and the lattice. Measurements made on the assumption that this is zero are in no greater error than

* Presented at the Fall 1930 Meeting at New York, N. Y.

** Eastman Teaching Films, Inc., Rochester, N. Y.

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1.7 per cent even if the runner is 0.5 meter behind the lattice. A Bell and Howell camera with ultra-speed movement is used. Frames are exposed at the rate of about 125 per second with a shutter opening of such a value as to give an exposure per frame of 0.001 second, a value which provides good definition of the rapidly moving parts. On the left side of the lattice is placed a vertical scale calibrated in units corresponding to tenths of a second and against which is photographed simultaneously with the runners a series of falling wooden balls four inches in diameter. This provides a continuous record of the time

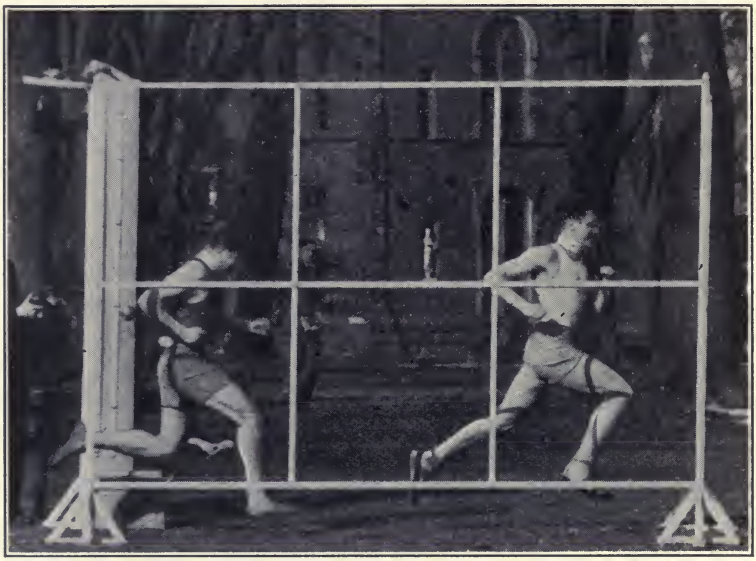

FIG. 1. Enlargement from a frame, showing runners and lattice.

by which variations of the speed of the hand-cranked camera can be determined throughout the experiment. The men, selected at random from physical training classes, run one after another across the camera field. Each man wears a black spot on a white cloth tied around the neck and a black spot on a circular white tag, which is fastened securely to the back of a wire frame placed around the waist. These serve as reference points in some phases of the analysis.

Movements of the various components of the body are determined from projected frames of the positive print. These are held in a gate consisting in part of two glass plates which clamp the film flat between

them in the object plane of the projection lens. The magnification is such that one meter on the lattice, which serves as a coördinate system, measures 16.6 cm. on the screen. In general, it is found to be unnecessary to measure every frame, excepting at those places where the movement of some member is extremely rapid.

For convenience of analysis in this particular experiment the runner is considered to be standing still, as though on a treadmill, running parallel with the plane of the camera field; in this case we have only to deal with the movements of the components with respect to the center of gravity of the whole body and with the deviations of this center of gravity. It is entirely feasible to consider that the runner is moving with respect to the ground, as he really is. Although both methods, of course, give as results the same value of kinetic energy, the first indicates a high value of kinetic energy in a limb when actual work is being done, whereas in the second case a small value of kinetic energy is indicated when the limb is going backward, although the runner expends as much energy in pushing it backward as in pushing it forward.

The principle of this analysis is a determination of the changes in the kinetic energy of each component with respect to the body as a whole. By determining the kinetic energies at small intervals throughout the cycle to catch all of the variations, and then summating the increases of energy, it is possible to compute the power required to accomplish them. The total kinetic energy of each part must be taken as the sum of its translational kinetic energy with respect to the body plus its rotational kinetic energy as it rotates about an axis, *e. g.*, the lower leg about the knee. The kinetic energy of the body as a whole will be (*cf.* Fischer and Steinhausen[4]):

$$K.\,E. = \frac{m_0 v_0^2}{2} + \frac{m_1 v_1^2}{2} + \frac{m_1 \omega_1^2 k_1^2}{2} + \frac{m_2 v_2^2}{2} + \frac{m_2 \omega_2^2 k_2^2}{2} + \frac{m_3 v_3^2}{2} + \frac{m_3 \omega_3^2 k_3^2}{2} + \quad (1)$$

where the suffixes refer to the various components of the body, m the weight, ω the angular velocity, v the linear velocity, and k the radius of gyration about the center of gravity of the component. Since v_0 is the velocity of the common center of gravity of the body with respect to the ground, it may be neglected in this phase of the analysis and is discussed elsewhere.[5] The values v_1, v_2, and v_3 are the velocities of the components with respect to the common center of gravity of the whole body.

Braune and Fischer[6] have determined the values of m and s from measurements of many cadavers. On the basis that the weight of

the body is unity, they calculated the following empirical factors of the weights of the components:

	m	s
Upper arm	0.0336	0.47
Lower arm plus hand	0.0312	0.66
Upper leg	0.1158	0.44
Lower leg plus foot	0.0705	0.61

The distance to the center of gravity of the component from the axis of rotation is s (Fig. 2), which is given in the table in terms of the fraction of the length of the limb. According to Braune and Fischer,[7] the radius of gyration, k, may be considered as 0.3 of the length of the limb. To account for the lengths of the hand and of the foot

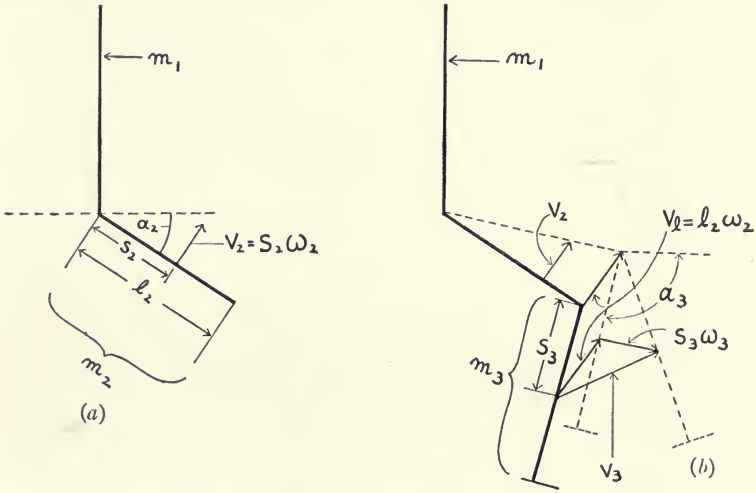

FIG. 2. Body (a) and leg (b) diagram for velocity analysis.

we have added 13 cm. to the length of the lower arm, measured from the elbow to the wrist, and 6 cm. to the length of the lower leg, measured from the knee to the lower extremity of the tibia. If, therefore, the length of the lower arm from the elbow to the wrist is 26 cm., the center of gravity of the lower arm plus the hand is 0.66×26, or 17 cm. below the elbow, and the radius of gyration around this center of gravity is $(26 + 13) \times 0.3$, or 11.7 cm.

From inspection of equation (1) it is seen that the only values to be obtained from the projected film are those of the translational and angular velocities of the components for any given instant. For these instantaneous values the translational velocities are determined

from the angular values; thus it is only necessary to read (Fig. 3) the value of angle α for each component, according to the convention of the diagram. These angular values for arms and legs in each frame are plotted against time (frames), as shown in Fig. 4, in which are also shown diagrammatically the corresponding positions of the limbs at various intervals during the cycle. The angular velocity ω is obtained by measuring graphically the slope from the smoothed displacement curve at every fourth frame.

The translational velocity of the upper leg, m_2, relative to m_1 is $v_2 = s_2\omega_2$ (Fig. 2*a*), from which the kinetic energy of translation with

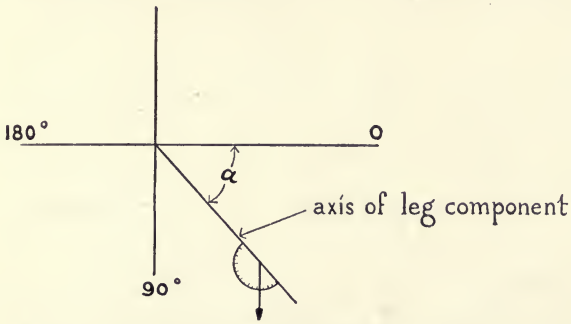

FIG. 3. Convention used for measuring angle α. This shows protractor in position for rapid determination of angles, using a plumb as index.

respect to m_1 is $\frac{m_2v_2^2}{2}$, and the kinetic energy of rotation about its center of gravity is $\frac{m_2\omega_2^2k_2^2}{2}$.

Fig. 2*b* represents a diagram of the entire leg. To measure the total kinetic energy of the lower leg we again have to determine the translational and rotational energies, but in this case the true translational velocity of the center of gravity of m_3 is the resultant of (1) a velocity $v_e = l_2\omega_2$, owing to the movement of the knee about the hip, assuming for this velocity that the angular velocity ω_3 is equal to zero, and (2) a velocity equal to $s_3\omega_3$, which is that due to movement of the center of gravity of m_3 about the knee joint with an angular velocity of ω_3. This resultant, v_3, of v_e and $s_3\omega_3$ is most readily obtained for this purpose by graphical methods rather than trigonometric. The angular velocity is obtained from the displacement

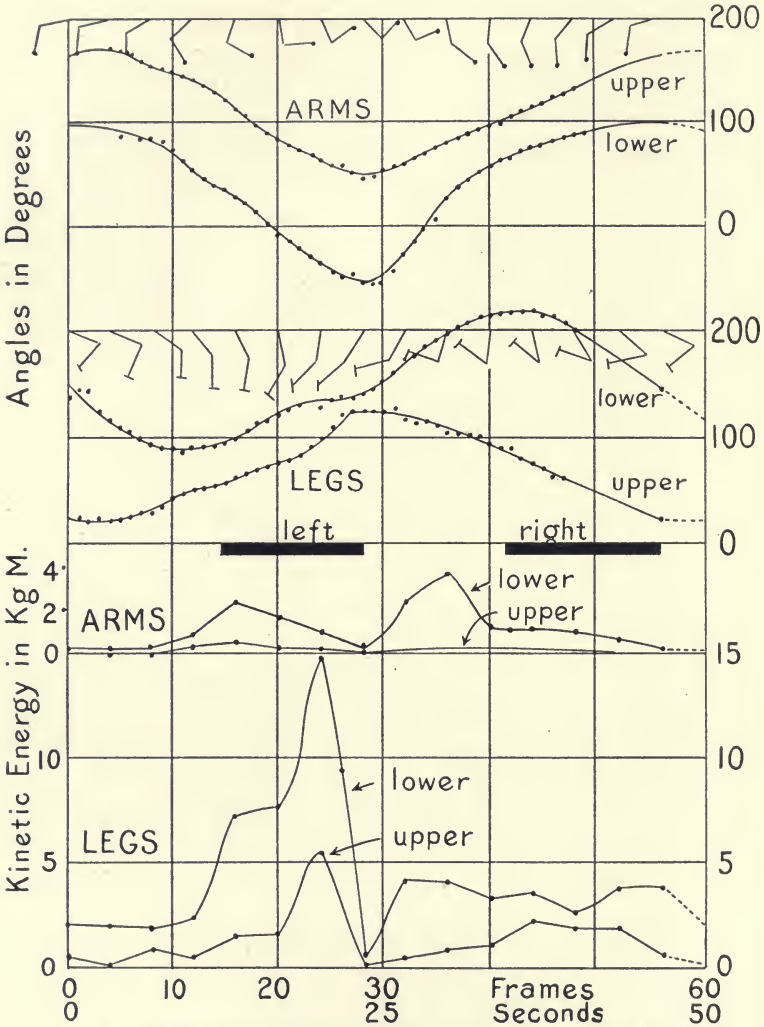

FIG. 4. Displacement and kinetic energy curves for runner No. 1.

curve in the same manner as for the upper leg. The kinetic energy for the lower leg is then calculated according to the formula:

$$K.\ E._3 = \frac{m_3 v_3^2}{2} + \frac{m_3 w_3^2 k_3^2}{2}$$

The values for the arm are obtained in an exactly similar manner.

Although the lattice behind which the runners pass is designed to

accommodate the average stride, in some cases it is not possible to obtain data for a complete cycle. In such cases it is necessary to extrapolate the data for the small remaining gap in the displacement curve. The exact length of the cycle is best measured from the interval between the moments when the toes leave the ground. The black blocks in Fig. 4 correspond to the intervals during which the respective feet are in contact with the ground. The curves are so smoothed out that the angles of the beginning and the ending of the cycle are alike.

Table I gives the data for the left leg of runner number 1 through one-half of the cycle. The values of angle α are measured from the

TABLE I

Kinetic Energy of Left Leg of Runner Number 1 during One-Half Cycle

Frame Number	Angles α, Degrees		Angular Velocity ω, Degrees per Frame		Linear Velocities, Cm./Sec.				Kinetic Energy, Kilogram Meters					
									Upper			Lower		
	Upper	Lower	Upper	Lower	$v_2=s_2\omega_2$	$v_e=l_2\omega_2$	$s_6\omega_6$	v_3	Translation	Rotation	Total	Translation	Rotation	Total
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
0	21	137	−2.6	−5.5	96	218	281	275	0.33	0.17	0.50	1.57	0.49	2.06
4	20	118	+1.0	−5.0	37	84	256	280	0.05	0.02	0.07	1.62	0.40	2.02
8	31	95	+3.5	−3.7	129	293	189	273	0.60	0.29	0.89	1.65	0.22	1.87
12	49	90	+2.5	+1.0	92	210	51	340	0.30	0.15	0.45	2.40	0.02	2.42
16	60	101	+4.5	+4.5	166	377	230	570	0.99	0.49	1.48	6.77	0.32	7.09
20	77	122	+4.5	+5.0	166	377	255	585	0.99	0.49	1.48	7.11	0.40	7.51
24	101	134	+8.5	+2.7	313	710	138	830	3.51	1.79	5.30	14.3	0.12	14.4
28	127	140	0.0	+2.7	0	0	138	138	0.0	0.0	0.0	0.39	0.12	0.51

Frame to frame interval 0.0083 sec.

projected images of the frames, according to the frame number in column (1). At these various times the slopes are graphically measured from the displacement curves by placing a straight edge tangentially at the point. This slope gives the value of ω. The linear velocities are computed from the instantaneous angular velocities by multiplying their equivalent values in radians per second by s_2 and l_2, respectively. The resultant velocity v_3 is obtained by plotting vectorially the velocities in columns (7) and (8). They will, however, be shifted through a phase difference of 90° because the angles α, from which they are obtained, are measured at right angles to the direction of their motion. The kinetic energies are then com-

puted directly from these velocities, and the masses of the components obtained from the Braune and Fischer data. The time-rate of doing the work of moving the components with accelerated velocities is computed from the total increase of kinetic energy throughout a cycle. It is assumed that there is energy expenditure by the muscles during the increase and dissipation of energy as heat during the decreases. The apportionment of the increases of kinetic energy of arms and legs of runner number 1 is shown in Table II. The horsepower is computed from the total kinetic energy, multiplied by 2, and divided by the time of a complete cycle, with the necessary chang-

TABLE II

Increases of Kinetic Energy (in Kilogram Meters) of Arm and Leg during One Complete Running Cycle

Weight, Kgm.	Arm					Leg						Arm and Leg	Hp.
	Upper		Lower		Total	Upper		Lower			Total		
	Forward	Backward	Forward	Backward		Forward	Backward	Backward	Knee Flex	Forward			
68	0.51	0.16	2.33	3.54	6.54	2.26	5.52	12.95	3.85	1.25	25.83	32.37	1.83

ing of units. The average rate of expenditure of energy in accelerating the arms and legs of 21 runners is 1.68 horse-power per runner.

From a complete analysis[1,5] of these experiments the following distribution of energy expenditure has been obtained:

Acceleration of arms and legs	1.68 Hp.
Deceleration of arms and legs	0.67
Work against gravity	0.1
Wind resistance	0.13
Contacts of feet with ground	0.37
	2.95 Hp.

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CONTINUOUS NON-INTERMITTENT PROJECTORS*

ARTHUR J. HOLMAN

Summary.—*The ideal projector and its product, ideal projection, are defined in terms of the screen image. The particular characteristics which distinguish continuous non-intermittent projection are given. The apparent attitude of the motion picture industry toward improvements in projection and the reasons therefor are presented. Types of variable refraction projection systems are discussed with a view to pointing out the advantages possessed by the revolving lens wheel system. The single lens wheel system is described briefly. The main purpose of the paper is to dispel scepticism regarding the possibilities of non-intermittent projection and to clear the way for scientific investigation of the continuously illuminated non-periodic screen image.*

In a former paper[1] the ideal projector was defined as one having "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." The ideal projector is not defined in terms of any particular mechanism or even in terms of any particular type of optical system, but it is defined in terms of the light picture it paints on the screen as the film moves uninterruptedly across its aperture plate. From the very nature of things it is evident that screen images produced by the ideal projector are alive and dynamic, since outlines of moving objects are continually shifting, due to the continuous dissolving action. But even if the ideal projector did not provide this mobility of image and many other advantages incidental to the dissolving action, it is worthy of the name because it substitutes uniformly lighted, non-periodic screen images for the lightning-like flashes shot at the screen forty-eight times a second by intermittent projectors.

Turning for a moment from the ideal projector to its product, ideal projection, let us illustrate the only kind of projection that may be properly termed ideal. In order to do this, let us go back to the days

* To be presented at the Spring 1931 Meeting at Hollywood, Calif. Received by the Editor April 24, 1931.

before the movies become popular, when stereopticon lectures were in vogue. First of all, the hall was usually quite dark during the exhibition, not because of any particular consideration of glare spots but primarily because it was difficult to provide a bright screen image for any considerable period without damaging the slides. Imagine sitting in such a hall and looking at a beautifully colored scene. On the screen, the sky is brightly lighted but there is no appearance of scintillation; the full details are distinguishable even in the dark recesses between the rocks along the shore; there is no appearance of graininess anywhere in the scene, not even in the intermediate halftones; all the natural gradations of light and color are there before the eyes and the illusion is as perfect as a one-eyed view can ever be, except that all moving objects, such as the waves, the spray, boats at anchor, and the trees, are as static as if the scene were cast in plaster. Now imagine that the screen image becomes mobile and dynamic; the waves roll and break on the shore, the spray shoots up and falls naturally, boats bob and toss and the trees bend in the breeze. In all other respects the scene retains its former characteristics; no scintillation in the highlights, no stroboscopic effect, no plugging up in the shadows, or other disturbance to the natural tone, no gradations, no appearance of graininess, no more eye-strain or nerve fatigue. This is *ideal* projection—the product to be expected of the ideal projector. Truly, it seems product of the imagination, but many, who have been experimenting with continuous, non-intermittent projectors, have really seen and have become accustomed to motion picture projection which reaches far up toward this ideal, and in comparison to which intermittent projection is a hopeless make-shift.

The subject is revolutionary. Scores of devices have been constructed both here and abroad, but these have fallen so far short of the ideal in performance, that the motion picture industry, observing endless failures, has almost entirely ceased to hope for and dream of fundamentally improved projection. Revolutionary attainments are often not in the least appreciated. It is surprising to find out how well satisfied the industry is, in general, with intermittent projection. It is only when it is emphasized that motion pictures are tiring to the eyes, produce nerve fatigue, and may even cause permanent injury, especially to children's eyes, that the industry girds itself to combat such propaganda. The arguments offered by spokesmen for the industry and much of the scientific data offered as evidence that motion pictures do not cause eye-strain are really amusing

in view of the facts which any intelligent observer can easily discover for himself. The lightning-like flashes shot at the screen by intermittent projectors produce entirely unnatural illumination. We are so constituted, both physically and mentally, that the unnatural and the unaccustomed are fatiguing, especially if we are exposed to their effects for long periods. When we think of the well-known phenomenon of retinal fatigue, it is not at all surprising that intermittent screen images differ materially in appearance and in their effect on the eyes of the observer, from continuous, non-periodic screen images and that the latter are more pleasing and less fatiguing to look at. Much could be written on the advantages of non-intermittent projection, but to date the subject has not been carefully studied or investigated, and why should it be, or rather, how could it be, till some inventor brings forth a practical non-intermittent projector? It is dangerous to discuss the ills of intermittent projection till the industry is provided with better means for exhibiting its product.

Non-intermittent projection, being such a dangerous subject, has had little consideration from the industry in the past year, as is evidenced by the fact that the demonstration of the revolving lens wheel projector before this Society a year ago[2] has had little or no effect in clearing up the "mystery" surrounding "continuous projection." As a matter of fact, there is no mystery about optical rectifying systems, except that which some unscientific sponsor of a particular apparatus may purposely create around one or another aspect of his device to avoid disclosing the inherent defects of his system. This paper is presented in an effort to clear up some of this "mystery" surrounding apparatus embodying the principle of variable refraction, which principle, as has been observed, offers the most promising means for providing ideal projection.

The principle of variable refraction has become so popular with inventors that practically all recent patents on optical rectifying means and all the latest "continuous projectors" appearing in this country embody variable refraction in one form or another. Most of the recent devices use multiple moving lens elements and these are circulated through the light beam. In general, these devices may be classified under two headings: first, devices wherein the lens-feeding mechanism handles each lens element individually, and, second, devices wherein the individual lens elements are rigidly mounted on a rotatable structure and are carried through the light beam by the

rotation of the structure as a whole. Devices coming under the first classification have been developed, notably in England, France, and Germany, and several of them have been brought to this country. The revolving lens wheel projector, representing the rigid optical structure, has been developed exclusively in this country.

Inventors providing lens-feeding mechanisms which handle the moving lens elements as individual units, undertake a very difficult mechanical and optical problem because they believe it is essential, at all costs, to provide the optical arrangement described previously[1] as the "perfect system," namely, "a stationary front optical element and a continuous procession of 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." The designer of the revolving lens wheel mechanism provides a rigid mounting for the moving lens elements thereby causing these elements to travel on a fixed circular orbit which is so arranged and located with respect to the axis of the fixed optical element, that the errors, introduced by causing the moving elements to travel at constant angular velocity through the active zone on the fixed orbit instead of along a straight path at uniform linear velocity, as in the above-described "perfect system," are negligible.

Inventors essaying the "perfect system" are faced with the problem of providing straight line motion and uniform linear velocity for each moving lens element during its passage through the bundle of rays which has passed through the film overlying the aperture plate. The total number of lens elements is limited by cost and other practical considerations, hence it becomes necessary to pick up the individual moving lens elements at the end of the straight path and return them, over a conveniently short curved path, to the starting point of the straight path. This simple circulation of the moving lens elements does not sound difficult of accomplishment, but when one considers with what precise accuracy it must be performed, one must admire any inventor's courage in assuming the task of constructing such precise mechanism. The mechanical problem is so extremely difficult that designers, not familiar with the optical problem, or at least not recognizing its supreme importance, have contented themselves with mechanisms designed to circulate small lens elements having circular apertures. In such devices the lens elements must be housed in cells which further cut down their effective apertures to such an extent that all the light transmitted to the screen by such systems must

pass through a lens aperture scarcely more than five-eights of an inch in diameter. It is difficult to conceive how anyone in the least degree familiar with projection lenses could ever hope to transmit the immense amount of light required to illuminate the modern theater screen through lens elements of such small aperture. The cells, wherein the moving lens elements are mounted, present fully as much opaque area, in passing through the light beam, as the lenses present transparent area, hence the passage of the lenses through the light beam is accompanied by considerable shutter effect. It is quite obvious that such systems do not offer the least possibility of producing the screen images required of the ideal projector. We may conclude that such devices are optically and mechanically impossible. Variable refraction, after the fashion of the "perfect system," offers far more obstacles and far less chance of success than does the variable reflection principle with its multiple, individually tilting rotating mirrors which can be made to function quite well, at least when the mechanism is new.

On the other hand, what are the possibilities of the revolving lens wheel system and what are its inherent errors? In the first place, the system is based on the theory of limits as outlined in the differential calculus, which simply means that the system may be designed to approach as closely to the theoretical accuracy of the "perfect system" as we may desire, *i. e.*, the inherent residual errors may be made as small as we are pleased to have them. In practice the system is so designed that the residual errors are insignificant as compared to errors inherent in the mechanical structures, as, for instance, the errors which are present even in sprockets of the highest precision, or the errors inherent in any rotating apparatus, which errors are due to the presence of running clearance in the bearings. Hence, for all practical purposes, and in so far as can be determined by measurements of the screen image, the revolving lens wheel system is as accurate as the "perfect system." The theory proves that the revolving lens wheel system is possessed of that precise accuracy which is a fundamental requirement of any apparatus or optical system designed to provide such precise placement of successive screen images as is required to produce a smooth, dissolving action between successive film frames.

The advantages gained by rigidly mounting the moving lens elements are quite obvious. Once these elements are located on the lens wheel, their spacing is established and subsequent wearing of the

mechanism in service cannot change or alter it in any way. This is a very important factor, for any variation whatsoever in the spacing of the moving lens elements causes the screen image to become unsteady. But what is of even greater importance, the rigidly mounted elements are moved over a fixed orbit and the only motion required to provide the precise image placement theoretically possible with the system, is pure rotation. Rotative movement is relatively easy of accomplishment, and, since all the moving lens elements are rigidly supported on one rotating member, it is obvious that subsequent wear in the lens-feeding mechanism is confined to the two bearings supporting the rotating member. Hence there is very little likelihood that wear in the mechanism will cause variation in the alignment or in the angular velocity of the moving lens elements as they pass through the light beam. Thus wearing of the working parts of the mechanism in service is reduced to a minimum, and, furthermore, whatever wear may occur is not liable to affect the steadiness of the projected image. Since no movement other than pure rotation at constant angular velocity is employed in the revolving lens wheel projector mechanism, it is obvious that such mechanisms will be quiet in operation and will remain quiet throughout years of service. The simplicity and inherent accuracy of the revolving lens wheel system and its obvious freedom from deterioration due to wear easily establish its mechanical superiority.

The aperture of the moving lens elments in the revolving lens wheel system is not limited by mechanical considerations. Moreover, these elements are mounted in such a way that no opaque substance whatsoever is caused to pass through the light beam. The entire periphery of the lens wheel, which passes through the light beam, is composed of glass. The individual lens elements, which compose the periphery of the wheel, are so formed and located that they constitute a composite unbroken band or ring of glass. Thus this system provides the full normal aperture, the equal of the effective apertures of standard projection lenses for any and all angular positions of the lens wheel elements, and, furthermore, the system is free from all shutter effect as the lens wheel rotates. It is for these reasons that the revolving lens wheel system of projection is capable of delivering ideal projection.

The proof of the accuracy of the fundamental theory of the revolving lens wheel system has been satisfactorily demonstrated time and again with the two lens wheel projector formerly described[1] and exhi-

bitied at the Washington Convention.[2] Within the past year or so the writer has invented an improved revolving lens wheel system which requires but one lens wheel and, for given over-all machine dimensions, provides a closer approach to the theoretically perfect machine than does the two lens wheel design. Incidentally, the new single orbit design lends itself very nicely to both projector and camera construction, providing, in each case, a simple, compact, and convenient structure. In the two lens wheel design there are three elements to be kept in synchronism, namely, the two lens wheels and the film. In the new single lens wheel design, it is only necessary to maintain synchronism between the one lens wheel and the movement of the film across the aperture plate. Hence the number of gears and the complexity of the gear train are reduced in the single lens wheel machine, all of which makes the new design cheaper to manufacture and more accurate in performance.

It is hoped that this paper will be helpful and illuminating to those unfamiliar with "optical rectifying systems" or "continuous projectors," as they are commonly called, and that it will be instrumental in clearing away the "mystery" surrounding the subject, thus opening the way for serious scientific consideration of the one system of projection which offers great promise of fundamental and revolutionary improvements in the art of recreating the true appearance of motion in either black and white or true color images.

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THE MOTION PICTURE INDUSTRY IN SOVIET RUSSIA*

Summary.—The first portion of this paper is a translation of an editorial in the November, 1930, issue of "Motion Pictures and Life," apparently an official organ of the Soviet motion picture industry. The Five-Year Plan of Soviet Russia embraces the development of the motion picture industry, and while most of the other industries fulfilled their assigned tasks during the first two years, the motion picture industry fell far behind. The weak points of the present system are outlined, and the general status of affairs is indicated.

The second portion of the paper is an abridgment of an article in "News of the Electric Industry," of May, 1930, entitled "Talking Movies," and describes apparatus developed by the Central Laboratory of Wire Communication in Moscow.

While most of the other industries fulfilled their assigned tasks for the first two years of the plan, the motion picture industry fell far behind. Its assistance in the political campaign was unsatisfactory; re-education of the masses and the preparation and training of new technical personnel took place without this powerful accessory. The main cause of this is the fact that the production of new films is under the continuous influence of commercial demand. It is still a combination of a little business and a lot of art. This combination hardly lends itself to planning and estimating.

The weak points of the present system are as follows:

(*a*) Too slow development of factories for making native film, causing great delay in work.

(*b*) Continuation of the policy of production of pictures for use in commercial theaters, which leaves the school, village, and political club screens without material—*i. e.*, making too many artistic pictures, and too few educational pictures.

(*c*) A decided increase in cost of production together with a decrease in quality, and an increase in time required for production from the normal four to five months for an average-length feature picture to ten or eleven months.

(*d*) Instead of an estimated cost of 60,000 rubles for such a picture, the cost reached in some cases 100,000 rubles. This resulted in

* Received by the Editor April 1, 1931. Translated and abridged by I. G. Maloff.

the establishment of an unjustified general opinion that the high cost of motion pictures is inherent in the process of their making. The increase in time of production decreases the output, and interferes with the whole program.

Notwithstanding the increase of technical possibilities, a large increase in the number of motion picture installations throughout the country, and the centralization of all work in the hands of the Motion Picture Department of the National Industrial Committee, the task assigned to the motion picture industry was not fulfilled at the beginning of the third year of the Five-Year Plan.

One of the great difficulties is the lack of native-made film, which is the main cause of an insufficient supply of films for the projection houses. Gradually the portable projectors, with which the villages were first supplied, are being replaced by new, permanent installations of recent design.

The talking pictures seem to be in worse condition than anything else in the industry. The production of apparatus for this branch is entirely too slow, The third year of the Five-Year Plan must become a year of creation of an entirely independent native supply, both of film and apparatus. It must become a year of talking motion pictures. The assignment for the production of 2000 talking motion picture projectors and 50 talking motion pictures must be completed without fail.

It is estimated that the year 1931 will see 18,000 new projection houses (including schools) in operation. This increase, which covers villages as well as cities, will demonstrate its effect not only politically, but also economically.

Other published articles in this issue of *Motion Pictures and Life* indicates serious activities along all the lines mentioned. Feature, news, animations, and educational pictures are reviewed. An article is devoted to a description of new courses given at the Moscow Motion Picture School of Technology. Apparently this school has several departments devoted to the technical and engineering phases of the business. It also trains production directors, and has recently instituted a course of instruction for scenario writers.

As to apparatus used at present in the U. S. S. R. for talking movies, recording and reproducing, an article in *News of the Electric Industry*, May, 1930, gives a brief description of present-day technic. This

article, entitled *Talking Movies*, describes the apparatus developed by the Central Laboratory of Wire Communication in Moscow.

The standard recorder is of the vibrating string type. It consists essentially of stretched bronze ribbon 0.15 mm. wide and 0.008 mm. thick. Light from the lamp, after passing through a system of lenses, meets this ribbon, after which it is directed through a slot aperture on a cylindrical lens, and the image of the slot is focused on the film in the shape of a narrow (0.01–0.02 mm.) band of light. One side of this band is partially covered by the real image of the ribbon. This brass ribbon is kept in the field of an electromagnet excited by direct current. The ribbon is in the output circuit of the microphone amplifier, and vibrates in the direction perpendicular to the magnetic field. If the direction of the ribbon is parallel to that of the slot, variable density recording is obtained. If the slot and ribbon are mutually perpendicular, variable area recording is possible. The article mentions an oil-damping method used in connection with the ribbon, but the details are not given. A large part of the article is devoted to synchronization methods, which are exact duplicates of standard American practice.

An interesting development is mentioned. It is a special magazine for 3000 feet of film, on which sound can be recorded in 8 rows and which can take records and conferences, political speeches, *etc.*, up to four hours' duration. The same magazine can be used in the reproducing apparatus.

The standard practice for all studios is to record sound on one film and the picture on another. However, for the portable equipment there is a special camera which photographs and records sounds simultaneously on the same film. A description of reproducing apparatus follows, which in no essential detail differs from standard American equipment.

Electrodynamic loud speakers very similar to those used in this country are apparently standard equipment in reproducing systems. In the amplifiers used with the recording and reproducing systems, the push-pull circuit is universally used. Unfortunately, the tubes used are identified by code letters, and no power ratings are given. In several articles, descriptions of new amplifiers, loud speakers, and other accessories are discussed. They show, however, very marked influence of the American practice, and do not represent anything really new from the American point of view.

The Five-Year Plan and its assignments are mentioned in practically every article. These assignments apparently are very large, and are very seldom fulfilled. However, a rough estimate would indicate that 70 per cent of the work scheduled is done on time, a remarkable fact considering the general conditions of the country.

COMMITTEE ACTIVITIES

REPORT OF PROJECTION AND SOUND REPRODUCTION COMMITTEE*

Education.—The committee feels that the Society will be interested in the following activities, all of which have for their main purpose the circulation of information pertaining to projection and sound reproduction to projectionists through the world.

The American Projection Society has chapters in all the principal cities of America. Its purpose is to disseminate information on projection and sound to its members at regular individuals. The RCA School, conducted in New York City, enrolled over six hundred projectionists from New York and the surrounding area. A handbook is now available which incorporates the essentials of this course and is supplied with new equipment installed by that corporation. The Projection Advisory Council organized only two years ago now has an international membership and has selected as officers regional vice-presidents from the ranks of the best-known projectionists in the United States, Canada, the Canal Zone, and Great Britain. Its most important activities are bringing to the attention of projectionists the publications of the Society of Motion Picture Engineers, the American Projection Society, the Academy of Motion Picture Arts and Sciences, and all other sources of technical development and information which are helping to raise the standards of projection. The Kaplan Projection Society, consisting of members of Local 306 of New York City, is organized for educational purposes only. This society meets twice a month with a regular attendance of from four hundred to six hundred projectionists. Similar societies are conducted by the majority of the Locals of the I. A. T. S. E. & M. P. M. O. of the United States and Canada.

Standard Release Print Make-Up and Practice.—Mr. Lester Cowan, representing the Academy of Motion Picture Arts and Sciences, appeared before the committee in connection with the approval of a

* Presented at the Fall 1930 Meeting at New York, N. Y.

Standard Release Print Make-Up and Practice. The committee wishes to recommend that the proposed standard be adopted by the Standards Committee with what minor changes may be found necessary after being put into actual practice.

Design of Projection Rooms for Sound Reproduction.—Some very complete and elaborate designs for projection rooms were submitted to the committee for consideration by Mr. J. H. Goldberg. These plans and layouts were very comprehensive, including what would be considered an ideal up-to-date layout for small, medium, and large theaters. It was decided to turn this material over to the new committee which will report at the Spring Meeting in Hollywood, California.

Fire Prevention for Motion Picture Projectors.—Most fires in motion picture projectors are caused by stopping or packing of film at or near the aperture when exposed to the intense beam of light from the illuminant. An ideal device to prevent fire in a motion picture projector should function when any of the following conditions occur:

Jamming of the mechanism due to lack of proper oiling
Broken gears or parts
Failure of take-up mechanism
Interruption of motive power due to broken belts or chains
Failure of clutch
Blowing of fuses
Extreme drops in motor supply voltage
Poor condition of film
Film breaks
Running off sprockets
Loose patches
Torn sprocket holes
Improper threading

A device which will give complete protection against the hazards in a motion picture projector by making impossible any stoppage of the film in the beam of light for a period longer than 0.1 second should operate within that space of time, first cutting off the light beam, and then stopping the mechanism. This can be done by a remote-control system which would detect any of the above dangerous conditions and function so quickly that ignition could not occur. A device of this character should consist of a light douser, a motor control relay, two film switches, and a rotary switch.

The douser should be mounted on the cone of the projector lamp and be equipped with a douser plate mounted on one end of a lever

which could be rotatably held in the unit. In order to operate the projector, the lever could be turned through one quadrant, lifting the plate clear of the light beam. The latter should be held in suspension by a well-designed, high-speed release mechanism. A pair of contacts should be arranged so as to energize the motor control relay as the plate is being turned through the first five degrees. A stop should also be arranged to prevent running of the plate beyond 10 degrees until a predetermined film velocity has been attained. This stop could be controlled by a no-voltage release coil in circuit with the film and rotary switches.

The film switches should be connected in series with the douser no-voltage release coil. Any interruption or derangement of the film during its passage through the projector would cause instant operation of these switches, whose function would be to de-energize the no-voltage coil and cause the douser plate to fall in the path of the light when a fire hazard occurs due to poor condition of the film. These switches should be equipped with contacts of pure silver to avoid difficulties due to corrosion. Various arms and rollers should be placed in loops and other strategic places, mechanically connected to the film switches so as to function at the proper moment.

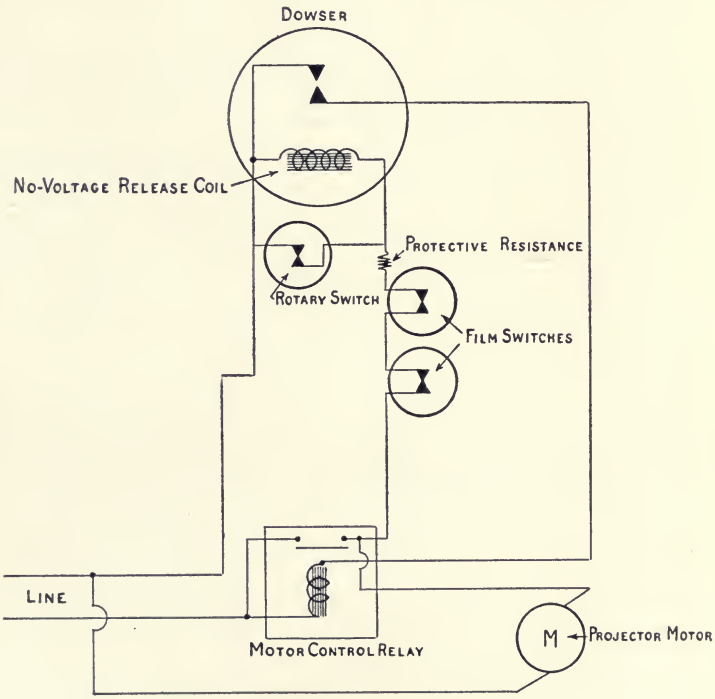
The rotary switch should be driven direct from the projector mechanism and should be designed to short-circuit the no-voltage release coil through a protective resistance until the projector accelerates to a speed at which it will pass film at the rate of 50 feet per minute. The contacts in this switch should open and allow the no-voltage release coil to hold the douser open for any speed above 50 feet per minute. When the velocity decreases to 50 feet per minute the contacts should close, short-circuiting the no-voltage release coil and thus cause the douser plate to fall.

The motor-control relay should be equipped with contacts and blow-out coils of sufficient capacity to successfully interrupt a current equal to that obtained when the rotor of a $^1/_2$ hp. motor is stalled. This device should be designed to meet the requirements of the Underwriters' Laboratories.

Theater Acoustics.—The committee recommends that the exhibitor should first look to the manufacturer of his sound equipment for acoustic analysis and acoustic recommendations for his theater. If the manufacturer has no consulting service to offer, he should go either to a recognized acoustic consultant or to a manufacturer of acoustic materials having a staff of acoustic experts. The committee

strongly advises every exhibitor to have his theater acoustically analyzed in every case, and to have it treated wherever there is economic justification.

Analysis of Quality Losses.—In approaching the subject of the analysis of quality losses an attempt has been made to group these losses into various classifications. In grouping such factors so closely related to one another, it is obvious that some overlapping will occur,



Suggested circuit for protective switches and relays.

and consequently several different groupings have been prepared. It seems likely that further study of this subject might make it possible to arrange these items into a more acceptable form than as presented at this time.

In the accompanying résumé four main causes are listed for the poor quality sometimes encountered during projection.

PRINCIPAL FACTORS AFFECTING REPRODUCTION QUALITY

1. *Wave-form distortion.*
   (*a*) Distortion caused by overloading:
   - Overload during recording.
   - Effect of poor prints.
   - Overload of photoelectric cell.
   - Overload of photoelectric cell amplifier.
   - Overload of power amplifier.
   - Overload of loud speaker units.

   (*b*) Distortion caused by irregular film motion:
   - Regularly recurrent changes in film speed causing pulses.
   - Irregular changes in film speed causing flutter.
   - Changes in amplitude causing modulation.

2. *Frequency discrimination.*
   - Discrimination introduced during recording.
   - Effect of poor prints.
   - Effect of sound-optical system.
   - Effect of photoelectric cell and couplings.
   - Discrimination in amplifiers.
   - Discrimination by loud speakers.
   - Discrimination by screens.
   - Effects of acoustics of theaters.

3. *Improper reproducing volume.*

4. *Extraneous noises.*

As a further elaboration, section 1(*b*) in the above table may be subdivided as follows:

CAUSES OF IRREGULAR MOTION OF FILM

(*a*) *Eccentric motion of sound sprocket:*
- Unbalanced flywheel.
- Sprung shaft.
- Defective filter.
- Binding gears.
- Excessive end-play in shutter shaft.

(*d*) *Dirt accumulations:*
- Dirt on sound sprocket.
- Dirt on rollers and guide rollers.
- Emulsion piling up on sound gate and film tension pad.

(*c*) *Miscellaneous causes:*
- Irregular pull from take-up reel.
- Lateral motion of film at sound gate.
- Lack of pressure at film tension pad.
- Insufficiently dried or poorly lubricated prints.
- Sprocket tooth distortion.

Section 3 of the table includes a number of effects with which all are familiar, and which may be improved or eliminated by suitable or improved control apparatus and supervision. This subject was given considerable attention by the projection committee in their report last spring.

Section 4, covering extraneous noises, may be elaborated as in the table below, including noises introduced by the projection apparatus itself, in addition to ground noise due to imperfections of the film. The latter form of disturbance is, of course, one of the principal causes of certain kinds of wave-form distortion introduced by overloading of the film during recording in attempting to reduce the ground noise resulting during projection.

4. OBJECTIONABLE NOISES ENCOUNTERED IN PROJECTION

(*a*) *Continuous noises with machine not running:*
- Regular hum:
  - Improper grounds on amplifiers.
  - Defective tubes in power amplifiers.
  - Charging equipment interference.
  - Light from incandescent bulb reaching photoelectric cell.
- Irregular noises:
  - Noisy photoelectric cells.
  - Noisy vacuum tubes.
  - Noisy batteries.

(*b*) *Noises introduced by running machine without film:*
- Regular hum or rumble:
  - Microphonic sound lamps.
  - Microphonic sound lamp bracket.
  - Microphonic adjustment of sound lamp.
  - Microphonic vacuum tubes in photoelectric cell amplifier.
- Irregular noises:
  - Loose connections in wiring.
  - Poor contacts on rheostats, *etc.*

(*c*) *Noises accompanying running of film through projector:*
- Regular noise effects:
  - Hum due to light falling on sprocket holes.
  - Hum or echo due to light falling on picture frames.
  - Ground noise in film emulsion.
  - Ground noise due to accumulated oil and dirt.
  - Noise of projection machines coming directly from booth.
  - Direct sound from monitor horn, sometimes causing echo.
  - Ringing sound caused by monitor horn acting on vacuum tubes.
- Intermittent noise effects:
  - Clicks due to wax accumulations on sound track.

Clicks due to poorly-made splices.
Sounds emanating from booth during re-winding of film.

(*d*) *Miscellaneous noises:*
Interference from projection arc and automatic feed relays.
Clicks due to automatic change-over switches.
Clicks and volume changes due to sound lamp switches.

Last fall an inspection was made of six motion picture theaters, including three of the largest and most up-to-date in the country and three of moderate size. While the inspection was restricted to certain classes of defects, other defects which were present were not of an order to be particularly objectionable in those houses in comparison with other theaters employing the same apparatus. The theaters inspected were selected quite at random with no previous knowledge of their conditions.

Included as a part of this report is a résumé of the defects found. These are classified in various groups and their prevalence is given in per cent. Owing to the fact that only six houses were covered, the figures appearing on this sheet cannot be regarded as accurate averages for all houses.

RÉSUMÉ OF DEFECTS ENCOUNTERED IN SOUND EQUIPMENTS IN SOME OF THE LARGEST MOTION PICTURE HOUSES

	Per cent
Optical systems:	
Out of focus	27
Adjusted too near picture	73
Adjusted too near sprockets	0
In focus and properly adjusted	7
Defective vacuum tubes:	
Lack of emission in small tubes	11
Loud speaker equipment:	
Poling reversed at loud speaker units	18
Loud speaker units not operating	5
Tone lines connected to wrong units	9
Horns tilted too high	73
Horns not flared sufficiently	45
Obstructions in front of horns	9
Additional loud speaker units necessary for safe load capacity	64
Additional horns necessary for proper house coverage	18
Miscellaneous defects:	
Inability to obtain sufficient filament current	17
Objectionable projection machine noise emanating from booth	17
Manager forces projectionists to run over 90 feet per minute	17

Objectionable noise disturbances from loud speakers when sound lamp switches are operated	100
Noticeable changes in volume when sound lamp switches are operated	100

It is believed that the conditions as indicated by these figures are gradually improving, but an analysis of quality losses would be incomplete without some mention of the effects upon sound quality which are due to apparatus not being properly maintained and operated.

L. M. TOWNSEND, *Chairman*
H. W. DREYER
G. C. EDWARDS
P. H. EVANS
T. FAULKNER
J. H. GOLDBERG
C. GREENE
H. GRIFFIN
N. M. LA PORTE
R. H. MCCULLOUGH
W. A. MACNAIR
R. MIEHLING
W. B. RAYTON
F. H. RICHARDSON
H. B. SANTEE
D. F. WHITING

PROJECTION PRACTICE COMMITTEE

The third meeting of the committee was held on Wednesday evening, March 18th, in the Paramount Building, New York, N. Y.

Secretary Hopkins reported that he had obtained the code on projection rooms from the authorities in British Columbia, and Pennsylvania, and also a letter from the Fire Marshall in Vancouver relative to their methods of reducing fire hazards. The codes in question were referred to the Chairman of the sub-committee on Projection Room Standardization.

Chairman Goldberg of the sub-committee on the Planning of an Ideal Lay-out of Projection Rooms submitted a report dealing with projector spacings; the size and location of observation ports and projector ports; recommendations for projection arc conduits and conduits for sound equipment; recommendations on desirable types of projection room lighting and ventilation and the location of extra rooms.

Chairman Griffin of the sub-committee on Improvements in Projector Design, reported that as a result of the suggestion of the committee, the manufacturers concerned had decided to build a projector unit which will eliminate the necessity of shimming, whereby the projector mechanism can be slipped on and off the base as was permissible before the advent of sound equipment.

Among other matters discussed were the problems relating to screen brightness and projection angles.

Members present were: H. Rubin, Chairman, H. B. Santee, Herbert Griffin, F. H. Richardson, J. H. Goldberg, J. J. Hopkins, P. A. McGuire, Rudolph Miehling.

MEETING OF THE PROJECTION THEORY COMMITTEE*

At a meeting of the committee held at the Hotel Sagamore in Rochester on March 25, 1931, three of the regular members of the committee were absent but the meeting was attended by Mr. F. K. Moss of Nela Park, Cleveland, as an advisory member of the committee and also by Mr. J. I. Crabtree, president of the Society. Subcommittees were appointed to deal with:

(1) Summarizing the literature
(2) Non-intermittent projectors
(3) Translucent screen projection
(4) The effect of curved film gates on picture quality
(5) Distorting systems for photography and projection
(6) Methods of measuring and expressing screen illumination

There was considerable discussion of the need for research in what might be called the physiological optics of motion picture projection and of means for having that research performed.

W. B. RAYTON, *Chairman*

PROGRESS COMMITTEE**

Most of those members serving on the committee last year accepted appointments for 1931. In order that all phases of the industry would be represented more fully, the chairman recommended several additional appointments to the president both in this country and abroad. In view of the wide geographical separation of the committee members, all business has to be conducted by correspondence, making it necessary that one member, actually the chairman, be responsible for the bulk of the work of preparing the semi-annual report.

It has been found effective, however, to distribute some of the duties of the committee fairly widely among its personnel. Some idea of the distribution may be gathered from the following assignments:

* Received by the Editor March 28, 1931.
** Received by the Editor April 1, 1931.

Studio and Theater Illumination (including projection)—R. E. Farnham, E. R. Geib; Technic of Production (scenarios, direction, acting, set design, costumes, make-up, *etc.*)—M. W. Palmer (Eastern Studios), G. F. Rackett (Western Studios); Sound Recording, Camera Technic, and Special Process Photography—J. G. Frayne, Carl Dreher; Laboratory Problems—R. C. Hubbard; Sound Reproduction, Acoustics, and Television—S. K. Wolf; Exhibition Technic—H. B. Franklin; Optics and Applied Cinematography—A. A. Cook, A. C. Hardy; Statistics—F. S. Irby; Cinematography in France—M. Abribat; Cinematography in Austria—P. von Schrott; Cinematography in Great Britain—W. Clark; Cinematography in Japan—M. Ruot; Cinematography in India—H. Sintzenich. Reports were also promised by L. Busch on Germany, and F. A. Jeffery on Australia. The abstracting of technical articles from various journals is also distributed among several members of the committee. Reports have been requested from each member to be forwarded to reach the chairman from four to six weeks before the Spring Meeting. These will be digested, a card reference prepared and filed with other card references of all abstracts. The final report will then be prepared from the card references and an abridgment written for press distribution.

One of the most difficult problems of the chairman is that of securing photographs of new apparatus or developments to be used to illustrate the report. Lantern slides are also made from these to enhance the interest of the report during its presentation. It is earnestly requested that all members or friends of the society send in such photographs that may be of use to the committee. They should be mailed directly to the central office of the Society at 33 West 42nd Street, New York, N. Y.

G. E. MATTHEWS, *Chairman*

JOINT MEETING OF THE MEMBERSHIP AND SUBSCRIPTION, AND PUBLICITY COMMITTEES*

Members Present: W. H. CARSON, H. T. COWLING, J. I. CRABTREE, C. D. ELMS, F. C. ELLIS, W. C. KUNZMAN, G. E. MATTHEWS, W. WHITMORE.

At the outset, Chairman Cowling explained that the meeting

* Held at Rochester, N. Y., March 23, 1931.

was called to consider ways and means of increasing both the membership and publicity of the Society of Motion Picture Engineers. The increase in membership bears a close relation to the publicity given the Society, and the fullest coöperation between the two is therefore essential.

After a lengthy discussion, it was resolved to make the following recommendations to the Board of Governors:

(1) That the initiation fee for associate members be cut in half, and that the dues for such members remain unchanged.

(2) That the new membership certificate designed by the chairman of the Membership Committee be accepted, and that the names and grades of members be hand-lettered, and that a charge for the certificate be made to associate members. It was also recommended that a gold seal be used on the active members' certificates, and that the seal be impressed in the paper stock for certificates of associate members.

(3) That a booster circular be issued for use only for obtaining JOURNAL subscriptions.

(4) That a pocket-size handbook outlining the aims and accomplishments of the Society be issued for the purpose of increasing the membership.

(5) That sample copies of the JOURNAL be mailed to applicants to the extent of 10 per cent of the mailing list.

A large number of business matters were transacted, including the following:

(*a*) The meeting did not favor any change in the present policy toward delinquents.

(*b*) A suggestion that Junior memberships be established for applicants under 21 years of age was regarded unfavorably.

(*c*) The suggestion that a biography of members be published was regarded favorably but was held in abeyance.

SOUND COMMITTEE

A general program outlining the activities of the committee has been prepared and circulated to its members. The following is a specific listing of the matters to be considered. It has seemed expedient to have a status report prepared on each of the items by individual members, as noted. In investigating matters for standardization and projects for further consideration, however, the need for sub-com-

mittees is indicated. To that end the following selections have been made:

(1) **STANDARDIZATION**— N. M. LA PORTE, *Chairman*
M. C. BATSEL
R. V. TERRY
S. K. WOLF

(2) **STATUS REPORT**—

Directional Sound Pick-Up Devices	M. C. BATSEL
Camera Silencing	W. C. MILLER
Noiseless Recording Methods	H. C. SILENT
Set and Studio Acoustics Theater Acoustics	S. K. WOLF
Preservation of Sound Prints	R. C. HUBBARD
Sound Apparatus for the Home Sound Apparatus for Non-Theatrical Activities	R. V. TERRY
Theater Reproduction	N. M. LA PORTE
New Methods or Mechanisms (not covered above)	P. H. EVANS

(3) **ITEMS FOR FURTHER INVESTIGATION**—

Preferred Sound Track Size and Location	H. C. SILENT, *Chairman* W. C. MILLER R. TOWNSEND
Sound from Separate Film	W. C. MILLER, *Chairman* H. C. SILENT R. TOWNSEND
Volume Control in Recording	P. H. EVANS, *Chairman* M. C. BATSEL R. V. TERRY
Film Processing	R. C. HUBBARD, *Chairman* N. M. LA PORTE P. H. EVANS

The individual and sub-committee reports will be assembled into a main report to be submitted to the Society at the Spring Meeting.

H. B. SANTEE, *Chairman*

ABSTRACTS

A Multi-Channel Television Apparatus. H. E. Ives. *Bell System Tech. J.*, **X**, Jan., 1931, p. 33. A proposed system for television transmission and reception whereby improved detail is obtained in the transmitted image. Whereas the television apparatus now employed uses approximately 4500 image elements, approximately 350,000 image elements are required for satisfactory transmission of news events. The difficulties encountered in increasing the amount of image detail are fully explained. The author describes an experimental model of a three-channel television apparatus, which was constructed and tested in an effort to increase the image detail of a transmitted image. In the usual practice, only one scanning hole is crossing the field of vision at any instant. In the three-channel system, three scanning holes are traversing the field of vision at any one instant. By means of prisms and three photo-cells at the transmitter and a three-electrode neon lamp and prisms at the receiver, 13,500 image elements are transmitted. A. H. H.

Absolute Calibration of Condenser Transmitters. L. J. Sivian. *Bell System Tech. J.*, **X**, Jan., 1931, p. 96. The advantages and disadvantages of "pressure" and "field" calibrations of condenser transmitters are treated quite extensively. The several methods of constant pressure calibrations as well as a method of constant field calibration are covered. The author points out that the significance of these methods depends entirely on the use to which the transmitter is put. The relation between the field calibration of the transmitter and its actual performance is explained. A. H. H.

The Use of the Copper-Oxide Rectifier for Instrument Purposes. J. Sahagen. *Proc. I. R. E.*, **19**, Feb., 1931, p. 233. The need of an a-c. measuring instrument of high sensitivity, the limitations of standard types of measuring instruments, and the reasons for using the present form of copper-oxide rectifier in sensitive a-c. instruments is well covered. The characteristics of these rectifiers as well as the instruments in which they are used are described with the aid of numerous characteristic curves. A. H. H.

Eastman Supersensitive Panchromatic, Type 2, Motion Picture Film. Emery Huse and Gordon A. Chambers. *Amer. Cinematographer*, **XI**, March, 1931, p. 9. (See also *Mot. Pict. Projectionist*, **IV**, March, 1931, p. 11.) Data are given on the latest Kodak product for the making of motion picture negatives. The new emulsion is not to be confused with hyper-sensitized material; the increased speed is a result of the method of making the emulsion and results in a product said to be twice as fast to daylight and three times as fast to tungsten light as the present type of panchromatic film. It has a lower gamma, requiring longer development for the same degree of contrast, and must be handled at a much lower light intensity in the dark rooms. Charts of the characteristic curves of the material are presented, together with spectrograms showing the color sensitivity, which are discussed at length. A. A. C.

Screen Definition. L. M. DIETERICH. *Amer. Cinematographer*, **XI**, March, 1931, p. 15. A brief discussion of the use of filters in motion picture photography, illustrated with sample shots of a few of the possible effects. A table of stops for use with Panchromatic Negative, Type 2, and Eastman Supersensitive Panchromatic film is given, together with spectrograms of the commercial negative materials. A. A. C.

The Pedagogy of Visual Education. HERBERT SORENSON. *Amer. Cinematographer*, **XI**, March, 1931, p. 13. The author points out the value of using lantern slides in the classroom and states that the successful use of such material requires that projection equipment be immediately available and convenient to use. Slides, views, and film should be kept on file at a central office from which they can be sent out on schedule to the rooms where required. Film material is of service in so many ways that only a beginning has been made in its use. The preparation of educational films with sound by scholars and scientists will doubtless be the next step in the process. At the University of Minnesota a committee on visual education is working on the development of all phases of this method of instruction. A. A. C.

Magnacolor Film Announced. *Amer. Cinematographer*, **XI**, March, 1931, p. 20. A new commercial bi-pack color film process is here briefly described. Sharpness equal to that of black and white is claimed for the method, to which standard cameras can be adopted, and the means of obtaining exact registration and of applying the colors in processing are patented. In addition to laboratory service, the promoting company will have cameramen and equipment available for all types of photographic work. A. A. C.

Bell & Howell Announce New Lamp for 16 Mm. Projection. *Amer. Cinematographer*, **XI**, March, 1931, p. 39; *Mot. Pict. Projectionist*, **IV**, March, 1931, p. 29. A projector equipped with a 375-watt, 75-volt lamp has been introduced and is said to achieve a light intensity 40 per cent greater than formerly available for 16 mm. projection. This makes possible the showing of a 12-foot picture in black and white, it is stated, thus greatly increasing the field of usefulness of this small size of film. A. A. C.

New Ashcraft Air-Blast H. I. Lamp. *Mot. Pict. Projectionist*, **IV**, March, 1931, p. 15. The feature of this reflector arc lamp is a cooling air blast, generated in a silent blower run by the arc-control motor. The air stream is diverted to all parts of the housing and lamp, removing the heat to such an extent that considerably higher currents can be carried, it is claimed, than were formerly practical with the 9 mm. electrode used. A. A. C.

Absolute Amplitudes and Spectra of Certain Musical Instruments and Orchestras. L. J. SIVIAN, H. K. DUNN, AND S. D. WHITE. *J. Acoustical Soc. of America*, **II**, Jan., 1931, pp. 330–71. The data, taken to permit the calculation of the absolute amplitudes and spectra of the musical instruments and orchestras studied, are statistical in nature and are taken with a view to their engineering applications. These applications are concerned, chiefly, with the transmission and reproduction of music, and the data should show the power and frequency requirements for systems which are called upon to perform these functions without distortion. In carrying out this purpose it has been thought well to measure both individual instruments, and instruments playing together in orchestras; to make measurements on actual musical selections, rather than on single notes; and to

take the measurements in such a way as to obtain an average or integrated picture of the selection, as well as the distribution of amplitudes in magnitude and frequency, the extreme values being particularly important.

The apparatus and methods of obtaining and reducing the data are described in some detail. The average and peak amplitudes of various musical instruments and several orchestras are given in 52 figures. It is also concluded that a system reproducing a large orchestra, the music ranging from a fortissimo ensemble to a pianissimo violin solo, might be called upon to handle a range as great as 70 db. A paper on "Speech Power and Its Measurement" based on data taken with the same apparatus appeared in the *Bell System Tech. J.*, October, 1929. W. A. M.

Acoustic Power Levels in Sound Picture Reproduction. S. K. WOLF AND W. J. SETTE. *J. Acoustical Soc. of America*, **II**, Jan., 1931, No. 3, pp. 384–98. This paper is an amplification of an earlier contribution by the same authors, "Factors Governing Power Capacity of Sound Reproducing Equipment in Theaters," which appeared in this JOURNAL, **15**, 1930, No. 4, p. 415. It is the purpose of the article to consider the power levels dealt with in sound picture reproduction, with reference to the ear, the auditorium, and the electrical system. The authors undertake a consideration of what constitutes desirable loudness levels in auditoriums, a study of the bearing of auditorium acoustics on the maintenance of adequate sound levels, and a determination of the power output of the reproducing equipment. Equations and curves relating required acoustic power and theater volume are derived. Data taken from observations on the intensity of reproduced sounds in nine theaters are compared with conclusions drawn from several theoretical analyses. W. A. M.

Wide Screen Instead of Wide Film? *Bioscope*, **85**, Dec. 17, 1931, p. 12. In the "Fulvue System," an attachment is fitted on any standard motion picture camera which permits photography of a field having twice the lateral dimensions of that possible with the usual lens. The compressed picture on 35 mm. film is expanded to natural proportions without distortion giving an image twice the normal width. No increase in vertical dimensions is realized. G. E. M.

Use of a Modulated Arc in Television. *Nature*, **127**, Jan. 10, 1931, pp. 67–8. The chief difficulty encountered when projecting television images on large screens is stated to be the production of a modulated light source of sufficient brilliancy. Baird has demonstrated the possibility of using this method of reproducing speech when current from a telephone transmitter is superimposed upon an electric arc. Television current was superimposed upon a small arc lamp placed behind an aperture in a diaphragm. A lens was used to concentrate the light on the aperture and a second lens was adjusted between the aperture and a revolving drum on which were 30 mirrors. The reflected images traversed a screen, forming a televised picture of remarkable brilliance. Losses of light encountered with systems using neon tubes or Kerr cells are said to be obviated by this scheme. G. E. M.

The Heinrich Hertz Institute for Oscillation Research. *Kinotechnik.*, **12**, Dec. 5, 1930, pp. 623–5. Facilities for the theoretical and practical study of sound and acoustics, mechanical vibration, radio, *etc.*, are provided by the recently established Heinrich Hertz Institute for Oscillation Research at Charlottenburg, Germany. M. W. S.

The Mutochrome. C. F. SMITH. *Brit. J. Phot.*, **77**, Oct. 31, 1930, pp. 655–8. A number of similar optical systems are incorporated in a lantern projector so arranged that they may be used alternately for photography or projection. Prisms located in the optical path of each lens permit the use of a common light source for all. Although designed chiefly for the development of decorative color schemes, the apparatus is readily adaptable to the projection of stage scenery. Photographs of each element of a design are obtained by photographing with each of the various units, and the resulting positive containing all the elements may be projected. Iris diaphragms and filters permit a wide variety of colors to be realized. G. E. M.

Positive Material for Motion Pictures in Colors. R. LANDAU. *Kinotechnik*, **13**, Jan. 5, 1931, pp. 12–3. It is suggested that three fine-grained photographic emulsions be made, each of a uniform grain size, but of a different size from the other two. These three emulsions are to give colloidal silver deposits of the three complementary colors when developed in the same developer. They are to be coated in superposition upon a common film support. The lowest is to be blue-violet sensitive only, and to give a red-silver deposit on development. The second is to be ortho- or panchromatic and to give a yellow-silver deposit. The uppermost is to be blue-violet sensitive only, and to give a blue-silver deposit. All three are impregnated with a yellow screening dye to limit the penetration of blue-violet rays. The film is exposed three times, each time to one of the three color separation negatives: to the green filter negative, through the support, with blue light; to the red filter negative, from the emulsion side, with blue light; to the blue filter negative, with yellow light. The film is then to be developed to obtain a positive in three colors. As an alternative to making the emulsions of three different grain sizes, they may be all of the same size, and the developer, preferably containing a silver halide solvent, may be altered in composition as it penetrates the emulsions. M. W. S.

New Functions of the Photocell in the Service of the Motion Picture Industry. LEOPOLD KUTZLEB. *Kinotechnik*, **13**, Jan. 5, 1931, pp. 8–12. The firm of Gans & Goldschmidt, Berlin, offers three forms of apparatus embodying a photocell for the following purposes: (1) to determine exposures in taking pictures; (2) to measure the illumination in the gate of a printer; (3) to measure the brightness of projection screens. Each instrument employs the Mihaly compensating circuit, which permits the use of only 4 volts of impressed e.m.f., and a pivoted moving-coil precision galvanometer as a recording instrument. The voltage is supplied by a storage battery. The instrument for use with the camera is so calibrated that it indicates when the stop or the illumination is sufficient for the shadows to fall on the point of least useful gradation or on the lower limit of the straight line portion of the H. & D. curve of the negative material. It is possible also to measure the range of brightness in the set. M. W. S.

The Electro-Optical Principles of the Kerr Cell as a Light Valve for Sound Films. F. HEHLGANS. *Kinotechnik*, **12**, Dec. 5, 1930, pp. 615–9. A mathematical analysis is made of the principles underlying the Kerr cell. The optical transmission of the cell with both parallel and crossed Nicols, and the effect of errors in the adjustment of the angles of the prisms are calculated. M. W. S.

An Aid to the Calculation of the Optical and Illumination Data of Motion Picture Projectors. H. NAUMANN. *Kinotechnik*, **13**, Jan. 5, 1931, pp. 3–8.

Equations based on already published theoretical and practical data are combined in such a manner as to make possible the construction of a nomographic chart, by means of which the relations between the following quantities may be found by the use of a straight-edge: (1) distance from projector to screen; (2) width of picture on screen; (3) focal length of objective; (4) screen brightness; (5) number of lumens required; (6) distance of reflector from film aperture; (7) diameter of light source (arc or tungsten filament); (8) diameter of reflector; (9) diameter of objective. The chart applies to reflector arc or tungsten filament lamp illumination. By its use, it is possible to determine whether or not a tungsten filament lamp will furnish sufficient illumination under given conditions.

M. W. S.

New All A-C. Photophone Equipment. *Film Daily*, **55**, Feb. 20, 1931, p. 1. Describes a new all a-c. operated sound-on-film projector which, it is claimed, is suitable for houses seating 1000 and under. Power supplied from a 110-volt, 50–60 cycle alternating supply to the amplifier is all that is necessary to operate the machine. The sound head developed for the reproducing unit is contained within an all-metal housing which sets upon the projector. The exciter lamp does not have to be focused accurately with respect to the optical system. The type of motor to be supplied will depend upon the available power supply. Direct-current motors are of the speed-regulated type, and a-c. motors are of the constant-speed type, either requiring the use of complicated control devices. For sound change-over a relay is used which is controlled by a switch conveniently mounted at each projector. The sound change-over switch simultaneously turns on the exciter lamp of the projector to which the amplifier input is transferred, thus preventing the possibility of losing sound through the neglect on the part of the projectionist to turn on the exciter lamp. The amplifier is of the unit-panel type, each unit being assembled on separate panels and mounted one above the other.

C. H. S.

Tricks to Try. MALCOLM G. JACKSON. *Movie Makers*, **6**, March, 1931, p. 145. Universal multiple-exposure effects may be obtained by the ciné amateur by shooting through a many-faceted glass button revolving slowly in front of the lens, or by slipping a kaleidoscope made of three mirrors over the sunshade of the lens. Distorted and amusing images are obtained by using in front of the lens a device known as the lens modifier.

H. P.

Professional Sixteen. RUSSELL C. HOLSLAG. *Movie Makers*, **6**, March, 1931, p. 138. Many of the advanced workers among the amateurs are demanding for their sixteen millimeter cameras the mechanical and technical aids that are available on the most advanced professional cameras. In many cases, this requires custom-built apparatus. An example of such work is shown in the changes made on one well-known camera, which include: a focus on film device, a standard thread lens mount, separate engraved focusing scale for normal and wide angle lenses, means for attaching a complete effect device, removable lens collar, special iconographic viewfinder, reverse take-up, adaptation to a standard Universal 35 mm. tripod, and adaptation to remote cranking device.

H. P.

Music for Silent Films. L. PALK. *Movie Makers*, **6**, Feb., 1931, p. 76. "Synchronized score" musical accompaniments are possible for the exhibitor of home movies without the necessity of specially prepared sound records and the supple-

mentary synchronizing equipment. The regularly listed phonograph records offer a wide choice of suitable material for practically every mood. Any desired number of record changes may be made during the showing of a film by the use of two small portable phonographs, or better, of two turntables with electric pick-ups and a change-over switch with fader controls. A reference list of records catalogued by appropriate subjects is appended to the article. H. P.

Underwater Shots. W. SARGENT. *Movie Makers*, **6**, March, 1931, p. 140. Apparatus required for amateur cinematography is a simple water glass, consisting of a water-proof box with a bottom of good glass, free from optical defects, and a clamp for attaching the camera firmly with some means of remote control for starting and stopping its mechanism. The shots are best made from a small boat by submerging the bottom of the box eight or ten inches below the surface of the water, when a clear view under water will be obtained. The shots should always be made toward the sun, because the boat casts a shadow which would show very plainly. The exposure will vary with conditions, and, if possible, should be determined by test exposures made in a small still camera and developed on the spot. Large stops will be found necessary, about $f/1.9$ to $f/2.9$. H. P.

Optical Properties of a Lippmann Lenticulated Sheet. H. E. IVES. *J. Optical Soc. of Amer.*, March, 1931, p. 171. A study is made of the optical properties of the process suggested by Professor Lippmann in 1908 for making photographs without the use of a camera. These photographs should change their appearance with the position of the observer and so show stereoscopic relief from all directions and distances. Of the two methods proposed by Lippmann, one is shown in the present article to yield reversed or pseudoscopic results. A. C. H.

The Perception of Motion and Cinematographic Illusion. L. RAITIERE. *Technique Cinemat.*, **2**, Jan., 1931, pp. 13–23. Persistence of vision is sometimes wrongly stated to be the explanation of why a series of motion picture images, each representing an object at a slightly different phase in its motion, gives, when projected, the impression of continuous motion. The illusion of continuity is really originated in the mind by a process of reconstruction of the (supposed) infinitely great number of intervening phases which represent continuous motion. This habit of the mind is a consequence of certain visual and psychological conditions. It is a matter of common observation that the eye, viewing a continuously moving panorama such as seen through the window of a moving railway car, fixes upon one object or element of view, follows it for an instant and then swings back and selects another. This cycle is repeated again and again even without the observer being conscious of directing his eyes upon any objects in particular. No matter how perfect the continuity of motion, the eye views it in a discontinuous manner. One or more images remain when each new one is presented because of persistence of vision, and the mind detects the logical continuity. In like manner, if a series of photographs showing successive phases of motion is viewed in proper sequence and time separation the impression is one of continuous motion. C. E. I.

The Optics of Fulvue. *Kinemat. Weekly*, **168**, Feb. 5, 1931, p. 67. Describes an optical system, whereby wide-screen pictures are obtained by compression of

the image onto standard 35 mm. film. A diagrammatical sketch of the lenses is given. Distortion and optical aberration have been overcome by using spherical lenses in conjunction with the cylindrical combination used for the compression and expansion of the images. W. J. W.

The "Brown" Talking Equipment. *Bioscope* (*Modern Cinema Technique Section*), **86**, Feb. 4, 1931, p. iii. A feature of this projection equipment is the elimination of background noises by placing a screened-grid valve immediately beside the photoelectric cell. A detachable flexible clutch is used in the center of the vertical drive of the turntable to correct any variation in shaft alignment. W. J. W.

A New High-Intensity Arc. *Kinemat. Weekly*, **168**, Feb. 5, 1931, pp. 71–2. The outstanding feature of this arc lamp is the use of a magnetic field to draw the luminous gases of the normal flame back into the arc crater. The flame size is thus reduced from one of 6 to 8 inches high to a small, steady intense flame not more than 1 to 2 inches in height. Its efficiency is correspondingly increased. W. J. W.

New Combined Projector and Camera. *Bioscope* (*Modern Cinema Technique Section*), **86**, Feb 4, 1931, p. i. Describes an apparatus designed for amateur work. It utilizes film stock about $4^1/_2$ inches wide and the pictures, which are approximately the size of those on 9 mm. stock, are taken in a series horizontally across the film. As the film comes to the end of each row, the mechanism automatically moves the film up for the return journey. By the use of a reflector of new design, a 25-watt lamp is said to give ample illumination in projection. W. J. W.

The Callier Effect as a Source of Error in the Reproduction of Sound Films. H. FRIESER AND W. PISTOR. *Kinotechnik*, **12**, Nov. 20, 1930, p. 601. The Callier effect enters in the reproduction of sound film. A reproduction gamma of 1.0, measured diffusely, has an effective gamma of 1.18 in a Leitz sound reproducer. This introduces a 6 per cent harmonic. It is recommended that this fact be considered in sound reproduction work. J. W. M.

The Influence of the Callier Effect on Sound Film Reproduction. A. KÜSTER AND R. SCHMIDT. *Kinotechnik*, **12**, Nov. 20, 1930, pp. 602–3. The work of Tuttle and McFarlane (J. Soc. Mot. Pict. Eng., **15**, 1930, p. 345) is reviewed in detail. Density measurements were made with a photo-cell and galvanometer, which were calibrated by means of altering the slit by known amounts. Details are not given of the type of sound reproducer used. Results agreed closely with those of the workers mentioned above. The measured density is shown to be nearer the values for collimated light than for diffuse light. The Callier constant is 1.2. It is pointed out that to realize an effective gamma of unity in reproduction, with a positive gamma of 1.8 to 2.0, the sound negative should be developed to a gamma of 0.40 to 0.45. Uniform development is difficult and such negatives have relatively high ground noise and other objections. Variable width sound film is free from such troubles. J. W. M.

The Measurement of Sound Absorption. V. L. CHRISLER AND W. F. SNYDER. *Bureau of Standards Journal of Research*, **5**, Oct., 1930. A description of the reverberation room of the Bureau of Standards. Methods of determining the reverberation time of the room by means of the ear, by inspection of oscillograph records, and by the use of an attenuator box and vacuum-tube voltmeter are

described. Comparative results obtained with these three methods are shown to agree quite closely. W. A. M.

Formation of Photographic Images on Cathodes of Alkali Metal Photoelectric Cells. A. R. OLPIN AND G. R. STILWELL. *J. Opt. Soc. of Amer.*, March, 1931, p. 177. A previous paper has described a treatment for the alkali metal surfaces of photo-cell cathodes that enhances their sensitivity to long wave-lengths. Thes ensitizing substances are dielectrics such as sulfur, water-vapor, and organic dyes. This sensitizing process resembles in many respects the sensitization of photographic materials to red or infra-red light and the present paper is concerned with an extension of the experiments, which serve to suggest an even closer analogy between photoelectric and photographic phenomena.

If a sensitized cathode surface is exposed for a few seconds to a strong beam of light, it becomes visibly darkened, and this phenomenon can be used to record an image focused upon it. The image may fade out in a few days but can be "fixed" by treatment with the sensitizer. Reversed or "positive" images can also be obtained under proper conditions. The photoelectric sensitivity decreases approximately 30 per cent during the time that the "photographic" image is forming, but after the image is fixed, there is little difference between the photoelectric sensitivity of the image-bearing portion of the cathode and the neighboring unexposed areas. A. C. H.

ABSTRACTS OF RECENT U. S. PATENTS

1,792,683. **Scanning Element for Television System.** P. R. EGGER. Feb. 17, 1931. A scanning element for a television system comprising a revolvable shaft which is spirally cut away. A plurality of narrow mirrors are formed integral with the cut away portion of the shaft. These mirrors extend transversely of the shaft and serve to reflect light over a broad scanning area as the shaft rotates.

1,792,752. **Light Control by Piezoelectric Crystals with Compensation for Anisotropy.** F. MICHELSSEN. Feb. 17, 1931. Piezoelectric crystals are arranged in the path of polarized light from a light source directed upon a light-sensitive film. These crystals are connected in circuit with an oscillator which is modulated in accordance with sound variations. One of the crystals is a dextro-rotatory quartz crystal, that is, a crystal having a clockwise rotational effect, while another of the crystals is a levo-rotatory quartz crystal, or one to produce a counter-clockwise rotational effect disposed ahead of the former, with the result that the second crystal neutralizes the rotation of the former, and that in the normal state mutual compensation of the anisotropy of the two crystals is produced. If, then, one of the two quartz crystals is excited, the penetrating luminous rays after their passage through the second quartz crystal will be influenced only by the action of the double refraction due to the oscillations, whereas the phenomenon of rotational refraction is eliminated. The automatic self-oscillation of the piezoelectric crystals operates to control the light which passes to the screen or film.

1,792,766. **Electric Light Relay Using Interferometer Principle.** F. SCHROTER. Feb. 17, 1931. A mirror is carried by a magnetic diaphragm which is electromagnetically actuated in accordance with sound variations for changing the path and phase-relationship of interfering light rays for correspondingly changing the effect of the light rays upon a recording element. The primary electric variations cause changes in the path of light in an interferometer arrangement of convenient kind, so that, according to the phase-differences thereby obtained, the amplitudes become added with positive or with negative signs. After combination of the light rays, there results, therefore, a light or dark record, or an intermediate value governed by the difference in path of the interfering luminous rays. The light relay is quantitative in its action. Differences in path are accomplished, for instance, by means of mirrors which are actuated or moved by electric or magnetic forces either directly or indirectly.

1,793,403. **Combination Disk and Photo-Cell Reproducer.** J. HUTT. February 17, 1931. A photograph record having sound waves recorded thereon actuates a stylus which carries a mirror. The mirror reflects a beam of light from a light source to a light-sensitive cell for the reproduction of sound electrically from the record.

1,793,772. **Apparatus and Method for Localization of Sound on Screens.** W. BOUMA. February 24, 1931. Sound is reproduced from any one of a number

of loud speakers which are located behind the screen in different portions of the field of the picture. One of the conspicuous defects in present-day talking pictures is that during the reproduction of a picture on a screen concurrently with the sound reproduction consonant with the scene the sound reproducer does not cause the sound to originate at or near that portion of the projected scene or pictures from which in actuality the sound would originate during the filming of the picture. For instance, during the projection of a picture of a singing quartette when any of the singers is singing alone and may be at either end of the line of singers, present-day reproducers cast the sound only from given sources irrespective of the fact that the singer may be at an extreme corner of the projected scene with the result that the sound pictures have an unnatural and false impression.

It is the general purpose of this invention to provide a method and means for filming a scene and for reproducing the picture in accompaniment with the desired sounds and especially to provide for the reproduction of the sounds immediately at that portion of the screen contiguous to the agent in the picture from which the sound apparently originates. This is accomplished by providing on the film successive impressions between the frames of the pictures and in different positions laterally of the film arranged for emitting light through light slits in predetermined positions to light-sensitive cells which are independently connected in different relay circuits for successively cutting in different loud speakers located adjacent to different portions of the screen. The loud speakers are energized from the main photo-cell circuit but are automatically switched as the subjects in the picture occupy different positions in the projected scene.

1,793,956. **Channel Selection with Multiple Sound Track Film.** F. H. OWENS. February 24, 1931. A multiple-channel sound film is moved by a sprocket-driving device having mechanism attached thereto for shifting the sprocket to move the sound film into position where a selected sound channel travels adjacent a sound slit. As each channel is shifted into operative position with respect to the sound slit the sprocket is locked in such position against displacement.

1,794,664. **Frequency Division and Multiplication for Recording and Reproducing.** J. R. BALSLEY. March 3, 1931. The frequencies of the original sound-wave microphone current are divided before the recording thereof on film. There is thus produced a sound record in which the physical lengths of the individual opacity variations are increased relative to the light-slit by the number of times which the frequency of the original microphone current was stepped down, and in reproduction a corresponding increase in accuracy will be gained. In reproduction, the electrical current produced from the divided-frequency record is put through a frequency multiplier, properly tuned and balanced to match the frequency divider, which reproduces the original microphone current. The output of the frequency multiplier is then amplified and reproduced as sound waves in the usual manner.

1,795,442. **Portable Motion-Picture Screen.** A. L. RAVEN. March 10, 1931. A portable motion picture screen in which a box-like structure encloses a pair of hingedly mounted folding arms which may be moved out of the box-like structure for supporting a roller-mounting for the screen which may be unrolled

and stretched taut with respect to the arms for providing a flat-surface screen for the exhibition of projected pictures.

1,795,490. **View Finder with Adjustable Field of View.** A. S. HOWELL. March 10, 1931. A simplified construction of view finder, the field of which may be varied quickly and conveniently for such purposes as defining the photographic fields of different photographic lenses with which the view finder may be used, whereby to facilitate the interchange of photographic lenses having different photographic fields on photographic cameras equipped with a view finder, and particularly with reference to motion picture cameras. The view finder consists of a cylindrical mask member angularly movable on its axis transverse to the focal axis of the view finder and provided with a plurality of mask openings of different sizes adapted to be selectively positioned in operative relation with the viewing device by the angular movement of the mask member.

1,795,751. **Copying from Variable Area Sound Record to Form Variable Density Record.** J. R. BALSLEY. March 10, 1931. The developed original film and the unexposed film on which the copy is to be made are run through the machine at exactly the same speed by moving the films by identical sprockets on the same shafts. A line of light is directed upon the variable area sound record portion of a film and a light-reactive element exposed to the light transmitted through the record. A variable density sound record is reproduced on a film corresponding to the sound record on the original film while the films are being moved at the same speed.

1,795,936. **Combined Loud Speaker and Screen.** LEE DE FOREST. March 10, 1931. A screen for the reproduction of sound pictures in which a loud speaker is built into the screen. The loud speaker or sound reproducer comprises a long-necked horn extending in the rear of the screen and terminating in a bell whose plane lies in the plane of the screen and at the top of the screen.

1,796,420. **Multiple Mirror Scanning Device.** F. W. ADSIT. March 17, 1931. A scanning device in which a rotatable drum is provided with a multiplicity of small mirrors for receiving light from successive portions of objects as the drum is rotated. The mirrors are arranged around the periphery of the drum in the form of a helix and have an inclined position relatively to a tangent drawn at the circumference of the drum whereby light, reflected by said mirrors, is moved both horizontally and vertically. A photo-cell is energized by the light reflected by the mirrors for modulating a control circuit.

1,796,931. **Electroöptical Transmission in Colors.** H. E. IVES. March 17, 1931. A television system for the transmission and reception of pictures in colors. At the transmitter a field of view is simultaneously scanned with a plurality of light beams having different wave-lengths, the beams being juxtaposed so that each beam scans substantially equal portions of the field of view and scans its proportionate share of the entire field of view in each scanning cycle. At the receiver the light is analyzed into different colors and successive elemental areas of a field of view illuminated by spots of light of the different colors.

1,796,970. **Change-Over for Picture and Sound Projecting Apparatus.** L. D. STRONG. March 17, 1931. Both pictures and sound are changed over from one reel to another on the adjacent machine by means of a single switch or one operation, whereby the continuity of the picture or projection will not be interfered with but will appear as a continuous movement without undue interruption of

either the picture or sound. The light is changed from one machine to another and the output circuits of the respective sound producing circuits on each machine simultaneously changed to connect the sound producing circuit on the second machine to the input of the sound reproducing amplifier.

1,797,149. **Sound Head with Removable Light Gate for Motion Picture Projectors.** E. M. JENSEN. March 17, 1931. A quickly removable light gate which may be moved into an operative or an inoperative position which will permit the film to be quickly and easily inserted or removed and which will further permit the surfaces over which the film passes to be readily cleaned when the light gate is lowered into the inoperative position. Light is projected through the sound record of a motion picture film and caused to fall upon a photoelectric cell to vary the conductivity of said cell, the light-controlling mechanism embodying a tubular light gate movable on an inclined trackway into and out of the path of the pencil of light which is passing through the sound record on the film.

1,796,359. **Optical Instrument for Altering Projected Screen Image.** A. S. CAMERON. Assigned to William J. Cameron. March 17, 1931. An image-projecting structure by which an image may be shifted and changed in color over a screen adjacent a chart. A stylus arm moves over the chart and is shifted with respect to the chart in a position corresponding to the movement of the image on the screen. The apparatus is utilized in analyzing the diagnosis of patients under treatment.

1,796,432. **Stereoscope Film Moving and Viewing Apparatus.** A. J. R. BARLATIER. March 17, 1931. A stereoscope device adapted to carry a strip of film having a series of stereoscopic views arranged in the form of a hand carrier through which the film may be inserted and removed. The carrier is provided with a pair of observing lenses adjacent to which the film is moved by a slidable engaging device adapted to shift the frames across the field of the observing lenses.

1,797,066. **Alternate Projection of Two Positive Films to Avoid Screen Flicker.** M. L. ZIMMER. March 17, 1931. The flicker in the projection of pictures is avoided by the projection on the screen of successive phased pictures. Two independent positives are provided on the same film with the pictures of a series on the film being alternately arranged. The frames are alternately projected and are focused at the same focal point on the screen, and the shutters are so mounted that the periods of transmission of light to the screen overlap, in order to relieve any tendency of flicker. Frame number one would be on one film, frame number two on the other, frame member three on the first film, four on the second, *etc.*, but the screen is at all times illuminated and a picture is on the screen before a previous picture leaves the same, the arrangement being such that one picture momentarily overlaps the other; therefore the illusion will not be accompanied by the disagreeable flicker and eye-strain commonly experienced.

1,797,202. **Objective for Large Working Aperture and Correction of Aberration.** A. WARMISHAM. March 17, 1931. An objective of the Petsval type in which the back component includes two asymmetrical convergent members presenting their more deeply curved surfaces toward the front component. The back component consists of a divergent member and two asymmetrical convergent members which present their more deeply curved surfaces toward the front component. The purpose of the lens system is to correct for the various aberrations throughout a useful field and provide a larger working aperture than hither-

to obtained. The residual zonal spherical aberration is so reduced as to secure an objective having relative aperture $f/1.5$ while maintaining a sufficiently good state of correction of the zonal spherical aberration to give definition comparable with that given by the conventional Petsval objective having about two-thirds of this effective diameter.

1,797,259. **Viewing Apparatus Combined with Scanning Disk for Securing Proper Framing.** R. L. DAVIS. Assigned to Westinghouse Electric & Manufacturing Co. March 24, 1931. A scanning disk is provided with spirally arranged apertures having a plurality of convolutions. There is a viewing assembly adjacent one portion of the scanning disk. A system of gears is provided for moving the viewing assembly radially of the disk. This movement of the viewing assembly which includes the lens system and the photoelectric cell corresponds to the proper framing of a motion picture projector as the object and photo-cell are brought precisely within the area covered by the movement of the apertured portion of the scanning disk.

1,797,274. **Shutter Mechanism for Motion Picture Camera.** O. A. ROSS. March 24, 1931. A shutter mechanism in which the time interval during which the film is stationarily positioned for exposure is comparatively long as compared to the time interval during which said film is being advanced by the shuttle mechanism, whereby the quantity of light employed for the illumination of sets when recording motion picture productions in studios may be reduced, or successful exterior exposures may be made under adverse light conditions. The film-advancing mechanism comprises two meshed gears, one of which rotates at twice the speed of the other. There is a film-advancing member pivotally supported independent of the gears, which member is arranged to engage and advance the film relatively to the photographic aperture. There are means operative by the high rotative speed gear member for effecting the engagement and advancement of the film by the film-advancing member during each revolution thereof. There are means operatively associated with the low rotative speed gear member arranged to annul the engagement of the film by the advancing member each alternate revolution of the high rotative speed gear member.

1,797,278. **Television System Eliminating Scanning of Frame Lines of Motion Picture Films.** T. A. SMITH. Assigned to Radio Corporation of America. March 24, 1931. Motion picture film is moved continuously at a uniform speed and the picture portion of each frame analyzed in such manner that the frame lines separating the successive portions of the film are omitted. The elimination of the scanning of the frame lines eliminates undesired interference and permits the reproduction of an accurate image. A scanning disk having apertures arranged in a spiral thereon is provided. The pitch of this spiral is selected equal to the width of a frame line on the motion picture film and only the actual picture is scanned as the film moves without scanning of the frame line.

1,797,286. **Stage Mounting for Producing Special Effects.** B. S. GLAGOLIN. March 24, 1931. Different portions of the stage for taking motion pictures can be moved at a different speed, one of these portions containing also the camera for taking pictures. This arrangement can be used to produce special effects by uncovering gradually or suddenly different portions of the stage setting so as to create an impression on the observer of the pictures, of a more intimate and personal contact with the scenery and action on the stage. The stage on which

the artists perform is circular in shape. There is a ring-shaped stage surrounding the circular stage. The ring-shaped stage and the circular stage are independently rotatable to permit filming in different arrangements.

1,797,544. **Projecting Images for Observation by Patient under Treatment.** A. S. CAMERON. Assigned to William J. Cameron. March 24, 1931. A projection apparatus for throwing an image upon a screen to be observed by a patient under treatment. The image may be caused to move upon the screen in an unlimited variety of directions in order to be observed by the patient in any position. The apparatus is known professionally as a "myoculator." A plurality of color plates are carried by an arm in such manner that the color plates may be shifted across the path of the light rays and in the path of a system of lenses for focusing the portion of the object on a screen in any desired position.

1,797,718. **Electric Contact Making and Breaking Device.** F. G. CREED AND A. ORLING. Assigned to Creed & Company, Ltd. March 24, 1931. A relay of high sensitivity which may be used for making and breaking an electrical circuit in response to control currents. The device includes a conductor of non-resilient material having a moist conducting surface and a metal conductor associated with actuating mechanism for moving the conductors into and out of contact. The moist, non-resilient conductor consists of a small pad of porous material mounted upon a support and moistened with a conducting liquid. The movable conductor consists of a length of stiff wire which is operated in conjunction with the moist conductor for controlling the making or breaking of an electrical circuit. The relay is connected in the input of an electron tube system.

1,797,778. **Electrostatic Device for Sound Reproduction.** C. KYLE. Assigned to United Reproducers Patents Corp. March 24, 1931. Loud speaker for sound reproduction in which two conductors having an interposed dielectric sheet are employed. The interposed dielectric sheet has a slight amount of conductivity for the rapid dissipation of static charges tending to remain residually in the dielectric. The loud speaker is intended for sound reproduction at large volume in the output circuit of the reproducing amplifier in any form of sound reproducing system.

1,798,118. **"Optiphone" for Detecting Presence of Optical Images by Blind Persons.** J. A. CLIFTON. Assigned one-third to Earl H. Holland and one-third to George W. Beckett. March 24, 1931. Apparatus which may be carried by a blind person and operative by optical effects for enabling the blind person to "hear" the presence or absence of images in any one of several directions. The apparatus includes a band which encircles the head of the wearer and carries light-sensitive cells in different positions. A switch is employed to selectively connect any one of the cells to an electron-tube circuit which in turn connects to a telephone worn by the blind person. A buzzer is selectively connected in circuit with any one of the light-sensitive cells and operates to control the telephone. Different images have different characteristic sounds to the blind person and enable the blind person to partially enjoy the effects of the sense of sight.

(Abstracts compiled by John B. Brady, Patent Attorney, Washington, D. C.)

BOOK REVIEWS

Acoustics, A Text on Theory and Applications. G. W. STEWART, Professor of Physics in the University of Iowa, AND R. B. LINDSAY, Associate Professor of Theoretical Physics in Brown University. *D. Van Nostrand Co.*, New York, N. Y., 1930, 358 pp. $5.00.

This book fills a long-felt need for a text to fit between the elementary texts and the advanced and detailed mathematical treatises on this subject. The authors have combined the results of the important researches of the last decade, both from the theoretical and practical viewpoints in such a way as to give the student or general reader a broad view of the present-day activities in the many phases of the science of acoustics.

Students of acoustics will gain an insight into the numerous fields of application of the science such as sound transmission in pipes, horns, sound filters, sub-aqueous sound signaling, architectural acoustics, and sound ranging, and will find the book convenient for reference to theoretical analyses.

In Chapter I are described some simple properties of acoustical waves such as reflection, diffraction, and energy content. The fundamental theory of acoustical waves including the general equations is set forth. Chapter IX includes a brief account of physiological acoustics, so important to the sound engineer. The topics discussed include the nature of speech sounds and binaural effects. In Chapter XI on architectural acoustics are presented the problems of reverberation, brought up to date to include the latest developments in the field, and a discussion of sound-proofing. These chapters contain much of the material which will be of interest to the motion picture engineer. While in many cases the presentation of the subject matter is very brief, ample reference to the literature will assist those who wish to go further into any particular phase of acoustics.

W. A. MACNAIR

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SOCIETY ANNOUNCEMENTS

MEETING OF THE BOARD OF GOVERNORS

At a meeting held at the Sagamore Hotel, Rochester, N. Y., on April 9th, a large number of business matters were transacted, including the following:

(1) *Resolved*, that the Apparatus Exhibit of the Spring Convention be held at the American Legion Auditorium, 2035 North Highland Avenue, Hollywood, California.

(2) *Resolved*, that the names, Atlantic City and White Sulphur Springs, be included on the ballot for the location of the Fall Meeting.

(3) *Resolved*, that a 15 per cent discount on the sale of JOURNALS and *Transactions* be granted to agencies and booksellers.

(4) *Resolved*, that the Society purchase 100 binders to sell to the membership at the rate of $2.00 each. The binders in question will hold a complete year's supply of the JOURNAL, and each issue is removable at will.

(5) *Resolved*, that in accordance with By-Law 10, Section 9, since the Active Membership of the London Section has fallen below 20, the authorization of this section is hereby rescinded.

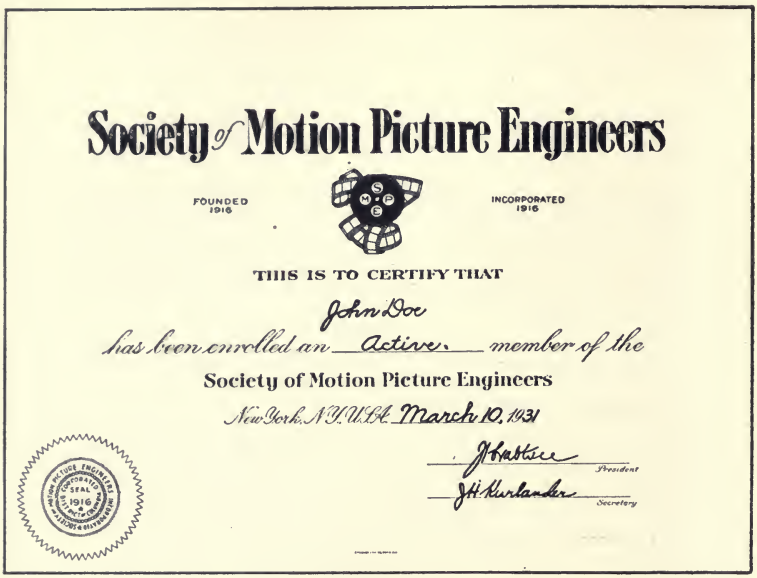
(6) *Resolved*, that the Membership and Subscription Committee be authorized to distribute sample copies of the JOURNAL to applicants to the extent of 10 per cent of the mailing list.

(7) *Resolved*, that in the case of applicants for membership who do not receive a three-fourths vote of approval (by mail) by the Board of Governors, the matter be brought up at a Board meeting, before the applicant is notified of rejection.

MEMBERSHIP CERTIFICATE

In accordance with a ruling of the Board of Governors, the Chairman of the Membership Committee assisted in designing a new membership certificate which is herewith illustrated.

This certificate is to be distributed *gratis* to all Active members of the Society in good standing, and may be obtained by Associate members in good standing upon forwarding one dollar to the general


Society of Motion Picture Engineers

FOUNDED 1916 INCORPORATED 1916

THIS IS TO CERTIFY THAT

John Doe

has been enrolled an Active member of the

Society of Motion Picture Engineers

New York, N.Y. U.S.A. March 10, 1931

President

Secretary

office. The seal used on Active members' certificates will be gold, and for Associate members', the Society's seal will be impressed in the body of the certificate.

DEUTSCHE KINOTECHNISCHE GESELLSCHAFT

The S. M. P. E. has been honored by the Deutsche Kinotechnische Gesellschaft by the appointment of the Presidency to honorary membership.

Some time ago, the S. M. P. E. conferred honorary membership upon the Presidency of the Deutsche Kinotechnische Gesellschaft.

NEW YORK SECTION

At a meeting held at the Westinghouse Lighting Institute, New York, N. Y., on March 24th, four interesting presentations were made as follows:

Studio Lighting; by E. W. Beggs.
New Film Phonograph for Re-recording; by E. W. Kellogg.
An A-C. Reproducing Amplifier; by E. P. Schultz.
Noiseless Recording—Variable Area Methods; by B. Kreuzer.

Mr. Beggs demonstrated various types of lighting equipment used

for studios and other motion picture purposes. Mr. Kellogg's talk dealt mainly with the passage of the film through the mechanism of recorders, particularly with regard to the strains set up in the film as it passes around the various rollers and sprockets.

The reproducing amplifier, completely operated by a-c., exhibited by Mr. Schultz, was demonstrated by Mr. Kreuzer, who used it in connection with the projection of a film showing the variation of width of the sound track with the volume of sound.

The next meeting of the Section is to be held on May 8th at the Westinghouse Lighting Institute.

CHICAGO SECTION

At a meeting of the Chicago Section held March 5, 1931, at the Electric Club, 20 N. Wacker Drive, Chicago, Ill., Mr. Burns gave an interesting demonstration of equipment and Mr. Jenkins, the Chairman, made a brief reference to various tests which he had made for checking the flutter and hunting of a sound recording sprocket operated by a synchronous motor through a mechanical filter. Tests were made recording a constant frequency set-up. Enlargements from these negatives were made which, when superimposed and overlapped (in reverse directions), showed the "beats" very distinctly. After a brief discussion regarding the effect of film shrinkage on the accuracy of the results, the meeting was adjourned.

At a second meeting held at the Electric Club on April 2, 1931, Mr. Oscar Depue presented a paper on a new device which he has developed for using two ordinary magazines for bi-pack color work without alteration. The distinctive feature of this attachment is that no alteration of the magazines is necessary. Further economy is effected by the arrangement of the magazines permitting the two films to be loaded in one magazine and taken up in another.

Mr. A. Warmisham, recently from England, gave an interesting talk on the mechanical methods of checking the accuracy of lens grinding, *etc.* He pointed out the fact that lenses were ground to much closer limits than ordinary mechanical units so that it was very difficult to use purely mechanical measurements for checking the accuracy of the grinding. Demonstrations of the spherometer, goniometer, and color bench were given. A brief description of the use of Newton's rings for checking the accuracy of master lenses was included in addition to information concerning the way in which master lenses are made.

PACIFIC COAST SECTION

At a meeting held at the Paramount Studios on February 19th, the Program Committee exhibited a picture entitled *The Eyes of Science* by Bausch & Lomb Optical Company. This was followed by a short paper by Mr. Mellor of the Technicolor Corporation on the development of present, day cinematographic lenses and one entitled *The Measurement of Heat from Stars by Photographic Means* by S. Nicholson of the Mt. Wilson Observatory.

The report of the newly formed Progress Committee was presented in which attention was called to the following: (1) A super-sensitive panchromatic negative manufactured by the Eastman Kodak Company; (2) Agfa color test chart and gammeter; (3) a precision densitometer presented by the Electrical Research Products, Inc.; (4) a ground noise reduction device and ribbon type microphone used by the RCA Photophone, Inc.; (5) the new biased light valve introduced by Electrical Research Products, Inc.

At another meeting held on March 25th at the RKO Studios a motion picture entitled *The Cathode Ray Tube* by W. B. Coolidge was presented. This was followed by papers on *Process Photography* read by G. A. Chambers of the Eastman Kodak Company and on *Liquid Air* by Ellis Manning.

ACADEMY OF MOTION PICTURE ARTS AND SCIENCES

The chief technical activities now under way are concerned with the new high-speed film stocks, a national survey of the standard release-print situation, the investigation of film processing, and the camera silencing survey. Meetings dealing with the new Eastman and DuPont panchromatic negatives were held March 31st, and will be reported on shortly.

In regard to the standard release-print service, a questionnaire entitled "Survey on How to Improve the Release Print Standard," has been distributed among projectionists throughout the country. This questionnaire requests information concerning the size of theater, the equipment used, the percentage of sound-on-film, sound-on-disk, and silent pictures used, and projectionists employed per shift. Further information is requested concerning the number of cues on leaders.

A survey of film processing practices is now under way. Both of these survey projects will require considerable time to carry

through but there is indication that they will prove very worth while. The Technicians Branch will hold a meeting on the Thursday before the opening of the convention of the S. M. P. E., to which meeting all the officers and members of the S. M. P. E. are invited.

NEW MEMBERS *

RAY J. BAKER (*A*)
1911 Kalakaua Ave., Honolulu, Hawaii.

JOHN L. CASS (*M*)
RCA Photophone, Inc., 153 E. 24th St., New York, N. Y.

EDWIN K. COHAN (*A*)
Columbia Broadcasting System, Inc., 485 Madison Ave., New York, N. Y.

MICHELLE C. DEVIGNY (*M*)
Ste. Française Cinechromatiques, 24 Rue de la Pepiniere, Paris, France.

PAUL DIETERLE (*A*)
Agfa Ansco Corp., Binghamton, New York.

LOUIS B. FISCH (*A*)
Beaded Screen Corp., 47 W. 24th St., New York, N. Y.

W. F. GARLING (*M*)
RCA Photophone, Ltd., Film House, Wardour St., London, England.

LORIN D. GRIGNON (*A*)
Paramount Publix Corp., 5451 Marathon St., Hollywood, Calif.

LOUIS H. MESENKOP (*A*)
Paramount Publix Corp., 5451 Marathon St., Hollywood, Calif.

LOREN L. RYDER (*A*)
Paramount Publix Corp., 5451 Marathon St., Hollywood, Calif.

JOSEPH UNDERHILL (*M*)
RCA Photophone, Ltd., Film House, Wardour St., London, England.

RAY VAUGHAN (*M*)
Filmcraft Laboratories, 35–39 Missenden Road, Camperdown, Sydney, Australia.

TRANSFERRED FROM ASSOCIATE TO ACTIVE GRADE

CARL BORNMANN (*M*)
Agfa Ansco Corp., Camera Works, Johnson City, N. Y.

ARTHUR C. HARDY (*M*)
Mass. Inst. of Technology, Cambridge, Mass.

HERBERT MEYER (*M*)
Afga Ansco Corp., 6370 Santa Monica Blvd., Hollywood, Calif.

WILLY A. SCHMIDT (*M*)
Agfa Ansco Corp., Binghamton, N. Y.

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* (*M*) indicates active grade; (*A*) associate grade.

ARRANGEMENTS PROGRAM

SPRING MEETING OF THE SOCIETY, ROOSEVELT HOTEL, HOLLYWOOD, CALIFORNIA

(May 25 to 29, 1931, inclusive)

TECHNICAL SESSIONS AT THE AMERICAN LEGION AUDITORIUM, 2035 NO. HIGHLAND AVE., HOLLYWOOD

The following committees and individuals will officiate during the convention:

COMMITTEES IN CHARGE OF ARRANGEMENTS

HOLLYWOOD LOCAL COMMITTEE

PETER MOLE, *Chairman*
D. MACKENZIE
C. W. HANDLEY
K. F. MORGAN
J. P. O'DONNELL

RECEPTION

D. MACKENZIE
G. F. RACKETT
E. HUSE
C. DUNNING
L. E. CLARK
C. WUNDER
W. QUINLAN
R. G. FEAR
C. W. HANDLEY
H. C. SILENT
H. B. FRANKLIN
J. A. BALL
G. A. VOLCK
J. P. O'DONNELL
O. M. GLUNT
F. W. BEETSON
P. MOLE
W. V. D. KELLEY
G. A. MITCHELL
G. C. MAUDSLAY

CONVENTION REGISTRARS

W. C. KUNZMANN
C. W. HANDLEY

HOSTESS TO CONVENTION

MRS. DONALD MACKENZIE
assisted by

MRS. E. HUSE
MRS. L. E. CLARK
MRS. C. W. HANDLEY
MRS. P. MOLE
MRS. E. C. RICHARDSON
MRS. H. C. SILENT
MRS. R. G. FEAR
MRS. G. F. RACKETT
MRS. G. A. MITCHELL

BANQUET ARRANGEMENTS

WILLIAM C. HUBBARD, *Chairman*

D. MACKENZIE
P. MOLE
W. C. KUNZMANN

BANQUET

Blossom Room—Roosevelt Hotel

7:30 P.M., May 27, 1931

Note: Master of Ceremonies and Speakers will be announced in the final program.

SUPERVISORS OF PROJECTION EQUIPMENT, INSTALLATION, AND OPERATION

H. GRIFFIN, *Chairman*

Officers and Members of the Executive Board,
Local No. 150 I.A.T.S.E., Los Angeles Projectionists.

C. S. ASHCRAFT
R. H. MCCULLOUGH
K. F. MORGAN

ENTERTAINMENT AND AMUSEMENTS

D. MACKENZIE
P. MOLE
C. WUNDER
E. HUSE
W. V. D. KELLEY
C. W. HANDLEY
K. F. MORGAN
J. P. O'DONNELL

PRESS AND PUBLICITY

W. WHITMORE, *Chairman*
CARL DREHER

MEMBERSHIP

H. T. COWLING, *Chairman*

J. W. SMITH
K. F. MORGAN
J. BOYLE

This committee together with the Press and Publicity Committee will have headquarters in the Registration Room, American Legion Auditorium.

TRANSPORTATION, BULLETINS, AND RESERVATIONS

M. W. PALMER
H. T. COWLING
C. W. HANDLEY
W. C. KUNZMANN

OFFICIAL CINEMATOGRAPHERS

JOHN BOYLE
IRA B. HOKE

REGISTRATION HEADQUARTERS

American Legion Auditorium

Procure banquet tickets and identification card when registering. This will be your means of identification at the various functions, studio, and courtesy theater visits.

LADIES HEADQUARTERS

Banquet Parlor No. 1,
Mezzanine Floor, Roosevelt Hotel

NEW APPARATUS EXHIBIT

American Legion Auditorium
Chairman, Exhibit Committee, KENNETH LAMBERT

Those who desire to exhibit new equipment developed within the past year, kindly communicate with the Editor-Manager of the Society at 33 West 42nd Street, New York, N. Y., in regard to exhibit regulations. Space is furnished *gratis* to the exhibitor.

Golfing privileges for S. M. P. E. members and guests have been arranged by the Roosevelt Hotel management at the Lakeside Country Club, Hollywood. The usual club course fee will be charged.

TENTATIVE PROGRAM

MONDAY, MAY 25TH

9:00 to 10:00 A.M.	Registration, American Legion Auditorium. Convention called to order at 10:00 A.M. Opening addresses. Speakers will be announced in the final printed program. Response by the President. Report of the Secretary. Report of the Treasurer. Report of the Progress Committee. Report of the Convention Committee. Papers program.
12:30 to 2:00 P.M.	Luncheon. Committee Reports. Papers Program.
8:00 P.M.	American Legion Auditorium. Get-together gathering of members and guests. Showing of a specially selected film program of unusual interest.

TUESDAY, MAY 26TH

9:00 to 10:00 A.M.	Registration, American Legion Auditorium.
9:30 A.M.	Papers Program.

12:30 to 1:30 P.M.	Luncheon.
1:30 P.M.	Studio Visit. Special buses will leave the Roosevelt Hotel promptly for studio to be visited, which will be announced in final printed program.
8:00 P.M.	The Papers Committee has a program under consideration for the evening at the American Legion Auditorium.

WEDNESDAY, MAY 27TH

9:00 to 10:00 A.M.	Registration, American Legion Auditorium.
9:30 A.M.	Papers Program.
12:30 to 1:30 P.M.	Luncheon.
1:30 P.M.	Visit to Paramount Publix Studios. Special buses will leave the Roosevelt Hotel promptly at 1:30 P.M.
7:30 P.M.	Semi-Annual Banquet and Dance, Blossom Room, Roosevelt Hotel.

THURSDAY, MAY 28TH

9:30 A.M.	Papers Program, American Legion Auditorium.
12:30 to 1:30 P.M.	Luncheon.
	Afternoon program of recreation is being arranged by the Hollywood Local Committee.
8:00 P.M.	The Papers Committee has a program under consideration to be announced in final program.

FRIDAY, MAY 29TH

10:00 A.M.	Papers Program, American Legion Auditorium.
	Open Forum.
	Discussion of location and plans for the Fall Meeting.

Note: Mr. O. M. Glunt, Chairman of the Papers Committee, will have the Spring Meeting papers and final program ready for distribution to the members early in May.

Reduced summer tourist rates become effective May 15th, and if you contemplate attending the Hollywood Spring Meeting, the Convention Committee suggests that you arrange your transporta-

tion, Pullman reservation, and stop-over privileges early in May, with your local railroad passenger agent over the desired route of travel.

CONVENTION COMMITTEE

W. C. KUNZMANN, *Chairman*
W. C. HUBBARD
M. W. PALMER

The Society regrets to announce the death of Alex G. Penrod, March 15, 1931.

OPEN FORUM

At a meeting of the Board of Governors at New York City on December 19th, it was resolved: "That an open forum be established as a new department of the JOURNAL, *in which might be published letters and communications from members relating to material in the* JOURNAL *or to other matters appertaining to the welfare of the Society, subject to the discretion of the Editor and Board of Editors."*

Correspondence on the following subjects is invited:

(*a*) *Better ways of conducting the conventions.*

(*b*) *Problems for research.*

(*c*) *Problems for investigation by the various committees.*

(*d*) *Discussion of technical papers appearing in the* JOURNAL, *with comments on the success or failure of their application.*

(*e*) *Description of interesting or new developments which have come to your attention during your travels, thereby giving all the members the benefit of this knowledge.*

(*f*) *Preliminary announcements of investigations and discoveries which are to be more fully reported at a later date in formal papers.*

15 So. Oraton Parkway
East Orange, N. J.
March 14, 1931

MR. J. I. CRABTREE, *President,*

SOCIETY OF MOTION PICTURE ENGINEERS

DEAR MR. CRABTREE:

Your article on the "Open Forum" appearing in the March, 1931, issue of the S. M. P. E. JOURNAL, is extremely interesting and, to my mind, of vital importance to our Society and to the motion picture industry. Your suggestion, inviting correspondence and discussion on the subject of "Problems for Research," prompts me to present for your consideration, and for open discussion in the Forum, the peculiar need of the motion picture industry for what might be termed a clearing house to investigate and pass on the merits of inventions pertaining directly to the industry but which are created outside the pale of organizations directly engaged in regular motion picture work. It may very well be that many useful and often original ideas, developed by free-lance investigators or others not directly employed

in the motion picture industry, are lost to the industry because no channel exists through which the ideas can be transmitted to those in position to practically apply them.

Members of our Society, who attended the Spring Convention in Washington last year, had the opportunity to witness demonstrations of a projector which functions without intermittent movement of the film and produces screen images which are presented through the medium of continuous, uniform, non-periodic illumination. This projector, designed in 1925 and built in 1926, has been matched, in direct side-by-side comparison tests, against intermittent projectors of the latest design, which were tuned to the best possible performance. Authorities thoroughly acquainted with the normal performance of intermittent projectors, on witnessing such tests, have time and again stated that the continuous image is every bit the equal of the intermittent image as regards the cardinal features of steadiness, definition, and illumination but there are other advantages resulting from a blending of the successively projected images such as diminution of graininess, diminished eye-strain, and lack of color-flicker in two- and three-color additive projection.

Under the circumstances, it is difficult to conceive of any way in which the Society of Motion Picture Engineers can be more helpful to the industry it serves than it can be, at the present time, in sponsoring and conducting some scientific studies of the properties and characteristics of continuous non-intermittent motion picture screen images. The projector demonstrated last spring before the Society is available for these tests and the Society has many scientists within its membership who are fully capable of conducting the studies and analyzing their findings. I believe this matter is of such vital importance to the industry as to warrant the appointment, at an early date, of a special committee to investigate, not the possibilities, but the actual accomplishments of continuous non-intermittent projection.

I shall be pleased to hear from you and others regarding the "Problem for Research" which I have herein proposed. Trusting that you and the Board of Governors may consider continuous non-intermittent projection a fit subject for discussion in the Open Forum and for study by a committee of scientists, I remain

Yours very truly,

ARTHUR J. HOLMAN

The suggestion of Mr. Holman has been referred to the chairman of the Projection Theory Committee.

From other sources the suggestion has been made that our Society undertake to encourage educational institutions to establish fellowships for research work on scientific problems cognate to the motion picture industry and this is under consideration by the Board of Governors.

J. I. CRABTREE, *President*

SUSTAINING MEMBERS

Agfa Ansco Corporation
Bausch & Lomb Optical Co.
Bell Telephone Laboratories, Inc.
Carrier Engineering Corp.
Case Research Laboratory
DuPont-Pathé Film Manufacturing Corp.
Eastman Kodak Co.
Electrical Research Products, Inc.
General Theaters Equipment Co.
Mole-Richardson, Inc.
National Carbon Co.
Paramount Publix Corp.
RCA Photophone, Inc.
Technicolor Motion Picture Corp.

BACK NUMBERS OF THE TRANSACTIONS AND JOURNALS

Prior to January, 1930, the *Transactions* of the Society were published quarterly. A limited number of these *Transactions* are still available and will be sold at the prices listed below. Those who wish to avail themselves of the opportunity of acquiring these back numbers should do so quickly, as the supply will soon be exhausted, especially of the earlier numbers. It will be impossible to secure them later on as they will not be reprinted. The cost of all the available *Transactions* totals $46.25.

	No.	Price
1917	3	$0.25
	4	0.25
1918	7	0.25
1920	10	1.00
	11	1.00
1921	12	1.00
	13	1.00
1922	14	1.00
	15	1.00
1923	16	2.00
	17	2.00

	No.	Price
1924	18	$2.00
	19	1.25
	20	1.25
1925	21	1.25
	22	1.25
	23	1.25
	24	1.25
1926	25	1.25
	26	1.25
	27	1.25
	28	1.25

	No.	Price
1927	29	$1.25
	30	1.25
	31	1.25
1928	32	1.25
	33	2.50
	34	2.50
	35	2.50
1929	36	2.50
	37	3.00
	38	3.00

Beginning with the January, 1930, issue, the JOURNAL of the Society has been issued monthly, in two volumes per year, of six issues each. Back numbers of all issues are available at the price of $1.50 each, a complete yearly issue totalling $18.00. Single copies of the current issue may be obtained for $1.50 each. Orders for back numbers of *Transactions* and JOURNALS should be placed through the General Office of the Society, 33 West 42nd Street, New York, N.Y., and should be accompanied by check or money-order.

JOURNAL

OF THE SOCIETY OF

MOTION PICTURE ENGINEERS

SYLVAN HARRIS, EDITOR

Volume XVI **JUNE, 1931** **Number 6**

CONTENTS

JOURNAL
OF THE SOCIETY OF
MOTION PICTURE ENGINEERS

SYLVAN HARRIS, EDITOR

Published monthly at Easton, Pa., by the Society of Motion Picture Engineers

Publication Office, 20th & Northampton Sts., Easton, Pa.
General Office, 33 West 42nd St., New York, N. Y.

Subscription to non-members, $12.00 per annum; to members, $9.00 per annum, included in their annual membership dues; single copies, $1.50. A discount on subscriptions or single copies of 15 per cent is allowed to accredited agencies. Order from the Society of Motion Picture Engineers, Inc., 20th and Northampton Sts., Easton, Pa., or 33 W. 42nd St., New York, N. Y.

Entered as second class matter January 15, 1930, at the Post Office at Easton, Pa., under the Act of March 3, 1879.

NOISE REDUCTION WITH VARIABLE AREA RECORDING*

BARTON KREUZER**

Summary.—*Methods of accomplishing noise reduction are described, together with the factors influencing equipment design. An analysis of the circuit operation is provided. "Time constants" of the apparatus are discussed and a complete description, as well as photographs of the final commercial equipment now in use in studios, are included.*

The elimination of "background noise" in recording increases the range of intensities that may be satisfactorily handled by a recording system as well as producing a finished record that is superior from a psychological standpoint in that it produces a better "illusion" for the audience.

Noise reduction with variable area recording may be accomplished in several ways. The idea behind all of these methods is the obtaining of a positive print in which part of the ordinarily clear portion of the sound track is rendered essentially opaque.

The earliest known work of this nature appears to have been carried on by C. R. Hanna of the Westinghouse Electric and Manufacturing Company, and by L. T. Robinson of the General Electric Company. A practical method for commercial recording, which was based upon certain of the principles developed by these investigators, was worked out by H. McDowell, Jr., of RKO Radio Pictures in September, 1929.

In reproduction of sound from film the "background noise" is chiefly due to two factors, *viz.*, photo-cell "hiss" and unwanted modulation of the light beam by the film. This modulation may be due to dirt of various kinds, scratches, or grain clumps.

If any unused clear portion of the sound track be made sufficiently dark so that a negligible quantity of light is transmitted through it, it is apparent that noise from the two sources mentioned will be reduced. As a matter of fact this reduction will occur in direct

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* Presented at the Spring, 1931, Meeting, at Hollywood, Calif.

** Development Section, Engineering Dept., RCA Photophone, Inc.

proportion to the darkened area on the print, since the photo-cell current *vs.* illumination characteristic is linear and the dirt, scratches, and grain clumps may be assumed to be uniformly distributed.

The variable area sound record employed by RCA Photophone, Inc., consists of an envelope of the recorded wave about a base line at the center of the track. "Zero modulation" track is half clear and half dark.

In the Hanna system of noiseless recording the clear portion of the track is darkened by moving the base line to within a few mils of the edge of the track at the "zero modulation" condition. This produces a positive print on which the sound track consists of a narrow white line a few mils wide, one of whose lateral boundaries is at the extreme edge of the track.

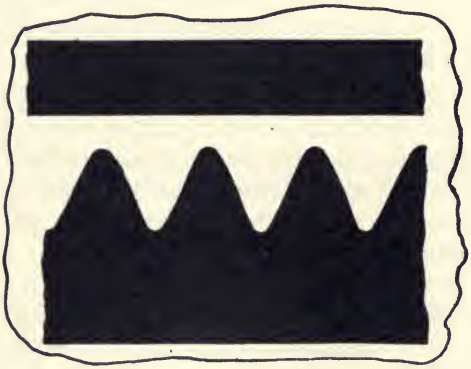

FIG. 1. The form of the sound track on the positive print obtained by rendering opaque the unused portion by masking during recording.

As modulation is recorded on the track, this base line is shifted toward the center of the track in proportion to the amplitude of the modulation. At full track modulation the base line is at the exact center of the track. This movement is secured by mechanically rotating the vibrator, with no signal impressed, so that the base line is at the edge of the track, as mentioned previously. A small portion of the input to the vibrator is then diverted, rectified, and used to electrically rotate the vibrator so that the base line is restored to the center position when the track is fully modulated.

This method of noiseless recording, while quite ingenious and easily applicable, produces a positive print which, at low modulation values, may be distorted when reproduced. This is due to the fact that when a bad "weave" exists in a projector, which very often appears to be the case, the scanning beam may actually miss part or all of the modulation.

Although several pictures have been produced by this process, for the time being preference has been given to McDowell's system,

which has been further developed by engineers of RCA Photophone, Inc., and the RCA-Victor Company.

In this method the base line is not displaced but the unused clear

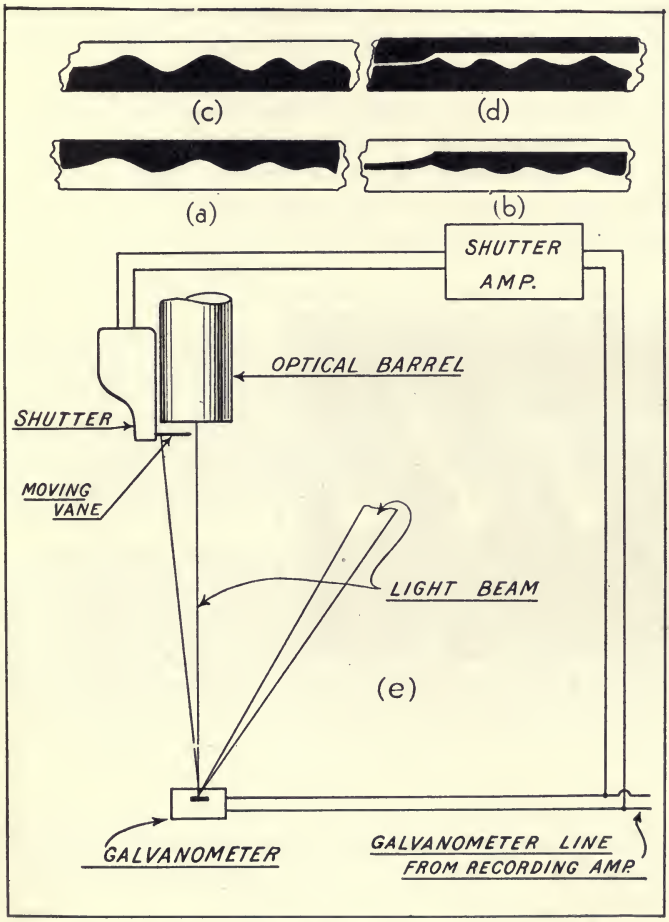

FIG. 2. (*a*) Form of normal sound track; (*b*) form of sound track negative produced by masking unused portion of track; (*c*) positive print obtained from (*a*); (*d*) positive print obtained from (*b*); (*e*) schematic arrangement of the masking mechanism.

portion of the track is rendered opaque by a "masking" action in recording. This leads to a positive print such as that shown in Fig. 1.

With this system the "zero modulation" track on a positive print consists of a narrow white line a few mils wide, one of whose lateral edges is the normal base line. A track of this nature is not affected by "weaving" any more than a normal variable area recording. The "masking" action is accomplished in recording by means of an electromagnetic shutter. A schematic view of this arrangement may be seen in Fig. 2(*e*).

As in the Hanna system, a small portion of the input to the vibrator is diverted, amplified, and rectified and then used to operate the shutter. At "zero modulation" the moving vane of the shutter mechanism protrudes into the light beam entering the optical barrel. This barrel houses the necessary lenses, slit, *etc.*, through which the light beam passes before registering on the film. It is apparent that this vane narrows the light beam to produce the fine track mentioned.

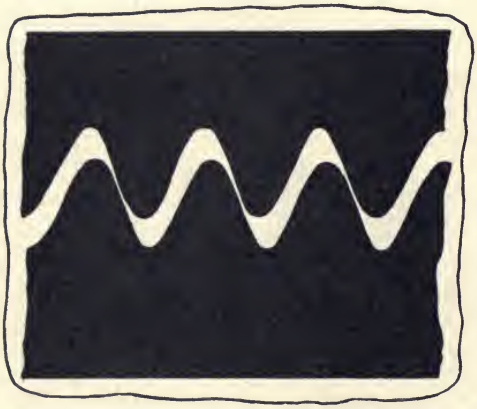

FIG. 3. Effect (exaggerated) produced on sound track due to secondary modulation by the shutter.

As modulation is impressed upon the vibrator the light beam is vibrated back and forth and the rectified portion of the current supplied to the shutter causes the moving vane to draw out of the way sufficiently to clear the modulation of the light beam.

The sound track negative produced in this way appears in Fig. 2(*b*), as compared with the normal track shown in Fig. 2(*a*). The positive print obtained from Fig. 2(*b*) is shown in Fig. 2(*d*), and the print obtained from Fig. 2(*a*) is shown in Fig. 2(*c*).

If proper care is not exercised in the circuit and equipment design several types of distortion may occur. These may be classified as due to the following causes:

(1) Secondary modulation on account of "tracking" of the shutter.

(2) Loss of the start of a sound due to shutter or circuit inertia or a combination of both inertias.

(3) Extraneous noises due to a too rapid "masking" or "unmasking" of the track.

Secondary modulation caused by the shutter will produce a print such as that shown in Fig. 3, in which the defect has been considerably exaggerated.

Since it is the variation in width of the light portion of the track on a positive print which can be said to cause the photo-cell response, this record may be analyzed as follows:

W_r = width of clear portion
W_o = width of half track
W'_o = width of portion darkened for noise reduction
W_m = maximum amplitude of sine wave a-c. being recorded
W'_m = maximum amplitude of sine wave record left by shutter

$$W_r = W_o + W_m \sin \omega t - [W_o' + W_m' \sin (\omega t \pm \theta)] \tag{1}$$

$$W_r = W_o + W_m \sin \left(\omega t \pm \frac{\theta}{2}\right) - W'_o - W'_m \sin \left(\omega t \pm \frac{\theta}{2}\right) \tag{2}$$

FIG. 4. Sound track obtained when the masking action after the cessation of modulation is too slow.

In order to get a clearer picture of this type of distortion, assume for the moment, that $W_m = W'_m$, and, dropping the non-periodic terms:

$$W_r = 2W_m \cos \omega t \sin \frac{\theta}{2} \tag{3}$$

Since, for any system the lag θ is a constant, this type of distortion will not produce harmonics but will produce amplitude alteration ranging from zero output to double output as well as a phase shift depending upon the value of θ.

If $W_m \neq W'_m$ the distortion will be of the type described and

will be due to the last term of equation (2). Its extent will be controlled by the values of W'_m and θ.

The occurrence of the second and third types of distortion are the limiting factors determining the speed of the shutter movement.

If the shutter moves too rapidly, thus tracing a steep wave front on the film, extraneous noises such as "clicks" and "plops" may occur at the start and finish of a sound.

On the other hand, if the shutter action is too slow, a portion of the sound may be lost at the start and under extreme conditions the action can be sufficiently slow to make the shutter useless in recording

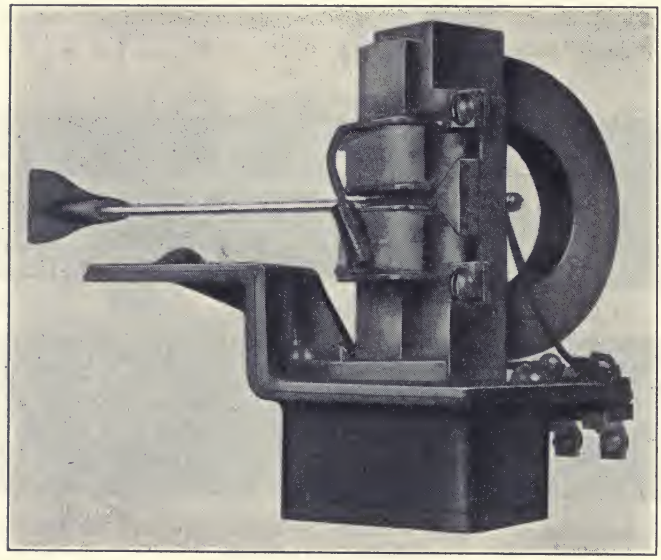

FIG. 5. Details of the shutter mechanism.

long passages. Fig. 4 shows a sound track in which the masking action, after modulation had ceased, was far too slow. By the proper design of operating circuits and the shutter all of the difficulties mentioned may be obviated.

It is apparent that, although some delay in "unmasking" is desirable, it would be best to have this occur in the electrical circuit where it may be controlled conveniently rather than in the mechanical system of the shutter where such control would be extremely awkward.

The shutter, which has been developed by RCA-Victor engineers at Camden, has therefore been made a relatively low inertia device.

It consists essentially, of a very light aluminum vane, pivoted at one end on a flat piece of spring steel and bearing an armature in a magnetic field supplied by a permanent magnet. Movement of the armature is accomplished by simultaneous strengthening of one part of the field and weakening of the other part when current flows through the two pairs of coils situated on the pole faces. The mechanism is electrically damped by copper end plates on the windings.

Since the resonance of this system, *i. e.*, between the mass of the armature and vane and the compliance of the steel spring, occurs at a very low frequency (approximately 15 cycles), above this point the device is essentially mass controlled. As the moment of inertia of the moving parts is small, its operation is relatively rapid. The shutter mechanism is shown in Fig. 5.

The function of the circuit controlling the shutter is to make the "unmasking" action as rapid as is consistent with quiet operation and the "masking" or closing of the track, after the cessation of the sound, sufficiently slow so that no secondary modulation can occur at the lowest frequency to be recorded. The latter part of this statement means, of course, that a true ripple-free d-c. must be delivered to the shutter down to the lowest frequency to be recorded.

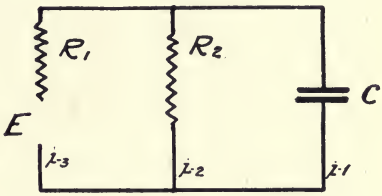

FIG. 6. Shutter control circuit in simplified form.

In simplified form the circuit used to accomplish this is shown in Fig. 6.

The voltage across R_2 varies the grid bias of a pair of vacuum tubes which in turn control the shutter. The input admittance of the tubes is negligible so no account is taken of them in the following analysis:

E = voltage impressed
R_1 = resistance of source (a rectifier)
R_2 = bias resistor
C_1 = capacitor
E' = voltage across C
i_1, i_2, i_3 = current in respective arms of the circuit

$$i_1 = C\frac{dE'}{dt} \tag{4}$$

$$i_2 = \frac{E - i_3 R_1}{R_2} \tag{5}$$

$$i_3 = i_2 + i_1 \tag{6}$$

From these simple network equations an expression for i_2 may be found.

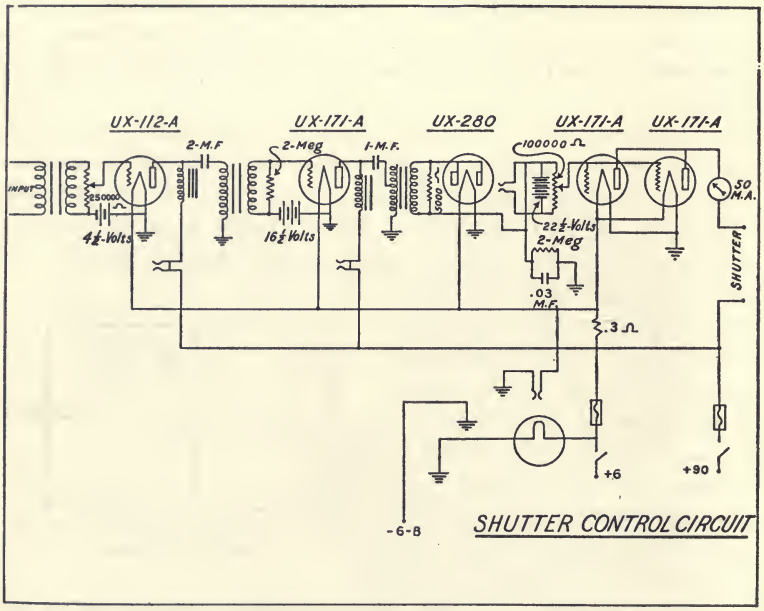

FIG. 7. Circuit diagram of the shutter control circuit, including amplifier and rectifier.

$$i_2 = \frac{E - E\epsilon^{-\frac{t}{R'C}}}{R_1 + R_2}$$

Where $$R' = \frac{R_1 R_2}{R_1 + R_2}$$

When $t = \infty$, then $i_2 = \dfrac{E}{R_1 + R_2}$

Solving for t when $i_2 = 0.9$ of this value,

$$t = 2.3 \frac{R_1 R_2}{R_1 + R_2} C \tag{7}$$

This expression deals with the time necessary for the growth of the rectified current. Now, since the voltage has been supplied

from a rectifier (which has been assumed to present d-c. to the circuit) there is no appreciable reverse current flow through R_1. The current at discharge may be written in the conventional form:

$$i_2' = \frac{E}{R_2} \epsilon^{-\frac{t}{R_2C}}$$

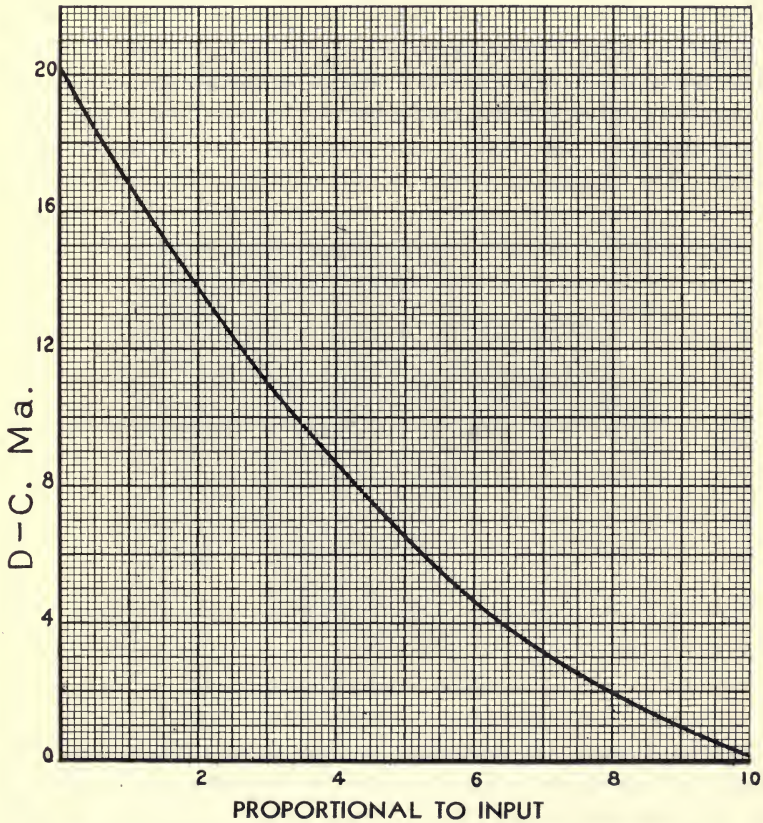

FIG. 8. Input *vs.* output characteristic of amplifier and rectifier.

Allowing for a decrease in current of ten to one, the time required is:

$$t' = 2.3\ R_2C \tag{8}$$

Equations (7) and (8) determine the operating time of the current in the shutter circuit. Actual shutter operation is further influenced by the inertia of the shutter mechanism and a certain amount of inductance inherent in the emf. source.

After careful consideration of the factors involved a choice has been made which provides satisfactory operation with circuit elements which can be quite easily used in commercial apparatus.

The time actually required for complete "unmasking" of the track is from 0.005 to 0.007 second and the time necessary for complete "masking" is 0.11 second.

The circuit diagram of the shutter control circuit embodying an amplifier and rectifier is shown in Fig. 7.

The input to the amplifier is bridged across the low impedance line to the vibrator and is a negligible load on this line. The transformer preceding the rectifier is a step-down transformer used to provide a low impedance source for the rectifier. By careful choice

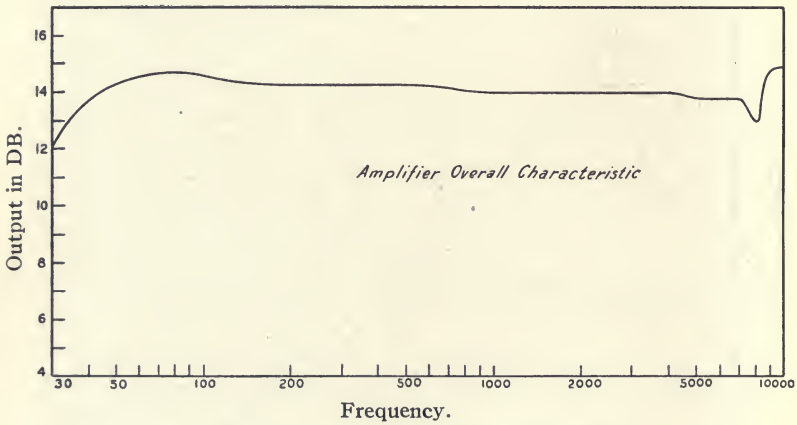

FIG. 9. Amplifier frequency characteristic.

of this transformer, the preceding vacuum tube, and the diode, the demands of equations (7) and (8), which determine speed of operation, may be satisfied and the resistance-capacity network may be constructed of elements which are quite practicable from a commercial standpoint. This means that the capacitor is not large enough to be bulky nor is the resistor great enough to require special insulation to guard against leakage.

Two suitable vacuum tubes in parallel are employed in the output stage on low voltage to insure extreme stability and long life. The variable bias supplied to these tubes is polarized to cause a decrease in their plate current as the signal voltage to the vibrator increases.

This means that the shutter draws away as the current through its windings diminishes.

Use is made of the curvature of the grid voltage *vs.* plate current characteristic of these vacuum tubes to provide a type of operation of the shutter that precludes the possibility of distortion occurring due to the "overshooting" of high-amplitude sounds of short duration. This means that at low modulation the shutter "unmasks" the track to a degree more than directly proportional to the modulation. This insures adequate track width for the recording of the high-amplitude, high-frequency sound components which occur so often in recording.

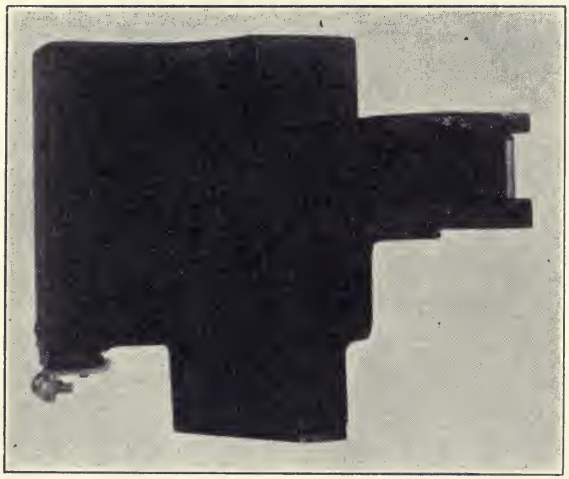

FIG. 10. View of shutter with cover in place.

Fig. 8 shows the overall input *vs.* output characteristic of the amplifier and rectifier. Fig. 9 shows the amplifier frequency characteristic. The control circuit has been built into the RCA-Photophone standard form which allows it to be used either as a portable unit or to be incorporated in the usual racks. External supply voltages necessary are 6 and 90 volts.

Fig. 10 shows the shutter as it is used, with the cover in place. A rear view of the complete control unit, with the dust cover removed, is shown in Fig. 11. Fig. 12 shows this unit as it is used when mounted on a rack.

The initial shutter setting is accomplished by means of the potentiometer below the meter. The gain control is located to the

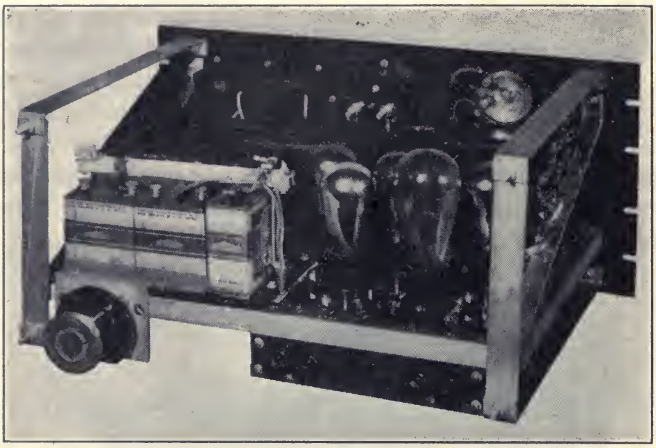

FIG. 11. Rear view of complete control unit with dust cover removed.

left of this meter. The only adjustment necessary for operation is an initial setting of the shutter to allow a narrow track width (5 mils)

FIG. 12. Complete control unit designed for rack mounting.

at "zero modulation" followed by an adjustment of the gain control to allow complete "unmasking" at full modulation. Fig. 13 shows an actual speech syllable recorded with this type of equipment.

The author wishes to acknowledge at this point the contributions of Messrs. E. W. Kellogg, C. N. Batsel, A. Shoup, S. Read, and L. J. Anderson of the RCA-Victor Company, all of whom were con-

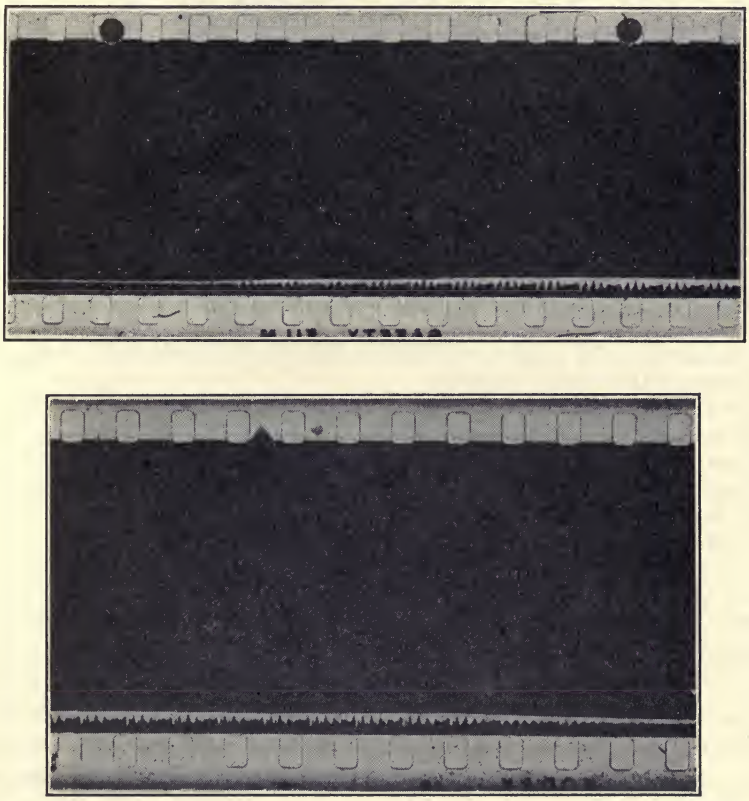

FIG. 13. Appearance of an actual speech syllable recorded with this equipment.

nected with the development of the equipment described in this paper, and each of whom contributed certain of the features upon which the final commercial model was based.

PROPERTIES OF LOW INTENSITY REFLECTING ARC PROJECTOR CARBONS*

D. B. JOY AND A. C. DOWNES**

Summary.—*The characteristics of the latest type of low intensity reflecting arc carbons (which are capable of burning at higher currents than those previously available) are presented. These include current capacity, candle-power, angular light distribution, crater diameter, and intrinsic brilliancy.*

These characteristics are discussed in relation to the optical system. It is shown that although the maximum screen light from the present optical system as determined by photometric measurements can be obtained at a comparatively low current, there are decided practical advantages in using a higher current and larger carbons than the minimum theoretically possible.

It is also demonstrated that the faster projection lenses now available, together with a change in the magnification of the reflector system, should make possible an increase of theoretically 75 per cent in screen light over that now available with the present system. This increased screen light will have the same uniformity, flexibility, and factor of safety as that now obtained, provided the correct carbons and currents are used.

Several years ago a paper[1] was presented before this Society summarizing the characteristics of the large size, low intensity carbons used at that time for light projection in theaters. Since then the low intensity lamps using large size carbons have been almost entirely replaced by the low intensity reflecting arc lamps, the high intensity reflecting arc lamps, and the high intensity condenser type lamps. In the last few years the need for more light even in the smaller theaters has been augmented by various factors such as the use of perforated sound screens, colored films, and the demand for a higher level of general illumination.

Carbon manufacturers have endeavored to aid the situation in the smaller theaters by recently developing low intensity reflecting arc carbons which carry higher currents than those previously available. It is believed that data on the characteristics of these carbons and their application to projection problems may suggest ways to improve still further the illumination of the screen.

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* Presented at the Spring, 1931, Meeting at Hollywood, Calif.

** Research laboratories, National Carbon Co., Cleveland, Ohio.

The current carrying capacities of these carbons are given in Table I. Approximately 2 amperes have been allowed as a factor of safety

TABLE I

Current Ratings of S. R. A. Positive Carbons

Carbon Diameter	Minimum Recommended Current	Maximum Recommended Current	Current above Which There Is Constant Sputtering
10 mm.	21	24	25
12 "	28	32	34
13 "	32	42	44
14 "	42	52	55

between the maximum recommended current and the extreme upper limit of the carbons. Data on the 10 and 14 mm. carbons have been included although there has up to this time been no active demand by the industry for these sizes. If the carbons are burned above their maximum current, the light will be unsteady and there will be no appreciable gain in candle-power. If the carbons are burned below the minimum current the efficiency of light production is decreased and the arc tends to become unsteady because the crater area is too small to sufficiently cover the end of the carbon.

It is the light from the crater of the positive carbon which is of value. The light from the negative carbon and arc stream is only approximately 10 per cent of the total light and cannot be utilized for projection purposes. The diameter of the positive crater increases with increasing current. The data in Table II illustrate the change for these particular carbons and correspond to similar values in the literature.[1,2]

TABLE II

Change in Crater Diameter with Current S. R. A. Positive Carbons

Carbon Diameter	Current	Crater Diameter in Inches
10 mm.	21	.262
10 "	24	.278
12 "	28	.311
12 "	31	.325
12 "	34	.344
13 "	34	.347
13 "	40	.378
13 "	44	.392
14 "	44	.404
14 "	50	.419
14 "	55	.432

The action of the direct current on the crater of the positive carbon heats it to approximately 4000°K., the vaporizing temperature of carbon. This gives the crater an intrinsic brilliancy of 130 to 180 candles per square millimeter, which is exceeded only by the crater of a high intensity carbon.

The variation in intrinsic brilliancy of the positive crater was determined by the method used by Benford.[3] As shown in Fig. 1, the intrinsic brilliancy is uniform on the core, rises sharply to a

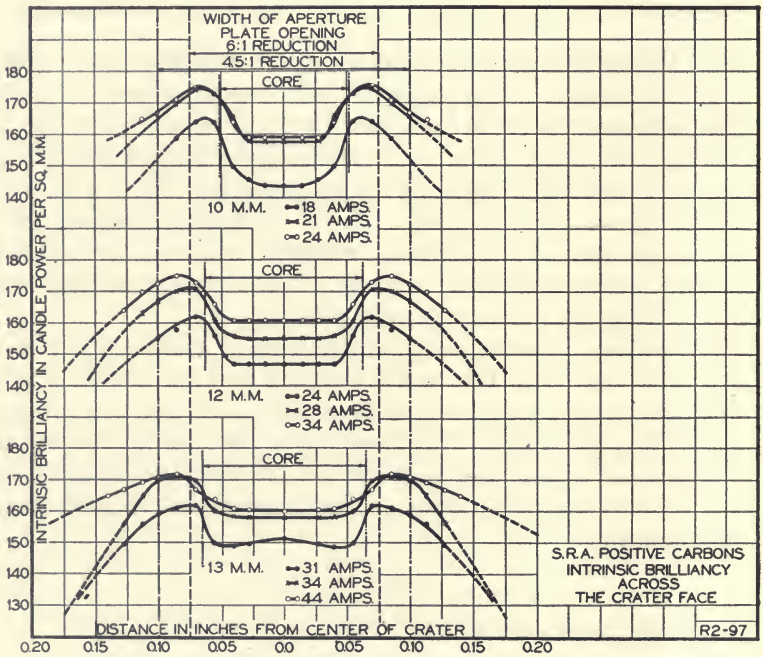

FIG. 1. Variation of intrinsic brilliancy of the positive crater.

maximum on the shell just outside the core, and decreases again near the edge of the crater. If the carbon were solid instead of cored, there would be no dip in the intrinsic brilliancy at the center of the crater. However, the core is necessary to furnish arc-supporting materials and to maintain the crater position constant with respect to the carbon. Without it, the current would have to be reduced materially and the crater would travel around the end of the carbon and would result in a very unsteady light on the screen.

It should be noted that above a certain current for each size carbon

there is practically no increase in the intrinsic brilliancy of the central part of the crater—merely an increase in crater size and intrinsic brilliancy near the edges of the crater. It is also evident that after this critical current has been reached the intrinsic brilliancy is the same for the central portion of the crater on a 10 mm. carbon as for the 13 mm. carbon. This important characteristic will be referred to

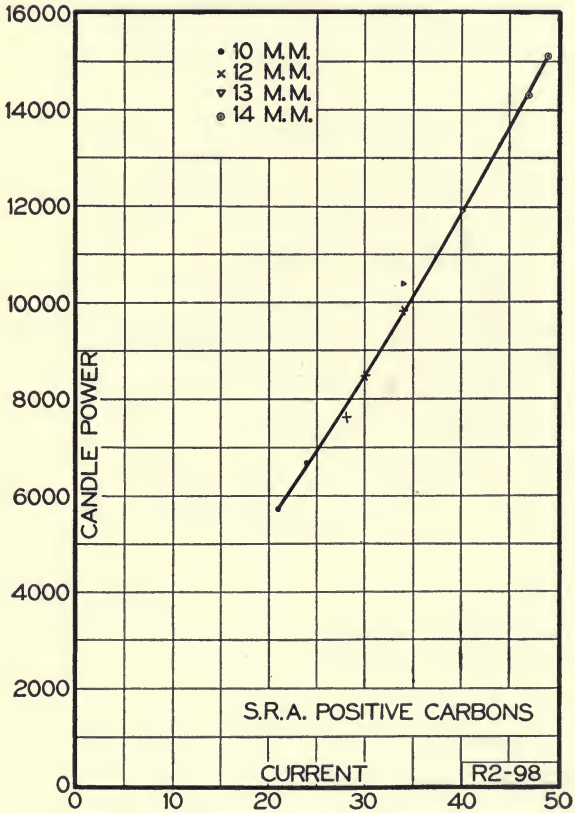

FIG. 2. Variation of candle-power of the crater with respect to the current.

later in relation to the optical system. The approximate current at which the central portion of the crater reaches its maximum is the minimum recommended current in Table I. The values of intrinsic brilliancy near the edge of the crater, in dashed lines, were extrapolated from the actual measurements made on the rest of the crater.

The candle-power of the crater could be calculated from these intrinsic brilliancy curves, but the values shown in Fig. 2 were obtained by the method[4] of measurement previously used for high intensity carbons. These values check within the limits of experimental error with values calculated from the intrinsic brilliancy curves.

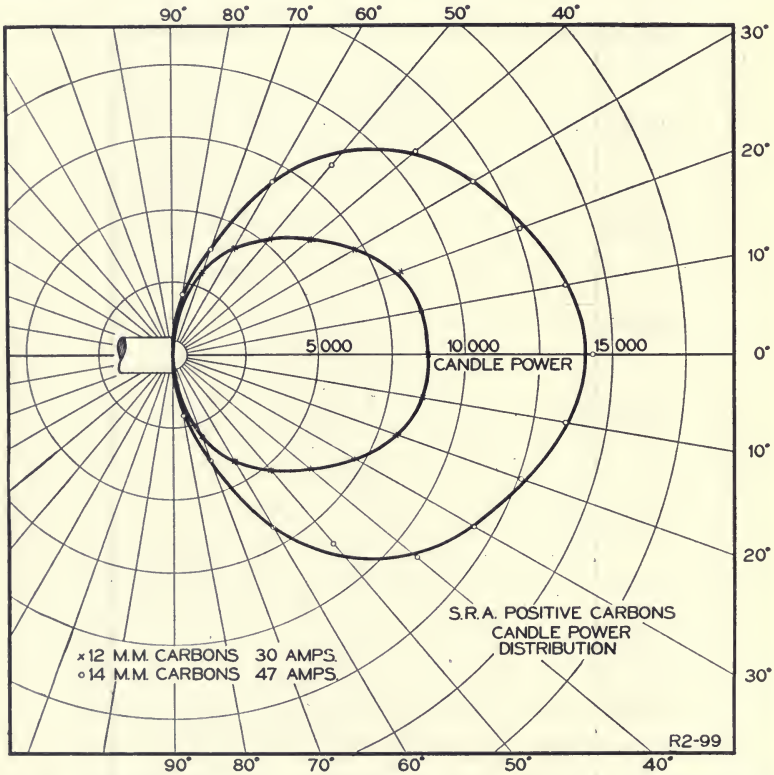

FIG. 3. Polar candle-power curves showing light distribution about the crater.

Of more importance for projection than the candle-power directly in front of the crater is the light distribution about the crater. This is obtained by the same method[4] and polar candle-power curves for two currents are given in Fig. 3. The polar curves for other currents and carbon sizes would be similar in shape and proportional to the candle-power values in Fig. 2. These polar curves are misleading if they are not carefully analyzed. A better method of ex-

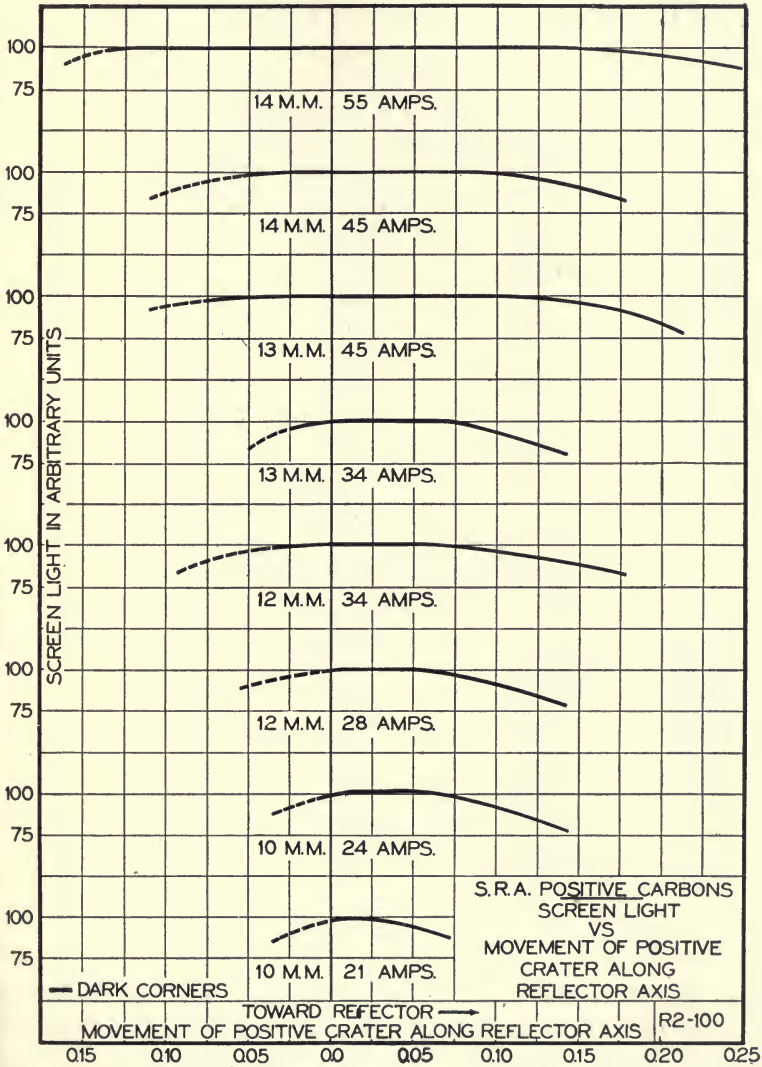

FIG. 4. Change in light on screen with respect to movement of positive carbon along the reflector axis.

pressing the same thing is to compute the quantity of light in each angular segment. These values as well as the total quantity of light and the accumulative percentages are given in Table III.

TABLE III

S. R. A. Positive Carbons Angular Light Distribution

12 Millimeter Carbon at 30 Amperes

Angle	Av. Cp.	Lumens Light Flux in Various Zones	Per Cent of Total Lumens	Accumulative Per Cent of Total Lumens
0–10	8695	825	3	3
10–20	8360	2360	9	12
20–30	7590	3520	13	25
30–40	6670	4180	16	41
40–50	5730	4430	17	58
50–60	4730	4230	16	74
60–70	3600	3570	14	88
70–80	2220	2260	9	97
80–90	720	780	3	100
		26,155 (Total Lumens)		

14 Millimeter Carbon at 47 Amperes

Angle	Av. Cp.	Lumens Light Flux in Various Zones	Per Cent of Total Lumens	Accumulative Per Cent of Total Lumens
0–10	13,950	1320	3	3
10–20	13,100	3700	9	12
20–30	12,200	5600	14	26
30–40	11,350	7130	17	43
40–50	9650	7460	18	61
50–60	7630	6850	16	77
60–70	5340	5300	13	90
70–80	2930	3100	7	97
80–90	1015	1110	3	100
		41,570 (Total Lumens)		

The optical systems used in the present low intensity reflecting arc lamps have been described by Bassett[5] and Stark.[6] Briefly, the systems commonly employed use a parabolic reflector with a condensing lens or an elliptical reflector alone. Irrespective of the system used, the light pick-up from the arc has usually been a cone of 120-degree opening which, according to Table III, would include approximately 75 per cent of the light from the positive crater. The light

gathered by the reflector is focused on the aperture plate in the form (neglecting spherical aberration) of an image of the crater. The magnification of the system is approximately 6 to 1. Under these conditions it is theoretically correct that the optical system is saturated when a current of 21 amperes is used on the proper size carbon and that higher currents merely give more light to be absorbed or reflected from the aperture plate. It can be seen that this is plausible by a reconsideration of Fig. 1. In this figure, instead of projecting

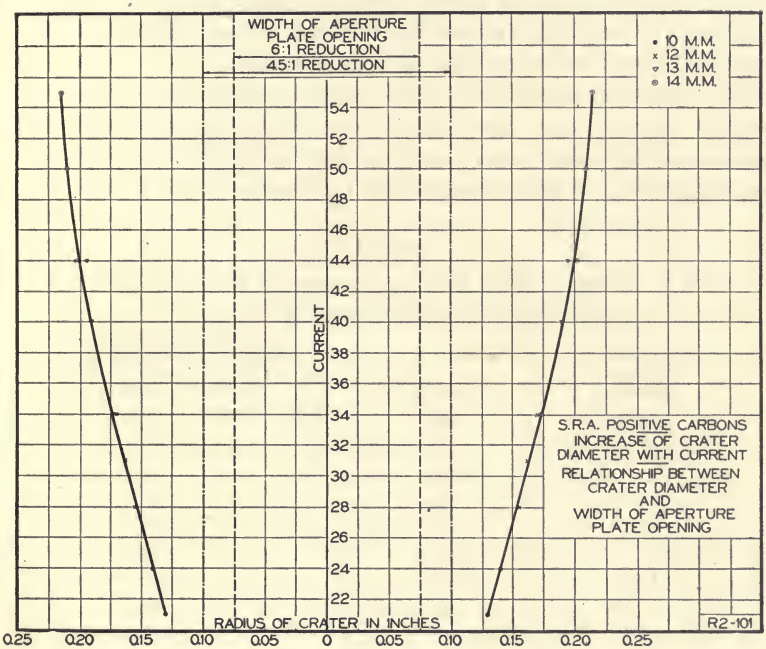

FIG. 5. Relation between crater radius and current.

the crater face onto the aperture plate, the width of the aperture plate opening with the proper reduction for 6 to 1 magnification has been projected back onto the crater. The values of intrinsic brilliancy for the portions of the craters within the aperture plate width indicate that no more light could be expected to go through the aperture plate from a 13 mm. carbon at 44 amperes than from a 10 mm. carbon at 21 amperes. They also show that if the carbon is run below its rating, for example, 31 amperes on a 13 mm. carbon or 24 amperes on a 12 mm. carbon, there will be less light through the

aperture plate opening because of the lower intrinsic brilliancy of the middle portion of the crater.

However, there are very important reasons for not using for ordinary theater projection the smallest size carbons or the lowest current theoretically possible. The total light and the uniformity of the light on the screen depend largely on the position of the positive crater with respect to the focal point of the mirror. In practical projection it is very difficult to hold the positive crater within 0.025 inch of the correct focal point. This accuracy would be necessary to obtain the maximum screen light from a 10 mm. carbon at 21 amperes with a mirror arc system in common use.

The change in the light on the screen with the movement of the positive carbon along the axis of the reflector of a typical optical system for various currents and sizes of carbons is shown in Fig. 4 and Table IV. The movement of the crater away from the axis

Table IV

S. R. A. Positive Carbons Extent of Movement of Positive Crater along Axis without Materially Decreasing Screen Light

Carbon Diameter	Current	Total Allowable Movement in Inches along Axis for a Change of No More than 5 Per Cent in Screen Illumination
10 mm.	21	.06
10 "	24	.10
12 "	28	.10
12 "	34	.15
13 "	34	.11
13 "	45	.21
14 "	45	.18
14 "	55	.34

for the various carbon sizes and currents without a material decrease in the screen light was not measured, but is illustrated in Fig. 1 and Fig. 5, where the aperture plate opening for a 6 to 1 magnification is compared with the crater diameters and intrinsic brilliancies. These data show the disadvantage of using a carbon below, or even near, its minimum current capacity rather than the next lowest size carbon near its maximum current capacity.

From these considerations, the use of a 13 mm. carbon at 40 amperes appears to be amply justified to guarantee uniformity of screen illumination. Even with this carbon and current, the positive crater must be held within 0.07 inch of the focal point of the reflector to

maintain the screen illumination within 5 per cent of the possible maximum.

The limitations of the present low intensity mirror arc optical systems have been clearly defined by Stark.[6] At that time the fastest projection lens would pass a cone of light only approximately 20 degrees in total angular diameter. This practically fixed the magnification ratio of the reflector system at 6 to 1 and the angle of light taken by the reflector from the crater at 120 degrees. If the angle of the reflector were increased to take a greater angle of light from the crater, this additional light could not be passed by the projection lens. If the magnification were reduced there would be no advantage because the projection lens could pass only a correspondingly smaller angle of the light picked up by the reflector.

Recently, however, projection lenses have been made available which will pass a cone of light approximately 29 degrees in total angular diameter. Such a lens will allow the magnification to be reduced from 6 to 4.5 and still take all the light from a reflector with a gathering angle of 120 degrees about the positive crater. This change would merely require a new reflector (possibly slightly larger in diameter and further from the arc to allow sufficient room in front of the lamp) of the proper magnification, the new type projection lens, and the proper carbons and current. The light on the screen would theoretically be increased inversely as the square of the magnification or approximately 75 per cent over that now available. A comparison of the relative sizes of the crater and aperture plate with the two magnifications is given in Fig. 1 and Fig. 5. It appears that an increase of only 10 amperes in the arc current over that used for the 6 to 1 magnification would give the corresponding flexibility and evenness of screen illumination to the 4.5 to 1 magnification. For example, a 14 mm. carbon at 50 amperes with the new magnification of 4.5 to 1 would have the same allowable movement around the focal point of the reflector for good screen illumination as a 13 mm. carbon at 40 amperes with the 6 to 1 magnification.

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THE RIBBON MICROPHONE*

HARRY F. OLSON**

Summary.—*The ribbon microphone consists of a light metallic ribbon suspendea in a magnetic field and freely accessible to air vibrations from both sides. The vibration of the ribbon due to an impressed sound wave leads to the induction of an emf. corresponding to the undulations of the incident sound wave. The ribbon is caused to move from its position of equilibrium by the difference in pressure existing between the two sides. In general, the ribbon is made light so that its motion corresponds to the motion of the air particles at very high frequencies. One of the important advantages of this type of microphone as compared with a pressure-operated microphone is that it possesses marked directional properties. This has decided advantages in sound motion picture work.*

The ribbon microphone consists of a light, corrugated, metallic ribbon suspended in a magnetic field and freely accessible to air vibrations from both sides. The vibration of the ribbon due to an impressed sound wave leads to the induction of an emf. corresponding to the undulations of the incident sound wave. The ribbon is moved from its position of equilibrium by the difference in pressure existing between the two sides. In general, the ribbon is made light so that its motion corresponds to the motion of the air particles at very high frequencies. This microphone can therefore very appropriately be termed a "velocity" microphone. One of the important advantages of this type of microphone as compared with a pressure-operated microphone (such as those of the condenser and carbon type in current use) is that it possesses marked directional characteristics, whereas a pressure-operated microphone possesses non-directional response. This has decided advantages in sound motiou picture work, as will be pointed out later. The use of a light, corrugated ribbon in acoustic devices was proposed some years ago by Dr. E. Gerlach (U. S. Patent 1,557,356). However, there apparently has not been any complete investigation of the factors which enter into the best utilization of this type of element in a microphone, particularly where velocity operation is desired, and hence the author

* Presented at the Spring, 1931, Meeting at Hollywood, Calif.

** Research Division, RCA Photophone, Inc., New York.

undertook the analysis which follows. This investigation has resulted in a design which has good frequency characteristics and uniform directional characteristics. It is particularly suited to sound motion picture work and for many applications it promises to supersede the condenser microphone at present in widespread use.

Various types of ribbon microphones have been investigated. One of the important details of construction concerns the size of the baffle surrounding the ribbon. "Baffle" is used here to designate a structure that determines the air-path between the two sides of the ribbon.

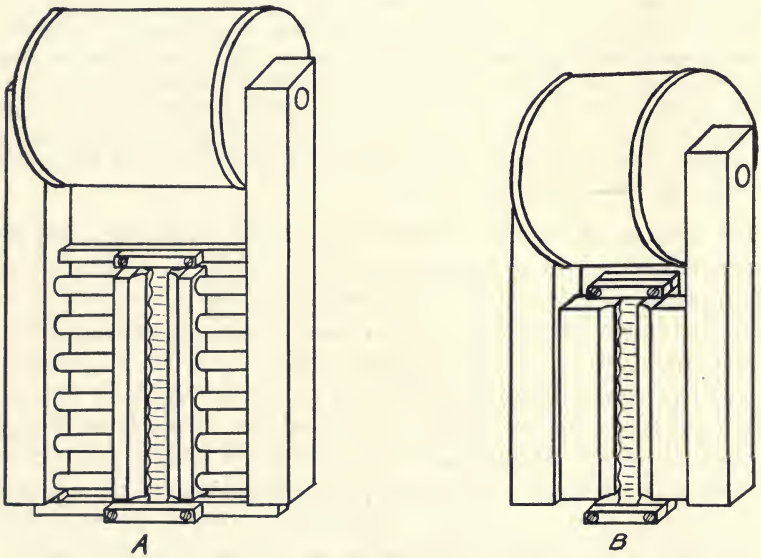

FIG. 1. (*A*) A ribbon microphone in which the structure surrounding the ribbon is small; (*B*) a microphone in which a baffle of moderate dimensions surrounds the ribbon.

Two types of baffle are indicated in Fig. 1: *A* shows a microphone in which the structure surrounding the ribbon is small; *B* shows a microphone in which a baffle of moderate dimensions surrounds the ribbon.

As we have previously stated, the ribbon is driven from its position of equilibrium by the difference in pressure between the two sides. To indicate the nature of this difference in pressure we will digress for a moment to the consideration of some allied phenomena.

Consider a rigid sphere[1] immersed in a plane wave sound field.

For wavelengths large in comparison with the diameter of the sphere the intensity is practically the same for all points on the sphere. Under these conditions the instantaneous difference in pressure between the diametrically opposite points on the surface of a sphere, the line joining which coincides with the direction of propagation, is approximately the same as that existing between two points in a sound field separated by the air distance between the points on the sphere. The finite circular baffle has been investigated by Strutt.[2] As in the case of the sphere the difference in pressure between the front and back is due to the difference in phase incurred by the shortest air distance between the front and back.

In these two examples, as the frequency increases the phase difference becomes greater, and, as a consequence, the difference in pressure between front and back becomes correspondingly larger. When the wavelength becomes comparable to the diameter, the intensity on all parts of the sphere or on the two sides of the baffle is not the same. Ultimately the pressure at the face of the sphere or baffle is twice that in free space and the pressure at the back is zero.

As will be seen from Fig. 1, the configuration of the baffle surrounding the ribbon is of rectangular shape. For this reason any rigorous mathematical consideration of the difference in pressure between the two sides of this baffle will be extremely complex. We will assume that the important parameter that designates the differential pressure between the two sides of the ribbon is the shortest air distance between the front and back of this portion of the ribbon. We will further assume that the difference in pressure between the two sides of the ribbon is the same as that in a sound field between two points in space separated by this distance.* It is this difference in pressure due to the difference in phase between the front and back that actuates the ribbon in the ribbon microphone.

We will now examine the difference in pressure between two points in space separated by a distance *2d* for a plane and spherical sound field.

In a plane wave the pressure is given by

$$p = -\rho\dot{\varphi} = Kc\rho A \sin K(ct - x) \tag{1}$$

* To state exactly the acoustic path between the front and back is beyond the scope of this analysis. However, the following analysis and conclusions will not be materially altered by a change in this distance.

where $K = 2\pi/\lambda$;
λ = wavelength;
ρ = density of air;
c = velocity of sound;
A = amplitude of φ;
φ = velocity potential;
x = coördinate of a particle in the medium.

Assume two points in space, A and B, separated by a distance $2d$ in line with the direction of propagation. The difference in pressure between these two points is

$$\begin{aligned}\Delta p &= Kc\rho\ A[\sin K(ct + d) - \sin K(ct - d)] \\ &= 2Kc\rho\ A \cos (Kct) \sin (Kd)\end{aligned} \tag{2}$$

In a spherical wave the pressure component is given by

$$p = \frac{A\omega\rho}{4\pi r} \sin K(ct - r), \qquad \text{where } \omega = Kc \tag{3}$$

Let the distance between the source and the point A be $r - d$ and the point B be $r + d$, the source, A and B, being in the same line; the difference in pressure is given by the expression:

$$\Delta p = -A\omega\rho\left[\frac{8\pi r \cos K(ct - r) \sin Kd + 8\pi d \sin K(ct - r) \cos (Kd)}{(4\pi r)^2 - (4\pi d)^2}\right] \tag{4}$$

If d is small compared to r and Kd is small compared to unity the above equation becomes approximately

$$\Delta p = -\frac{A\omega\rho d}{4\pi}\left[\frac{2Kr \cos K(ct - r) + 2 \sin K(ct - r)}{r^2}\right] \tag{5}$$

In the above expressions, for wavelengths large in comparison to d, the magnitude of Δp is proportional to the frequency. If this force Δp acts upon an element which is "mass controlled," the velocity of this element for a plane sound wave of constant intensity will be independent of frequency. In the case of spherical waves the velocity of this element will be a function of $1/r$ and $1/r^2$ as well as the frequency. Therefore, with a structure as indicated and a vibrating element in a magnetic field, the voltage output of this microphone corresponds to the velocity component of the sound wave. Considerations of the response of this microphone in standing wave systems substantiate the above conclusions.

Consider two plane waves of equal amplitude traveling in opposite directions along the x axis. The pressure is given by

$$\begin{aligned}p &= Kc\rho_0 A[\sin K(ct - x) + \sin K(ct + x)] \\ &= 2Kc\rho_0 A[\sin(Kct) \cos (Kx)]\end{aligned} \tag{6}$$

The difference in pressure between two points located at $x - d$ and $x + d$ is given by the expression

$$\Delta p = Kc\rho_0 A \{\sin (Kct)[\cos K(x - d) - \cos K(x + d)]\}$$
$$\Delta p = 4Kc\rho_0 A \sin (Kct) \sin (Kx) \sin (Kd) \tag{7}$$

The particle velocity in this system is given by

$$u = -2KA \cos (Kct) \sin (Kx) \tag{8}$$

The maxima of Δp and the particle velocity along the x axis coincide. Therefore, the maximum response of the ribbon microphone will occur at a velocity loop.

The above consideration applies to reflection of a plane wave by

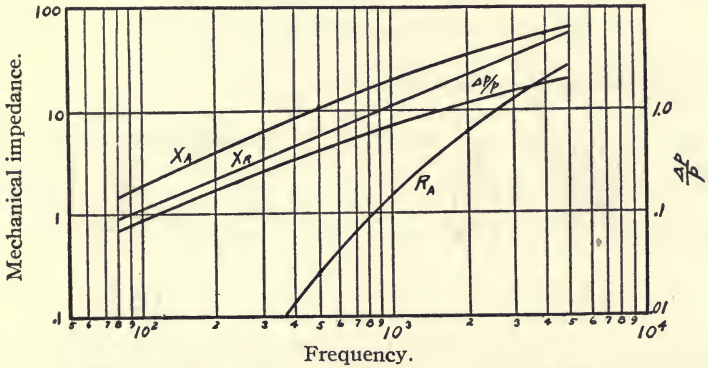

FIG. 2. Impedance characteristics of the components of the mechanical system.

X_R—Mechanical reactance of the ribbon
X_A—Mechanical reactance due to air
R_A—Mechanical resistance due to air
$\Delta p/p$—Ratio of difference in pressure between the two sides of the ribbon to free space sound pressure.

a wall. Assume normal incidence of a plane wave upon a perfectly reflecting wall. The coördinate of the wall is $x = 0$. Therefore, the response of the ribbon microphone will be zero for points near the wall. The maximum response will occur at intervals of $(2n - 1)\lambda/4$ from the wall (where n is an integer and λ the wavelength). The maximum response of a pressure measuring device will occur at the surface of the wall and at intervals of $2n\lambda/4$ from the wall.

The instantaneous pressure available for driving the acoustic and mechanical systems of the microphone for two types of acoustic waves has been derived above. This difference in pressure, for a plane wave, for microphone A, Fig. 1, is shown in Fig. 2. Expres-

sions will now be derived for the impedance of the acoustic and mechanical systems.

The mechanical reactance due to the mass of the ribbon is given by

$$Z_R = X_R = 2\pi f m_R \tag{9}$$

where f = frequency;
m_R = mass of the ribbon.

The reaction of the air upon the motion of the ribbon will now be considered.

The pressure[3] at a distance r from an elementary source is

$$p = \frac{dS}{4\pi r} j\rho\omega\dot{\xi} e^{j\omega t} e^{jKr} \tag{10}$$

where $\dot{\xi}$ equals velocity of the element dS.

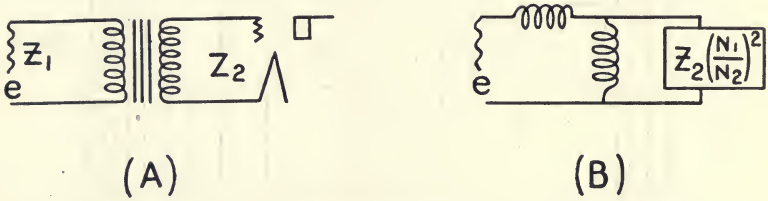

FIG. 3. (A) Circuit showing the output of the ribbon coupled to the input of the vacuum-tube amplifier; (B) the equivalent circuit of (A).

The pressure at any point on the ribbon is

$$p = -\rho\dot{\phi} = \frac{j\rho\omega\dot{\xi}_0 e^{j\omega t}}{4\pi} \int\int \frac{dS}{r_1} e^{jKr} \tag{11}$$

where r_1 is the radius vector having the shortest air distance from point l to the surface element dS. The integration extends over both sides of the ribbon. To compute the force on the ribbon we must perform the above integration and then integrate the resulting pressure over the surface of the ribbon. Cognizance must be taken of the 180-degree difference in phase between front and back when integrating between these two surfaces.

The total force is

$$\psi = \frac{j\omega\rho\dot{\xi} e^{j\omega t}}{4\pi} \int\int dS' \int\int \frac{dS}{r_1} e^{jKr_1} \tag{12}$$

The impedance is

$$Z_A = R_A + jX_A = \frac{\psi}{\xi_0 e^{j\omega t}} \tag{13}$$

This integral was evaluated for the particular ribbon by an approximation. The resistive and reactive components of the impedance presented to the ribbon by the air are given by the graphs in Fig. 2. For the size of ribbon and baffle employed it will be seen that both the reactive and resistive components of the system increase with frequency within the range indicated.

The output of the ribbon is coupled to the grid of a vacuum tube by means of a step-up transformer as shown in Fig. 3(A). The

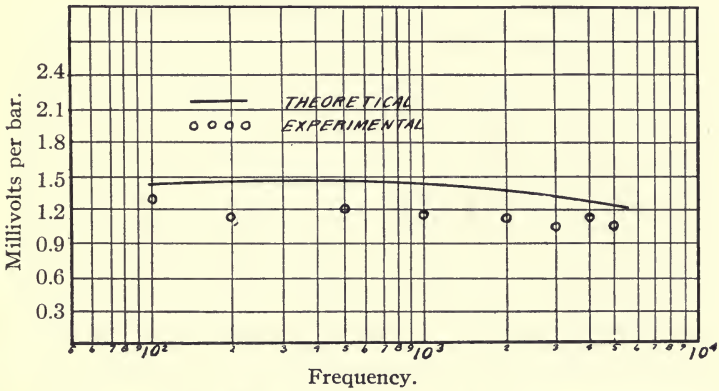

FIG. 4. Curve showing the millivolts per bar at the grid of a vacuum tube as a function of the frequency.

equivalent circuit of this system is shown in Fig. 3(B). We will designate the total impedance at the point e by Z_T, and will now compute the effect of the electrical circuit upon the motion of the mechanical system.

The electromotive force developed by the ribbon is

$$e = BlX \tag{14}$$

where B = the flux density;
l = the length of the ribbon;
X = velocity of the ribbon.

The force required to generate a current i in the equivalent circuit Fig. 3(B) is

$$F = Bli \tag{15}$$

The mechanical impedance due to the electrical circuit is

$$Z_B = \frac{F}{\dot{X}} = \frac{(Bl)^2}{Z_T} \tag{16}$$

The mechanical impedance due to the electrical circuit is, in general, negligible compared to the mechanical impedances considered above.

Expressions for the important mechanical impedances of the system have now been derived and we are prepared to compute the motion of the ribbon. The velocity of the ribbon is given by the expression

$$\dot{X} = \frac{\Delta p}{Z_R + Z_A + Z_E} \tag{17}$$

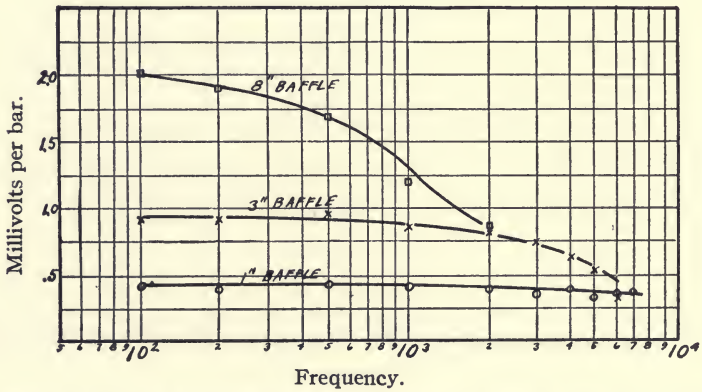

FIG. 5. Curves showing the effect of various sizes of baffle on the output of the microphone.

It has been shown that the magnitude of Z_R, Z_A, and Z_E are all practically proportional to the frequency. It has also been shown that Δp is proportional to the frequency. For this reason $\dot{X}$ *remains practically constant throughout the frequency range.* The generated voltage e is given by

$$e = Bl\dot{X} = Bl\,\frac{\Delta p}{Z_R + Z_A + Z_E} \tag{18}$$

This indicates that *the generated voltage will be independent of frequency.* The voltage presented to the grid of the vacuum tube may be computed from the electrical circuit shown in Fig. 3(B).

A microphone of the type shown in Fig. 1(A) was calibrated by

means of a Rayleigh disk. The millivolts per bar at the grid of a vacuum tube as a function of the frequency are shown in Fig. 4. It will be seen that the voltage output is practically independent of the frequency. It will be seen also that the theoretically predicted curve agrees with the experimental results and confirms the theory outlined above. These results were obtained at low flux densities. In the commercial microphones the flux density is considerably greater and the voltage output is from 2 to 4 millivolts per bar.

The uniform output over a wide frequency range indicates that this microphone is free from resonance systems. The natural period of the ribbon is below the audible frequency range. In a condenser microphone[4] at least two resonances occur within the audible range

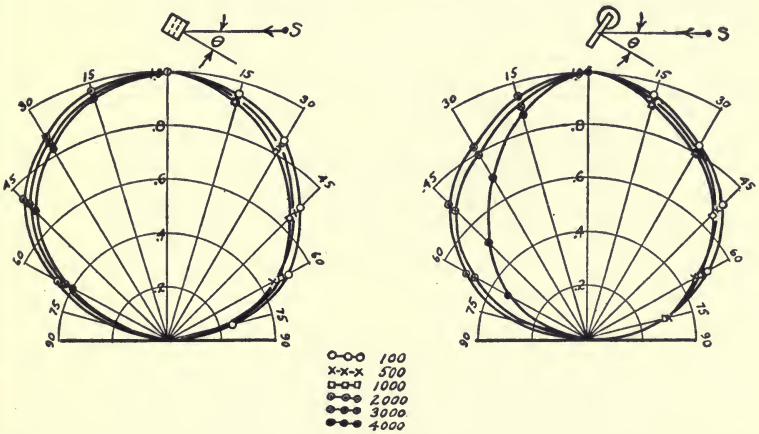

FIG. 6. Polar diagrams showing the directional characteristics of the ribbon microphone.

that influence the output, namely, the cavity resonance and the diaphragm resonance.

To test the effect of the air distance between the front and back of the ribbon this microphone was equipped with various sizes of baffle. The results are shown in Fig. 5. As predicted by the theory outlined above the output increases with increase of the size of the baffle. When the distance between front and back is approximately a half-wavelength, complete reflection occurs at the face of the baffle and the pressure is twice that in free space. Above this frequency the pressure remains twice that in free space and the output of the microphone decreases.

The above considerations have been concerned with the face of the baffle normal to the line of propagation of the sound. When the normal to the face of the microphone is inclined by the angle θ to the line of propagation the air distance from front to back is multiplied by the factor $\cos \theta$. When θ is 90 degrees the pressure difference between front and back is zero for all frequencies and the ribbon remains stationary. This holds true provided the ribbon microphone has as small a baffle as possible (that is, its construction is similar to Fig. 1(A)). However, where the baffle is of appreciable dimensions peculiar distortions of the directional characteristics occur, particularly at the higher frequencies where the dimensions

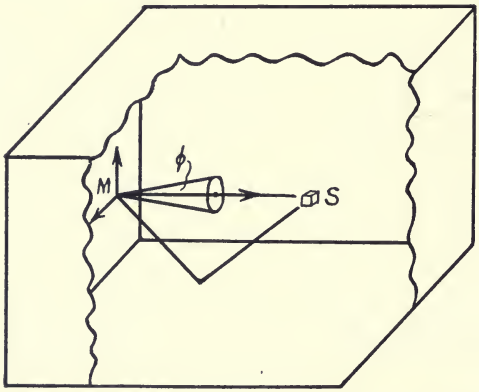

FIG. 7. The pick-up system placed as here shown will respond to the direct sound with the same efficiency as a non-directional system.

of the baffle become comparable to the wavelengths of the sound. Hence, in order to obtain true "cosine" directional characteristics the construction which we have adopted has as short an air path as possible between front and back of the ribbon while still retaining a good magnetic structure.

The observed directional characteristics of this microphone are shown in Fig. 6. It will be seen that the experimental results are in close agreement with the predicted performance. These results indicate that the directional characteristics of this microphone are practically independent of the frequency. For this reason this microphone does not produce frequency distortion due to its directional characteristics.

APPLICATION OF THE RIBBON MICROPHONE

In recording a sound motion picture it is desirable and important that the dramatic action shall not be hampered or cramped by limitations of the sound pick-up system. To accomplish this objective no limitations within the confines of the set should be placed upon the distance over which possible sound must be recorded. In practice it is found that the distance over which sound can be successfully recorded is limited by two factors: the permissible reverberation and the passable ratio of ground noise to signal. In general, excess reverberation resulting from distant pick-up in reverberant

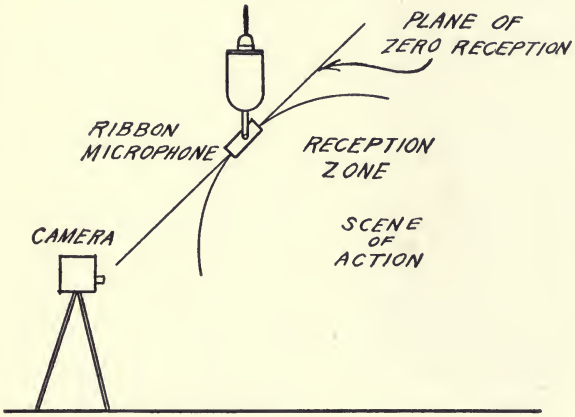

FIG. 8. By placing the microphone overhead, tilted so that the camera lies in the plane of zero reception while the maximum reception zone includes the action, the effect of the camera noise can be practically reduced to zero.

sets is the primary limitation to sound pick-up over large distances. The excess reverberation can be overcome by the use of highly damped sets; however, highly damped sets require materials which are objectionable from a photographic viewpoint.

There is another expedient that can be employed to overcome excessive reverberation, namely, a *directional sound pick-up system*. It is the object of the following discussion to consider the relative merits of directional and non-directional pick-up systems primarily from the viewpoint of reverberation.

Consider first a non-directional pick-up system, the most common example of which is the condenser microphone. For all practical

purposes the condenser microphone (3.5 inches in diameter) receives sound with the same efficiency, regardless of the direction of the source. (The condenser microphone does exhibit directional characteristics to some extent at the higher frequencies—above 2000 cycles—but the detrimental effects of reverberation are in general due to the lower frequencies.) The intensity of sound reflected from the walls, ceiling, and floor of the room is practically constant for any position in the room. Therefore, as we change the position of the microphone to different parts of the room, the pressure at the microphone due to reflected sound is independent of its position in the room. The magnitude of this pressure is a function of the reverberation time and increases with it. The pressure of the direct sound at the microphone varies inversely as the distance from the source to the microphone. The ratio of the pressure received from reflections to the direct sound is a measure of the recorded reverberation. The following conclusion can then be drawn: the amount of recorded reverberation for any particular room depends upon the distance from source to pick-up. For a certain limit upon the permissible reverberation there is a corresponding limit to the distance over which sound may be successfully recorded.

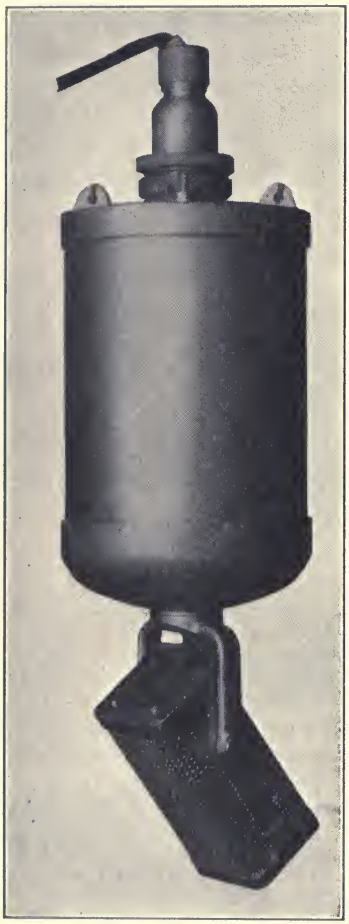

FIG. 9. The commercial form of the ribbon microphone.

Consider next a directional sound pick-up system. This system is characterized by its efficiency of response as a function of the direction with reference to some axis of the system. Assume a system which responds to sound with the same efficiency over a solid angle

ϕ and does not respond in the remaining solid angles. Its efficiency in picking up sound originating in random directions, all directions equally probable, as compared to a non-directional system is $E = \phi/4\pi$. In this expression it has been assumed that the efficiency of pick-up of sound within the solid angle ϕ is the same as a non-directional system. This pick-up system, placed as shown in Fig. 7, will respond to the direct sound with the same efficiency as a non-directional system. As in the non-directional system the direct sound pressure varies inversely as the distance between pick-up and source. As the ratio of reflected sound to direct sound is a measure of the recorded reverberation we can draw the following conclusion: for the same room the amount of recorded reverberation in the directional system will be $\phi/4\pi$ of that in the non-directional system. This means that the distance of recording can be increased $\sqrt{4\pi/\phi}$ of that in a non-directional pick-up system, allowing the same reverberation in both systems.

The efficiency of the ribbon microphone in receiving sound originating in random directions will now be derived. The voltage output of the ribbon microphone for a sound originating in the direction θ is

$$E_R = p_0 K_1 \cos\theta \tag{19}$$

where E_R = the voltage output of the microphone;
K_1 = a constant of the microphone, expressing the relation between sound pressure and voltage output;
p_0 = the average sound pressure;
θ = angle between the direction of propagation and the normal to the face of the microphone.

The voltage output of a non-directional microphone for sound originating in any direction is

$$E_{ND} = K_2 p_0 \cos\theta \tag{20}$$

where E_{ND} = voltage output of the microphone;
K_2 = a constant expressing the relation between sound pressure and voltage output.

Assume that $K_1 = K_2$, which is equivalent to making the sensitivity of the ribbon microphone for sounds originating in a direction normal to the face equal to the sensitivity of a non-directional microphone.

The efficiency of energy response of the ribbon microphone as compared to a non-directional microphone for sounds originating in random directions, all directions being equally probable, is

$$\text{Efficiency} = \frac{\sum_{\phi=0}^{\phi=4\pi} E_{R\phi}^2}{\sum_{\phi=0}^{\phi=4\pi} E_{ND\phi}^2} = \frac{4\pi K_1^2 p_0^2 \int_0^{\pi/2} \cos^2\theta \sin\theta \, d\theta}{4\pi K_2^2 p_0^2} = \frac{1}{3} \quad (21)$$

The following conclusion can be drawn:

The energy response of the ribbon microphone to sound originating in random directions is one-third that of a non-directional microphone. For the same allowable recorded reverberation the ribbon microphone can be used at 1.7 the distance of a non-directional microphone.

The particular directional characteristics exhibited by the ribbon microphone have been found very useful in overcoming objectionable noises. It is possible to orient the ribbon microphone so that the objectionable source of sound lies in the plane of the ribbon and does not actuate the microphone. For example, camera noise is a sound that is very often picked up by the condenser microphone. It has been found that camera noise can be practically reduced to zero by proper orientation of the ribbon microphone. An example of how this is done is shown in Fig. 8. Note that the microphone is placed overhead and is tilted so that the camera lies in the plane of zero reception while the maximum reception zone includes the action.

The ribbon microphone and its associated amplifier as designed for use in motion picture recording is shown in Fig. 9. This equipment is now being supplied to recording licensees of RCA Photophone, Inc.

In conclusion, the author wishes to express his appreciation to Mr. J. Weinberger, under whose direction this work was done, to Mr. B. Kreuzer who was associated with the author during a part of this investigation, and to Dr. I. Wolff for valuable discussions.

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SOME INTERESTING PROPERTIES OF CONTINUOUS PROJECTORS*

WILLIAM C. PLANK

Summary.—*The prism type of continuous projector has the advantage that plane reflectors can be very accurately matched and totally reflecting prisms of a rhomboidal cross-section have the rare and peculiar property of maintaining the projected image in the same vertical plane and of exactly the same size throughout their optically effective travel. These requirements are all indispensable in obtaining definition and flatness of field. The registration of the continuous projector depends upon the indexing of the prisms and uniform motions of prism-wheels and film. The optical advantages to be noted are a characteristic smoothness in the projection, a restful quality to the eyes, and a noticeable plasticity in the projected image.*

In the art of cinematography there is nothing more important than registration; and so, improvements in taking, printing, or projecting the successive film photographs with greater precision will always be of interest to motion picture engineers. In this important matter the continuous projector offers a valuable contribution.

To fully appreciate this fact a consideration of the essential features of a continuous projector will first be necessary. The prism projector, in which the compensating elements are totally reflecting prisms having a rhomboidal cross-section, will be taken as an example. It is fairly representative, as the identical mechanical features can be used in other continuous projectors. Furthermore, its definition and flatness of field will be found to meet the requirements.

With a properly corrected objective and a tandem condenser lens system, excellent definition may be obtained. The rhomboidal prisms are (in their optical effect, at least) like two parallel plates of thick glass interposed between the film and the objective lens, and this relation does not vary in any position of the prisms. The axial ray is always maintained perpendicular to the faces and is displaced, not deflected, to counteract the motion of the film.

This displacement, which occurs with every pair of prisms, is the optical intermittent movement and the counterpart of the mechanical intermittent movement in standard projectors. The primary re-

* Received by the Editor February 15, 1931.

quirement, as with the Geneva movement, is that it be repeated with exactness. This brings us to an important advantage of the rhomboidal prisms: the distance between the parallel reflecting surfaces of these prisms determines the distance the axial ray is displaced or the amount of the optical intermittent movement for a given number of prisms on a wheel.

The displacement is entirely independent of the distance the prisms are situated from the axis of rotation, the objective lens, or the film so it cannot readily be affected in the mounting of the prisms. In fact, as long as the faces of the prisms are maintained perpendicular to the axis, it cannot be made to vary. When a set of prisms is, therefore, made from a plate glass that has been ground and polished flat and parallel to within two wavelengths, the optical intermittent movement will be exceedingly uniform in all the prisms, and will not vary because of wear, which is equally important.

A great advantage in a reflecting system is that it is not difficult to match a plurality of plane reflectors so that the images reflected by them will also match accurately in size and composition. But the rhomboidal prisms have the additional advantage of maintaining the image at exactly the same size and in the same vertical plane throughout their optically effective travel. This property is indispensable in obtaining definition and flatness of field.

Tilting a prism backward or forward with respect to the axis while in the light beam, will move the projected image laterally on the screen. Rotating it from a radial position will move the image up or down. It will be seen that these two adjustments suffice to make the prisms register when they are indexed. With the faces of the prisms always perpendicular to the axis, only one adjustment is necessary.

The mechanism in its simplest form consists of but three moving parts: a sprocket shaft, which carries a ten-frame sprocket, and two parallel shafts situated above and at right angles to the sprocket shaft. These carry the wheels or disks upon which the compensating elements are mounted. Right- and left-hand spiral gears revolve the disks or prism-wheels in opposite directions when the sprocket shaft is turned. The sprocket shaft revolves at 96 rpm. and the two prism-wheels rotate at the unusually slow speed of 48 rpm.

The mechanic will see at once that there are no restrictions as to weight or size and that the three essential parts may be made unusually heavy and, therefore, very rigid and accurate. The three

shafts, for instance, may be made up to two inches in diameter, and the bearings sufficiently long to last indefinitely. An advantage of importance in a slow-speed mechanism is that excessive oiling is avoided with its consequent ill effects on the sound track and picture surfaces.

The spiral gears (which constitute the heart of the mechanism) may also be made unusually heavy so as to assure long and accurate service. The wear on these gears depends largely on the pressure exerted by the teeth. The work involved is very light, since it is only necessary to turn over two freely revolving prism-wheels, which once set in motion, require but little effort to keep them revolving. The wear will then also be evenly distributed in both sets of gears, so they may be used until quite worn out without loss of accuracy.

The outstanding advantage of this construction is therefore seen to be its capacity for sustained accuracy. It is one thing to construct motion picture apparatus with a high order of precision, but quite a different problem to maintain this precision through continued use. The more frequent and familiar experience is to have motion picture machines vary very noticably in their performance from time to time because of dryness, stickiness, or grit, if not because of wear.

But there is another and more important reason for the more uniform performance of the continuous projector. It is a fundamental one and is based on the principle upon which its registration is based. A property that is peculiar to the continuous projector is that the precision of its registration depends, upon uniform motions in the film and the revolving compensating elements.

The law of inertia tends to provide this uniformity of motion despite certain imperfections in the mechanical parts. The fly-wheel effect of the prism-wheels, for example, will tend to bridge over a missing tooth in the gears and the momentum of the film will tend to carry onward a pair of worn or enlarged perforations so that they will not slip back to the sprocket teeth and affect the registration.

This unusual feature overcomes many inaccuracies in the perforations and provides for steadier projection. The momentum of the film also tends to carry it along a straight path and thus prevent certain lateral movements and vibrations that occur with intermittent projection. The technician will therefore see that it is an advantage of major proportions to have a law of nature constantly operating to assure precision in the registration, instead of constantly operating to prevent it.

To realize these advantages the compensating elements of the continuous projector must, of course, be properly indexed. This operation may be performed by any careful person with great accuracy. The important thing is that when the compensating elements are once indexed and fixed in place, they cannot vary or get out of adjustment through wear.

In the present device, each prism may be quickly adjusted while in the light beam, to make the image of cross-hairs that have been placed in the aperture register to fine pencil marks upon the screen to within about 0.01 inch. This precision may be further increased by using more refined means for adjusting the prisms and by increasing the distance to the screen. It is only limited by the accuracy of the dividing head used for indexing, and this may be easily tested by turning a prism-wheel that has been indexed, partly around on its shaft and checking up on it.

In the present device, film shrinkage is taken care of by interposing a thin lens between the film and the compensating elements whenever an old film is projected. By adjusting this lens the film may be brought up to its proper size. It will also be seen that the same lens can be used for correcting a set of over-sized prisms, so that whenever a lens is interposed between the compensating elements and the film, a very liberal tolerance may be allowed as to the dimensions of these elements, and uniformity becomes the principal requirement. As the ordinary sprocket constitutes a variable-speed drive within narrow limits, it automatically takes care of the requirement for the slightly slower speed of the shrunken film.

The principle of the registration in the continuous projector is better appreciated when the prism-wheels and the film are driven by entirely independent means. With the prism-wheels revolving at standard speed (about 48 rpm.) and with the film stationary, the projected image of the film will be seen streaking downward on the screen at a high velocity. If we start the film moving and gradually increase its speed by means of a variable-speed drive, we can slow down the motion of the image until the frames creep downward very slowly. An inspection of the picture will now reveal the fact that the registration is exceedingly close, in fact, it should almost equal that to which the prisms were adjusted and which we have seen may be within 0.01 inch or so, depending upon the care taken in indexing the prisms. When the velocity of the film is further increased so that the picture no longer tends to creep out of frame, as happens

when the film photographs are in synchronism with the prisms, the registration of the successive images on the screen will exactly equal that to which the prisms were adjusted or indexed, assuming the film to be perfect and the motions of the film and prism-wheels to be uniform.

The registration will therefore be seen to depend upon radically different factors from those of the intermittent projector. These factors are:

(1) The registration of the compensating elements, which may be adjusted or indexed with extraordinary precision and which cannot get out of adjustment or vary because of wear.

(2) Uniform motions in the compensating wheels. The law of inertia tends to keep these motions uniform, and wear in the gears should not affect the uniformity of the motions.

(3) Uniform motion in the film. With a friction drive this is also unaffected by wear. A moderate amount of wear in a sprocket would tend to reduce the high-spots and make the teeth more even.

(4) Synchronization.

The advantages, derived from the mechanical features and the principle of the registration, may be summarized as follows:

(*a*) A higher order of precision.

(*b*) A more uniform and longer sustained accuracy.

(*c*) The mechanism has fewer parts and is of the heavy-duty type.

(*d*) Oiling nuisance is avoided, and the sound track and picture surfaces are kept free from oil.

(*e*) Noiseless operation.

(*f*) Freedom from vibration, as all the moving parts are balanced and revolve uniformly.

(*g*) Momentum of prism-wheels tends to overcome certain inaccuracies in the mechanism.

(*h*) Momentum of the film overcomes many inaccuracies in the perforations.

(*i*) Wear on the film has less effect on the projection.

(*j*) Momentum of film prevents sudden lateral movements.

(*k*) Elimination of tension shoes possible, as a loose loop of film can be made to press itself with sufficient flatness against the aperture plate.

(*l*) Elimination of tension shoes makes possible the use of raised or embossed margins on the emulsion side of film, thus forming an air space and preventing scratches on the sound track and picture surfaces when wound up.

(*m*) Absence of tension shoes eliminates the effects of variations in the thickness and smoothness of the film, and the effects of variations in the "give" or flexure of the film at the perforations when under strain.

(*n*) Minimum of strain and wear on film.

(*o*) Fire hazard reduced as there is less possibility of splices parting

(*p*) Moving film fans itself, so withstands higher temperatures.

(*q*) Even distribution of heat reduces buckling of frames.

(*r*) Most of the work of pulling the film may be done by the frictional contact of the sprocket drum.

(*s*) Minimum of work for the sprocket teeth prolongs their life.

(*t*) Fewer and smaller perforations may be used.

(*u*) The need of only one row of perforations, giving room for a wider sound track or a wider picture.

(*v*) The use of one row of perforations eliminates errors in parallelism in the perforations and in the sprocket teeth and makes for greater accuracy in the registration.

The technician will now see that there are a number of pertinent reasons for the more accurate registration of the continuous projector, and of course, the same reasons hold for the continuous camera. The cumulative effect of the more accurate registration improves the definition and increases the contrast of the projected image. It also adds to it a smooth quality that is characteristic.

THE STRAIGHT-LINE LUMINOSITY CURVE

A screen luminosity curve, taken in any of our best motion picture theaters, will show at a glance one of the most serious defects of motion picture projection as it is practiced today. The curve rises rapidly from zero to the mean or average intensity level, then soars upward to a peak where the brightness is twice that of the average intensity; it then falls as rapidly back again to zero. The motion picture engineer who is familiar with the requirements of the human eye need not be told that this curve is far from being an ideal one.

With this condition of screen illumination, the iris of the eye makes a vain, and in some sensitive persons, a fatiguing effort to adjust itself to the alternations of light and darkness. But it is obvious that on account of the inertia of the nerves and muscles that control its action, it cannot do so at the high frequencies employed. At most, the muscular movements are but incipient ones, which, nevertheless, are tiring to some people. The more probable thing to expect is that the iris becomes adjusted to an illumination on the retina that is an average of the different intensities of the intermittent light falling upon it.

In this case the aperture or pupil will be entirely too large for the excessively brilliant peaks of the curve. In other words, nature has not provided us with an efficient protection against brilliant illumination of an intermittent character and a high frequency. It is, therefore, an easy matter to exceed the safety limit, which will lie in

only a moderate difference between the brightness of the average intensity and that of the peaks, and which should be determined for every theater.

The excessively bright light-periods, however, are not the only defects which the luminosity curve will show up, for the dark periods are equally faulty and are frequent causes of eye-strain. Besides the fatiguing efforts already mentioned, there is the possibility of effects derived from the photoelectric nature of the retina, and the response of delicate pigment grains to intermittent light.

Another serious defect of the dark-periods is that they cause gaps or interruptions in the continuity of the projection. These tend to make the representation of motion appear incomplete and unnatural. Still another defect is that in order to overcome the flicker of the dark periods and make it imperceptible to the eyes, such a high rate of projection must be employed that it is wasteful of film. This defect is particularly noticable in amateur cinematography, where rates of from six to twelve pictures a second may often be employed.

An exclusive property of the continuous projector that will therefore appeal to the motion picture engineer is that its luminosity curve approximates a straight line at the average intensity level and thus overcomes the defects in projection mentioned here. A direct result of continuous projection is a restful quality in the image that many immediately notice.

THE UNUSUALLY LONG REST OR STATIONARY PERIOD

In motion picture projection it will be found that if we shorten the stationary periods, or the time the film images are held arrested upon the screen, by means of adjustable shutter blades or the like, we will noticeably detract from the quality of the projected image. It will appear to lose something in the half-tones and depth of perspective, or in that quality projectionists call "snappiness." On the other hand, when we make the stationary period longer, we strengthen and improve these same qualities.

This fact has always been well known, and one manufacturer of an intermittent movement that gave a ten or fifteen per cent longer stationary period than others, claimed very much for this advantage and advertised it extensively. In the continuous projector, however, a gain of fifteen per cent would seem small, for in passing by the double aperture the image of the film photograph is held on the screen four times as long as usual.

THE FORMATION OF COMPOSITE IMAGES

One of the most singular and interesting properties of the continuous projector is that of filling in the gaps of the photographic record with resultant or composite images, formed by superposing the images of two adjacent film photographs upon the screen. This blending-period takes the place of the usual dark-period in intermittent projection, and thus very conveniently and appositely fills in the blanks in the record.

When two film photographs are held in the double aperture of the continuous projector and their images are superposed upon the screen, it becomes possible to see how a composite image with an intermediate posture or pose of its own is created. Two cases may be demonstrated: one in which the moving parts are light upon a dark background, and the other where they are dark upon a bright background.

In the first instance, the parts of the two images that coincide will have their full value of illumination, but the parts that do not coincide (those parts that were in motion in the object) will be only half illuminated and but faintly noticable. Where these parts overlap, however, the illumination will be brought up to its full value and a new outline will be formed which will be different from that of either of the two original images. In the second case, the parts that do not coincide will tend to become obliterated by the highlights of the opposite frame falling upon them. But where these parts overlap, the highlights cannot fall upon them and a new outline or posture will be created.

In considering an arm, for example, in a forward movement, it will be observed that the created or composite image merely shows a much thinner arm. The front outlines are still those of the first film photograph, but the rear outlines can be proved to belong to the second frame by shutting off the light to it. On either side of the thin arm will be noticed the faint fringes or borders of the outlines upon which the highlights have fallen. This composite posture could not, of course, be formed if the difference between the postures in the photographs were so great that no overlapping occured. In a case of this kind, both postures would tend to become obliterated.

In the above example, if the change from one film photograph to the next were made very slowly, we would expect it to occur in two distinct and spasmodic steps, that is, from the first film posture to the composite posture, and then from the composite posture to that of

the second film photograph. But the extraordinary thing is that it is not spasmodic or jerky. It appears as a continuous uniform movement no matter how slowly it is made, provided, of course, that the difference between the two film postures be not too great. Turning movements of the head or body appear particularly even and natural at the slowest possible rates.

We cannot explain this phenomenon excepting upon the principle of irradiation, which makes a narrow fringe or border of light or shadow appear to vary in width with a variation in the illumination. It results, however, in a more complete and natural representation of motion—the primary object of the art of cinematography.

THE THIRD DIMENSION EFFECT

When we hold two frames of titles in the double aperture and pull them slightly out of the perpendicular so that their images do not quite superimpose or register upon the screen, it becomes possible to demonstrate an important reason for the remarkable plasticity given by the continuous projector. When equally illuminated, the two images will appear to be in the same focal plane, but if the illumination of one of the frames be reduced considerably, the images will appear to be in distinctly different planes.

The more strongly illuminated titles will appear to be considerably closer than the dim ones; so, if we straighten up the film again, the dimmer titles will appear to move in behind the bright ones, giving a distinct impression of a third dimension on the screen. When projecting pictures, this effect occurs with every dissolve-period and accounts for much of plasticity in the projected image.

Again, when the double aperture is tilted with respect to the optical axis, the two images will actually lie in different focal planes. It will be seen, therefore, that in moving the film photograph downward from the upper position of the double aperture to the lower one, the image will successively occupy the farther plane, the intervening planes, and then the nearer one. In other words, the image can be made to approach or recede along the optical axis. This property is very useful in bringing out the depth of perspective, especially with an appropriate screen.

SUBDUING THE COLOR FRINGE

A useful property of the continuous projector in natural-color projection is that of superposing two images in different colors upon

the screen. This tends to subdue objectionable color fringes. A red fringe, for instance, would be blended with the green of the background of the opposite frame and would show as a subdued and less noticable tone. Again, by using a shutter, only the blending-periods need be shown and the pictures could be taken simultaneously in the camera.

The high speed at which it may be operated is another useful feature in natural-color projection, where an unusually high rate of projection is necessary for blending the colors or for reducing the amount of color fringe.

AN A-C. OPERATED SOUND MOTION PICTURE REPRODUCING EQUIPMENT*

T. D. CUNNINGHAM**

Summary.—This paper describes the RCA-Photophone type PG-30 sound motion picture reproducing equipment, which requires no batteries or motor-generator sets for plate, filament, and bias voltages, for operation in theaters wired with the normal 105 to 125 volt, 50 to 60 cycle, a-c. power. This equipment, primarily designed for theaters having seating capacities for 1000 persons or less, operates with inaudible output hum under operating conditions, is economical of the space it occupies, is easily serviceable, has an over-all frequency characteristic anticipating future improvements in sound-on-film recordings, has sufficient undistorted power output for providing satisfactory distribution of sound in the type of theater for which it is designed, and has provision for the addition of a remotely operated volume control where desired.

HISTORICAL

Early designs of sound motion picture reproducing equipment depended to a large degree upon batteries for supplying the direct current to the photo-cell, the exciter lamp, the amplifier tube, and the loud speaker field.

Later designs employed multi-unit motor-generator sets in conjunction with suitable filters. The motor-generator set proved to be more satisfactory than batteries in a number of ways. In the first place, the expense of replacing dry batteries every few months and charging the storage batteries daily was eliminated. In the second place, it was possible for the motor-generator set to be installed in the projection booth, since it was not necessary that it be isolated in a detached room, as in the case of storage batteries, in order to reduce the fire hazard due to the liberation of hydrogen during charging.

During the past few years, the trend in the radio broadcast receiver field has been toward complete alternating power supply. Today, radio broadcast receivers of the house socket power operated type have reached a state of fine performance and compactness at a comparatively low cost. It is only a natural consequence that the trend

* Presented at the Spring, 1931, Meeting at Hollywood, Calif.

** RCA-Victor Company, Camden, N. J.

in the design of sound motion picture reproducing equipment should be toward a similar end. It is the object of this paper, therefore, to describe an RCA-Photophone a-c. operated sound motion picture reproducing equipment, to be hereafter referred to as the type PG-30 equipment.

The requirements to be met in the design of this equipment were as follows:

(1) It must be completely operable from an a-c. source.

(2) It must function with inaudible output hum under operating conditions.

(3) It must be small in size.

(4) It must be easily serviced.

(5) It must have an over-all frequency response characteristic such as to anticipate future improvements in sound-on-film recordings.

(6) It must have sufficient undistorted power output to satisfactorily provide sound distribution for theaters having seating capacities of 1000 or less.

(7) It should have provision for a remotely operated volume control.

Without doubt, the introduction and development of the indirectly heated cathode tubes of the UY-224 and UY-227 types has contributed more toward meeting these requirements than possibly any other single development during the past few years. Large-quantity production of these types of tubes has brought about a product which is quite applicable to equipment of this type.

The development of the copper oxide rectifier has also played an important part. This type of rectifier has proved its reliability in the radio, railroad, and other fields during the past few years to such a degree that it likewise is quite applicable to an equipment of this type. The elimination of the motor-generator has considerably simplified the problem of the transmission of objectionable projection booth noise to the ear of the balcony patron. This improvement is of particular importance in theaters having small seating capacities and with balconies extending up to the projection booth, especially where the reproduction of sound motion pictures was not considered during their construction.

DESCRIPTION

A double projector installation of type PG-30 reproducing equipment comprises two Simplex or Powers projectors, two sound at-

tachments, one reproducing amplifier, one stage loud speaker, and one monitoring loud speaker. This equipment is designed primarily

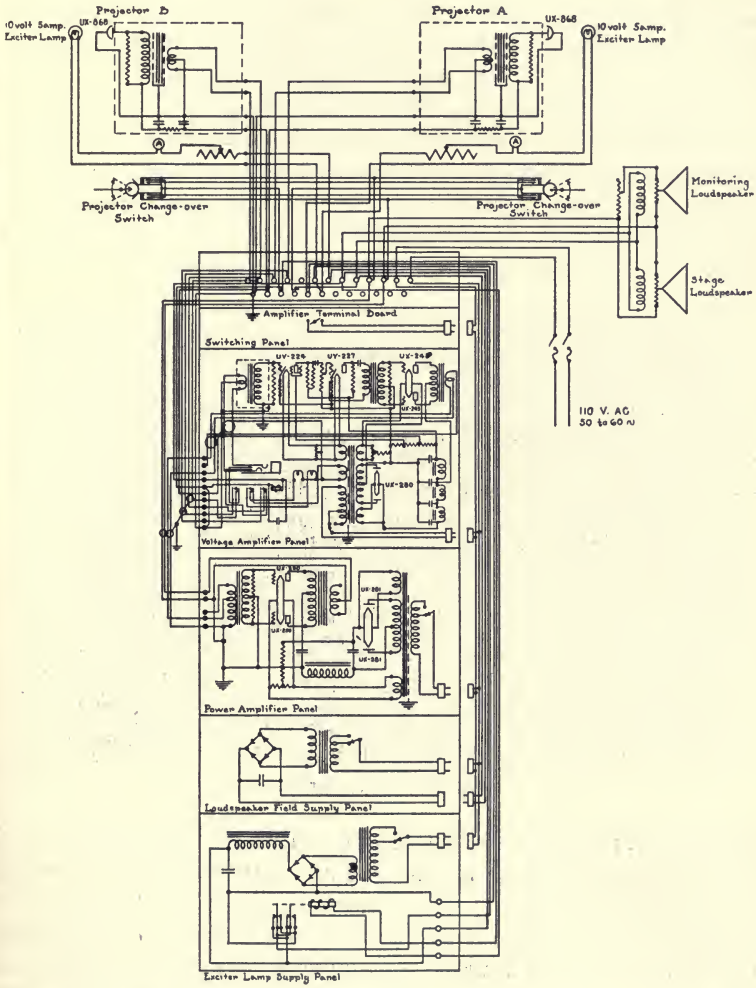
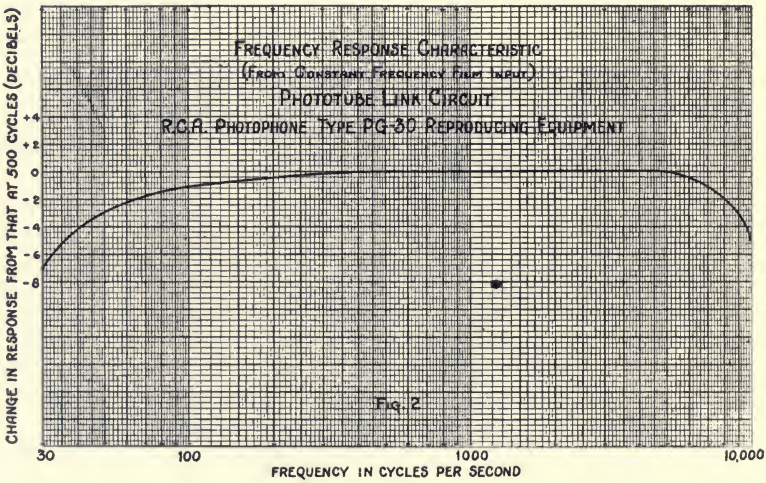


FIG. 1. Schematic circuit diagram of RCA Photophone reproducing equipment (PG-30).

for sound-on-film reproduction, but if sound-on-disk reproduction is required, the synchronous disk drive mechanism may be added to the sound attachment which is designed to accommodate it.

Fig. 1 shows the over-all schematic circuit diagram for this equipment. The two projector audio change-over switches shown in this figure are mounted upon the wall of the projection booth, each conviently located with respect to the projector near which it is mounted. Each of these switches controls the audio input and exciter lamp supply relays simultaneously during the projector change-over operation.

A shielded low-impedance "link" circuit is employed between the sound attachment of each projector and the reproducing amplifier. This means of conveying the photo-cell output to the amplifier has been found to have the advantages of avoiding the transmission of projector vibrations to the amplifier, of requiring only a few conductors between each projector and the amplifier, and of not requiring



special precautions for preventing the leakage of projector oil to it. Both the photo-cell and amplifier input transformers are of special construction to permit good frequency response. This was accomplished by reducing their leakage inductance and distributed capacitance to a minimum. A frequency response characteristic of this link circuit including the photo-cell, the photo-cell coupling transformer, and the amplifier input transformer is shown by Fig. 2. Fig. 3 shows an over-all frequency response characteristic of the complete equipment. Both of these characteristics were taken by using a constant-frequency film as "input" to the complete reproducing system.

SOUND ATTACHMENT (PS-16)

The sound attachment comprises two major sections, the film compartment and the photo-cell compartment. This arrangement is shown by Fig. 4.

The film compartment comprises a main case and a center plate which provide the mounting of the sound film gate assembly, the optical system, the exciter lamp, the constant-speed sprocket, the take-up sprocket, the sound-attachment drive shaft, the impedance roller, and the flywheel. The drive shaft is supported by two bearings and is located at the upper part of the film compartment on the driving side. This shaft is provided with the proper gears to permit its being driven from the picture head above, and to permit its driving

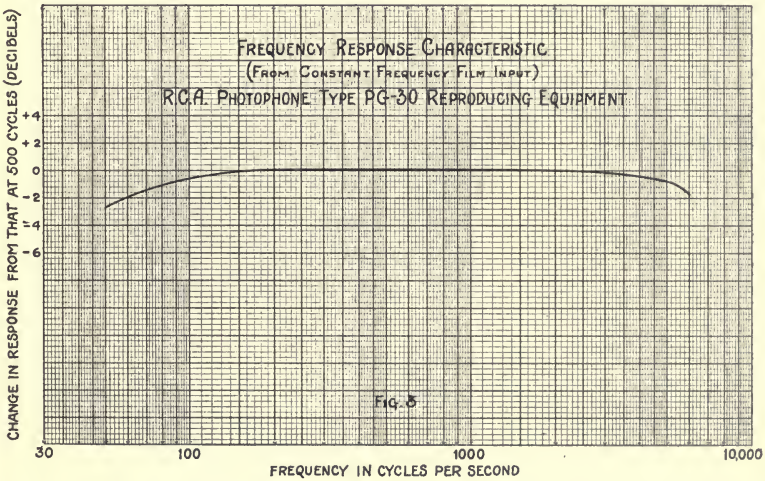


FIG. 5

the constant-speed and take-up sprockets through a suitable gear train. In addition, this drive shaft is provided with a pulley for driving the take-up magazine. The flywheel which is driven by the wrap of film around the impedance roller, a part of the flywheel shaft, is located on the driving side of the film compartment. The shaft supporting this flywheel is mounted in ball bearings located in a detachable bearing-housing in the center-plate casting. The exciter lamp, which is of the 10 volt, 5 ampere type, is mounted in a detachable and prefocusing type of socket attached to the center-plate casting. The optical system and the sound film gate are mounted upon the center-plate casting directly in front of the exciter lamp.

The curved surface of the sound film gate is hardened and polished to facilitate the smooth passage of film. The shoe-holder provides two spring-steel shoes which are adjusted by means of two tension springs. This design assures a constant normal pressure over the surface of contact and reduces wear. Adjustable guide rollers located at the top of the sound film gate maintain the sound track in its proper relation to the light beam. At the bottom of the sound film gate, an idler roller passes the film on to the impedance roller around which the film is wrapped. Below the guide roller is the constant-speed precision sprocket which pulls the film through the sound film gate over the idler and impedance rollers. The function of the im-

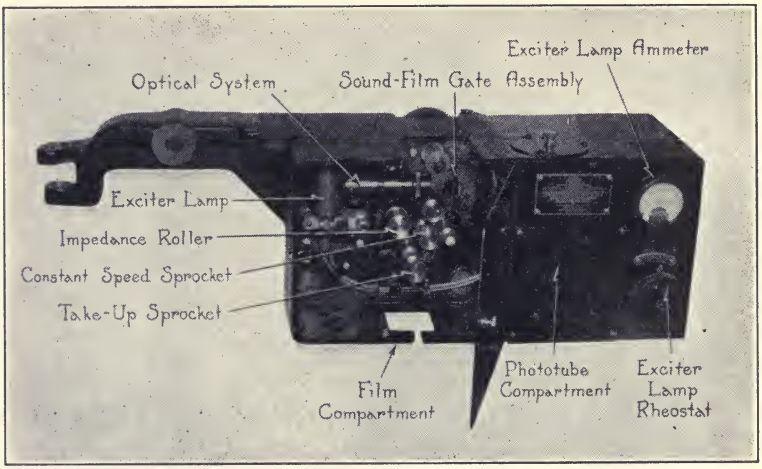


FIG. 4. View of type PS-16 sound attachment.

pedance roller is to impart mass to the film and thereby steady its motion. The take-up sprocket is located beneath the constant-speed sprocket, to prevent lower magazine reaction from affecting the constant-speed sprocket.

The path of the film through the film compartment of the sound attachment is shown by Fig. 5.

The photo-cell compartment houses a UX-868 Radiotron with its socket, a photo-cell coupling transformer, and an exciter lamp rheostat, and ammeter. The photo-cell coupling transformer is mounted upon sponge rubber inside a shielded case. The photo-cell socket is mounted directly on top of this case, thus keeping the connecting leads as short as possible and permitting them to be com-

pletely shielded against surrounding electrical fields. A cover plate is provided in the front part of the photo-cell compartment to permit the rapid removal of this transformer case whenever servicing should

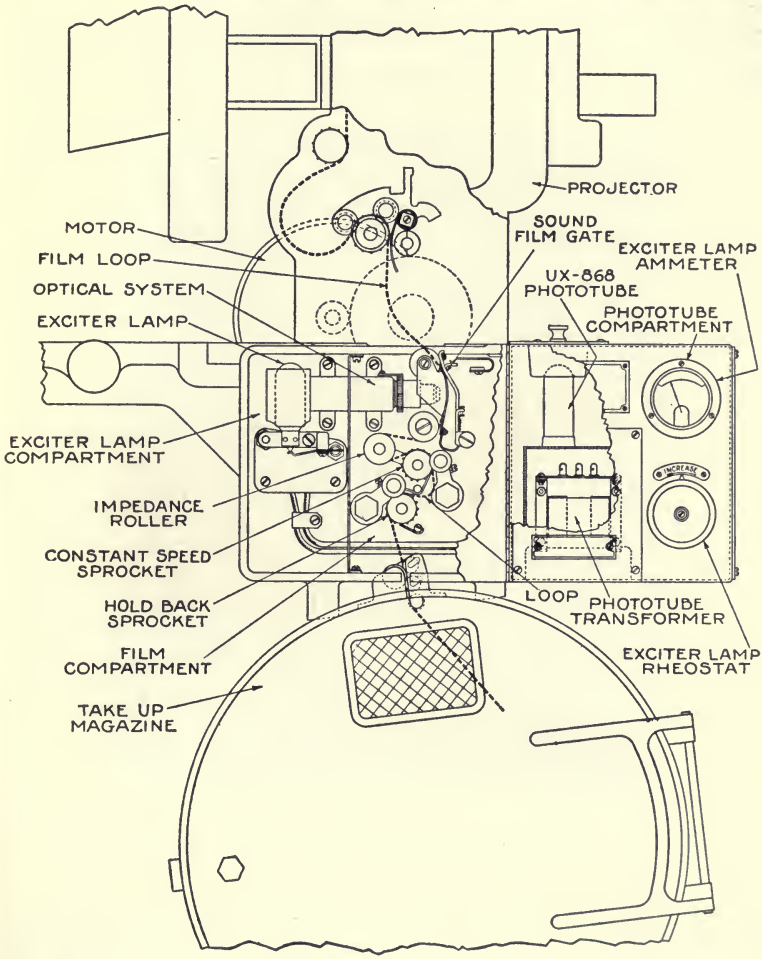


FIG. 5. View of operating side of sound attachment PS-16 showing the path of film.

require it. This is facilitated by making the terminal board a part of the transformer case. The exciter lamp ammeter and rheostat are mounted upon the front of the photo-cell compartment where they are readily accessible to the projectionist. Careful control of the

exciter lamp current by means of this ammeter and rheostat greatly increases the life of that lamp. Openings are provided in the bottom of the photo-cell compartment for the termination of the conduit from the projector change-over switch and the amplifier rack.

The UX-868 Radiotron is a caesium coated central anode type of photo-cell into which a small amount of inert gas has been introduced.

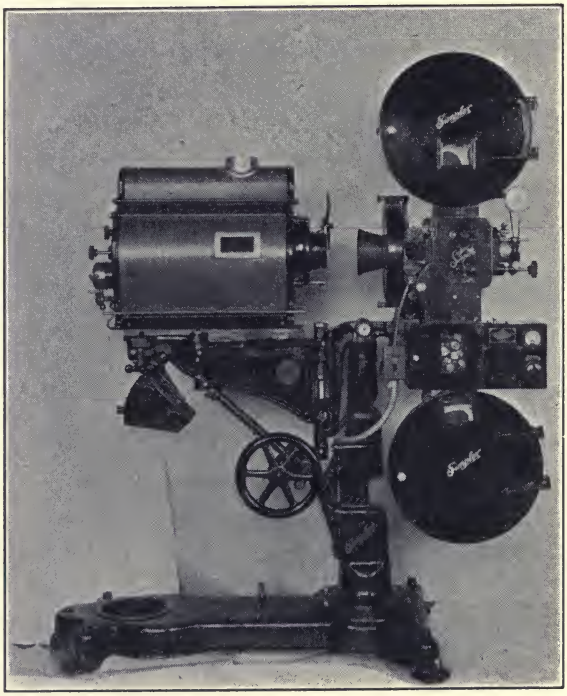


FIG. 6. View of super Simplex projector showing assembly of type PS-16 sound attachment.

The resultant gas amplification increases the sensitivity of this type of photo-cell by approximately ten times over that of a vacuum type caesium photo-cell. It is the high sensitivity of the UX-868 that makes it possible to employ a transformer-coupled link circuit, and thus obviate the necessity for preamplification of the photo-cell output before transmission to the main amplifier.

A view of the sound attachment assembled in a Simplex type pedestal is shown by Fig. 6.

REPRODUCING AMPLIFIER (PA-50)

The reproducing amplifier is of the rack type of construction as shown by Fig. 7 and Fig. 8. The several components comprising the assembled amplifier are mounted upon vertical panels which in turn are mounted upon the vertical rack. The order in which these panels are mounted upon the rack is as follows, from top to bottom:

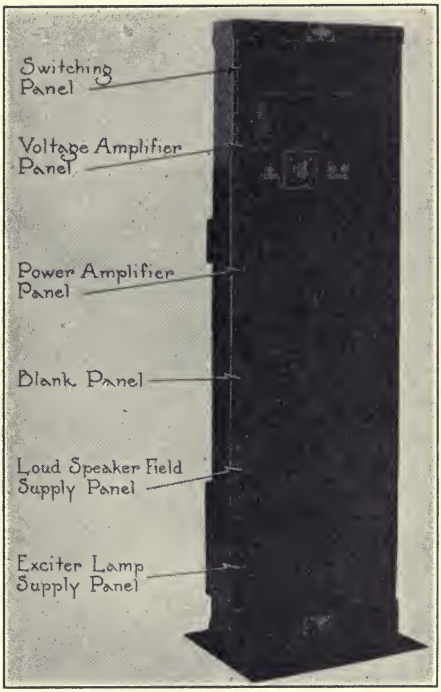


FIG. 7. Front view of type PA-50 reproducing amplifier.

(1) switching panel;
(2) voltage amplifier panel;
(3) power amplifier panel;
(4) blank panel;
(5) loud speaker field supply panel;
(6) exciter lamp supply panel.

All components of the voltage amplifier panel, the power amplifier panel, and the exciter lamp supply panel such as transformers, ca-

pacitors, reactors, *etc.*, are mounted upon vertical base panels with their terminals projecting through openings in the panels so as to permit their being wired together. These parts, particularly the transformers and reactors, are housed in metal containers so constructed as to properly shield them both magnetically and electrostatically, and thus serve as an aid in minimizing output hum. The base panels are then mounted upon the rear flanges of the rack channel in such a

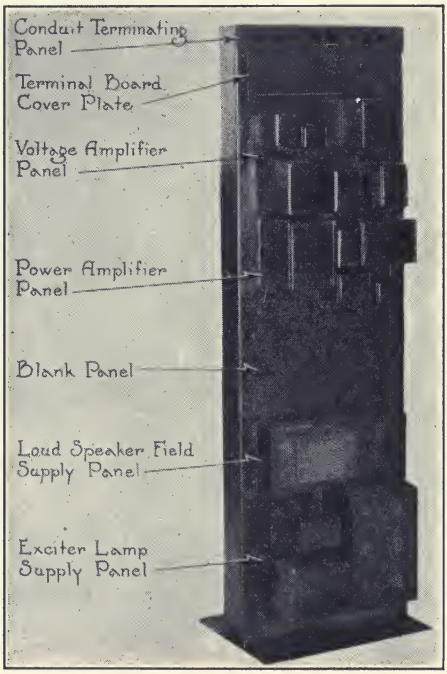


FIG. 8. Rear view of type PA-50 reproducing amplifier.

manner that they are removable from the front of the rack, as may be seen by Fig. 9. Handles are provided on these base panels to facilitate their removal by way of the front of the rack. Since the wiring of the panels is done upon the front and since they are removable through the front of the rack, the assembled reproducing amplifier may be mounted closely to the wall of the projection booth. Whenever servicing is necessary it may be done from the front without removing the rack from its normal location. In all cases except

that of the loud speaker field supply panel, front panels are mounted upon the front flanges of the rack channel independently of the mounting of the base panels. The voltage and power amplifier front

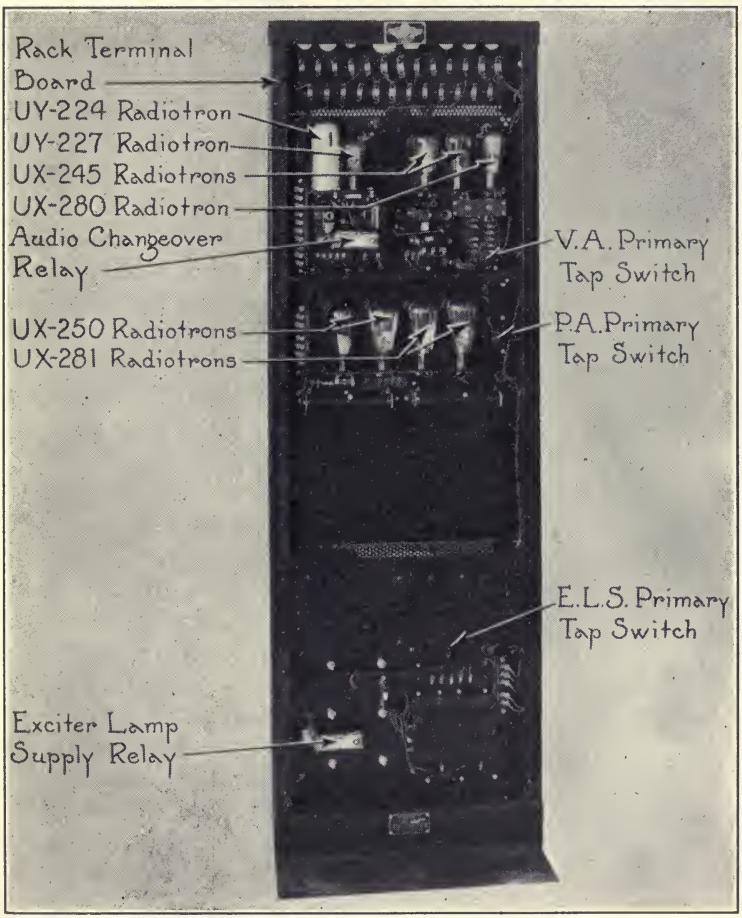


FIG. 9. Front view of type PA-50 reproducing amplifier (front panels removed).

panels are in two sections, the one removable by means of thumb screws for changing tubes, and the other removable by means of machine screws only whenever servicing is necessary. This arrangement is shown by Fig. 10.

Upon all of the panels except the switching panel, a power transformer primary tap changing switch is provided to assure operation of the amplifier within the power supply voltage limits for which it is designed, namely, 105 to 125 volts. The undistorted power output of this amplifier is approximately 9.0 watts, an amount which amply provides the required sound distribution for theaters having seating capacities of 1000 and less. A frequency response characteristic of this amplifier is shown by Fig. 11.

FIG. 10. Front view of type PA-50 reproducing amplifier (tube changing panels removed).

The switching panel mounts directly in front of the rack terminal board and is removed during installation to permit the conductors emanating from the conduit to be terminated at this terminal board. This switching panel mounts an "on-off" switch which controls the a-c. power input to all the panels of the rack.

The voltage amplifier panel is a three-stage audio amplifier and as such is complete with its own "A," "B," and "C" current supply. In addition, this panel provides polarizing voltage for the photo-cell in each sound attachment. The first stage of this amplifier is a UY-224 Radiotron coupled by means of an input transformer to the photo-cell "link" circuit heretofore described. The second stage is a UY-227 Radiotron coupled to the first stage by means of resistance and capacitance. The second stage is in turn coupled to a UX-245 Radiotron push-pull stage by means of a resistance, a capacitance, and an interstage transformer. The UX-245 Radiotron stage is followed by an output transformer which is designed to operate into the power

amplifier panel to be described later. The current requirements for each of the audio stages of this amplifier, as well as for each of the two photo-cells in the sound attachments, are provided through a UX-280 Radiotron full-wave rectifier followed by a three-stage inductance-capacitance filter system. All filaments and heaters including those of the projector change-over indicating lamps receive their current from secondary windings of the power transformer. The sockets for all tubes are mounted upon shelves attached to the amplifier panel proper, so as to permit their operation in a vertical position. Near the center of this amplifier a manually operated volume control is located. It is so designed as to permit a change of 40 decibels in volume. A space is

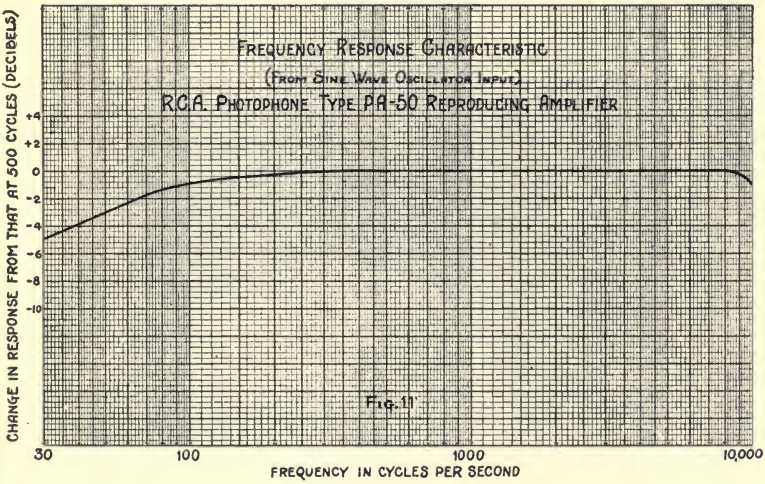


FIG. 11

provided between the UY-227 and UX-245 Radiotron stages and convenient to the manually operated volume control, to permit the installation of a remotely operated volume control wherever desired. The projector audio change-over relay and its two indicating lamps are mounted upon this amplifier. This is an advantageous location for this relay in that it makes the audio input connections as short as possible.

The power amplifier panel is a single-stage audio amplifier and like the voltage amplifier panel, is complete with its own "A," "B," and "C" current supply. The amplifier of this panel is comprised of the two UX-250 Radiotrons connected in push-pull. These two tubes are coupled to the output of the voltage amplifier panel by

means of an audio inter-stage transformer, and to the stage loud speaker by means of an audio output transformer. The current for this audio stage is provided by two UX-281 Radiotrons connected for full-wave rectification and followed by a single stage of inductance-capacitance filtering. The filaments of both the rectifier and amplifier tubes are heated by secondary windings of the power transformer. The sockets for all four of these tubes are mounted upon a shelf attached to the amplifier panel proper, thus permitting their operation in a vertical position. As may be noted by referring to Fig. 7-10, a blank panel is provided directly beneath the power amplifier panel. This is provided for the addition of a second power

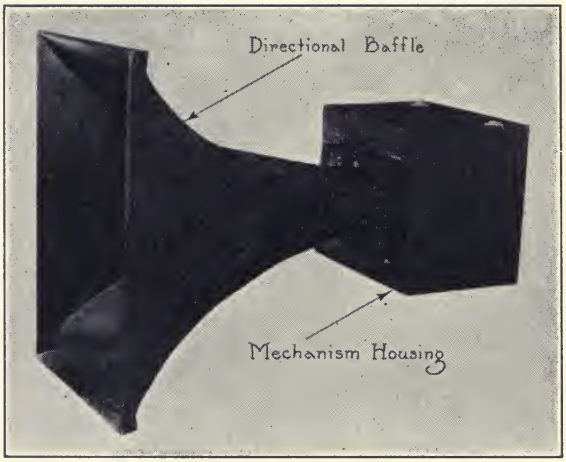


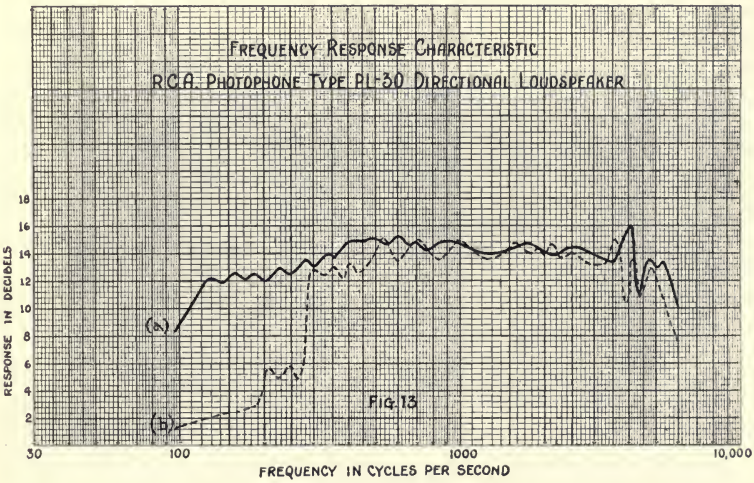
FIG. 12. View of type PL-30 stage loud speaker.

amplifier panel in installations having seating capacities somewhat in excess of 1000 seats, where greater undistorted power output is needed to provide the required sound distribution.

The loud speaker field supply panel, as its name implies, provides field excitation for the stage and monitoring loud speakers. It is comprised of a power supply transformer, four stacks of copper oxide rectifier disks connected for full-wave rectification, and a filter capacitor. This circuit provides excitation voltage to the projector audio change-over and exciter lamp supply relays in addition to that for the stage and monitoring loud speakers. All the components of this unit are mounted upon a vertical panel which in turn mounts

upon the two front flanges of the rack channel. In order that the rectifier unit may receive the proper circulation of air to limit its temperature rise to the value for which it was designed, namely, 15°C., a perforated cover is provided.

The exciter lamp supply panel furnishes excitation voltage to the filament of either exciter lamp. It is comprised of a power supply transformer, six stacks of copper oxide rectifier disks arranged for full-wave rectification, a single stage of inductance-capacitance filtering, and a change-over relay. As mentioned above, this relay receives its energizing voltage from the loud speaker field supply panel. Its contacts are arranged in the circuit of this panel so as to switch the



exciter lamp voltage supply simultaneously with the voltage amplifier input, by means of the projector audio change-over switch, from one projector to the other. A perforated metal screen is provided around the rectifier unit to permit ventilation.

STAGE LOUD SPEAKER (PL-30)

The stage loud speaker is of the electrodynamic type provided with a six-inch cone and a directional baffle. Fig. 12 shows a view of this loud speaker in completely assembled form. Recent improvements in the design of the cone of this loud speaker have increased its efficiency and extended its response in the frequency range from approximately 4000 to 6000 cycles.

In well designed theaters, a 50-inch directional baffle is employed. This combination has a frequency response characteristic as shown by (*a*) of Fig. 13. In poorly designed theaters where reverberation or other low-frequency acoustical difficulties are encountered, a 27-inch directional baffle is employed to obtain the proper intelligibility of speech in that type of theater. The frequency response characteristic of the stage loud speaker with the shorter baffle, is indicated by (*b*) of Fig. 13. In theaters having small seating capacities, this shorter directional baffle has the advantage of requiring a smaller space. The field winding of this loud speaker obtains its magnetizing voltage from the loud speaker field supply panel described under the reproducing amplifier above.

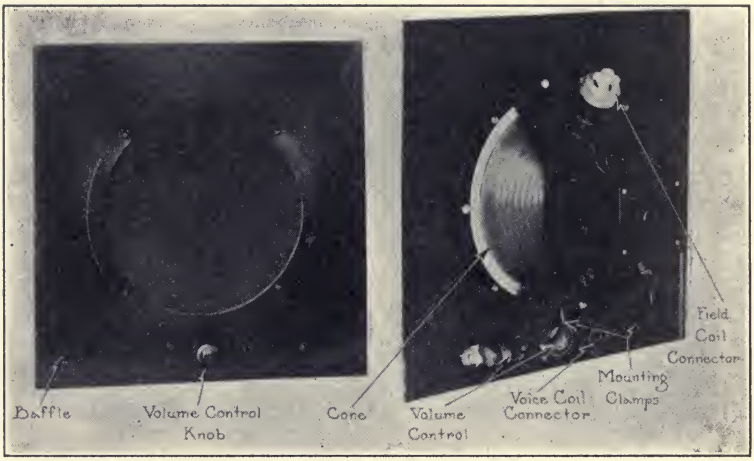


FIG. 14. Front and rear views of type PL-34 monitoring loud speaker.

MONITORING LOUD SPEAKER (PL-34)

The monitoring loud speaker is of the electrodynamic type provided with an 8-inch cone and a square flat baffle. Mounted upon the baffle is a volume control and an audio input plug. This loud speaker is mounted by two pipe clamps. Fig. 14 shows a front and rear view of the assembly. The field winding also receives its magnetizing voltage from the loud speaker field supply panel.

THE MERCURY ARC AS A SOURCE OF INTERMITTENT LIGHT*

HAROLD E. EDGERTON**

Summary.—*The possibility of using intense intermittent light for motion pictures and special photography is discussed. Physical limitations of sources of intermittent illumination are reviewed. The characteristics of the mercury-arc thyratron which give it advantages as an intermittent light source are enumerated, viz., (1) the light is photographically actinic; (2) the duration of a light flash can be made less than ten microseconds; (3) the light intensity is high; (4) the frequency of flash is easily and accurately controlled by means of a grid. An example of the use of intense intermittent light is given, showing how stroboscopic motion pictures of the angular transients of synchronous motors are taken.*

Motion pictures are ordinarily taken by means of a mechanical mechanism that stops the film intermittently on each frame and then opens a shutter. The shutter can be eliminated if the light is intermittent and in phase with the film so that the light is on only when the film is stopped. With a light of very short duration but of high intensity it is possible to run the film at continuous speed, the limitation being that the film must not move an appreciable distance while the light is on. Framing by this method is accomplished by flashing the light at time intervals determined by the speed of the film so that the pictures do not overlap and are not spaced too far apart.

Another application of intermittent light for motion pictures is the possibility of taking slow-motion pictures of rapidly moving machines or mechanisms. This is conveniently done by arranging the frequency of the light so that it differs slightly from the frequency of the mechanism. For each exposure the mechanism will have gone through its entire sequence of events plus an increment. The apparent motion of the projected mechanism is then at a frequency which is the difference between the light and mechanism frequencies.

Practical difficulties and physical limitations in the past have imposed restrictions on the production of flashing intermittent light by ordinary methods. Neither the incandescent nor the carbon arc

* Presented at the Spring, 1931, Meeting at Hollywood, Calif.

** Massachusetts Institute of Technology.

can be induced to give intense light flashes of short duration since their illumination depends upon the temperature of a filament or an arc. Both of these lamps can only change their illumination qualities slowly because of the heat capacity of the incandescent parts. The efficiency of an alternative arrangement using a shutter or a rotating

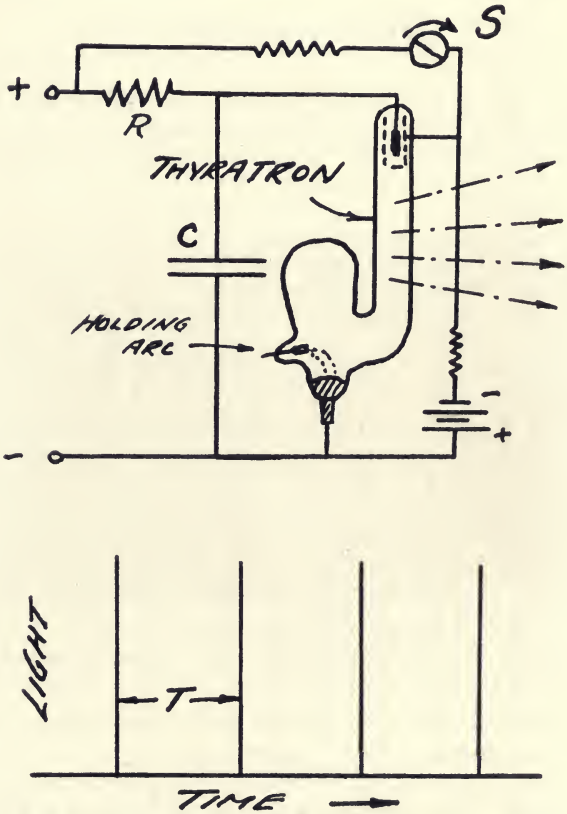


FIG. 1. Electrical circuit which affords a source of intense intermittent light of high actinic value. The lower figure shows how the light intensity varies with the time.

disk with slots is poor since the light needs to be operated at full brilliancy all the time. There are also mechanical limitations upon the speed of the shutter or the disk due to vibration and stresses.

Light sources that obtain their illumination qualities from electrical discharges in gases, such as neon or mercury, have practically no time

lag when turned on or off. The neon tube, because of this property, has been used for television and for stroboscopic observations. However, the light from the neon discharge is mainly red and is not very effective for photographic uses. Intense sparks in air have been used successfully for rapid photography but the auxiliary apparatus is generally bulky because of the necessary high voltage and, moreover, the control of the discharges is difficult.

The familiar mercury-arc lamp, slightly modified, can quite readily become an intense source of intermittent light if connected to the proper electrical circuits. The light from the mercury-arc consists mainly of strong violet and blue colors which are very actinic.*

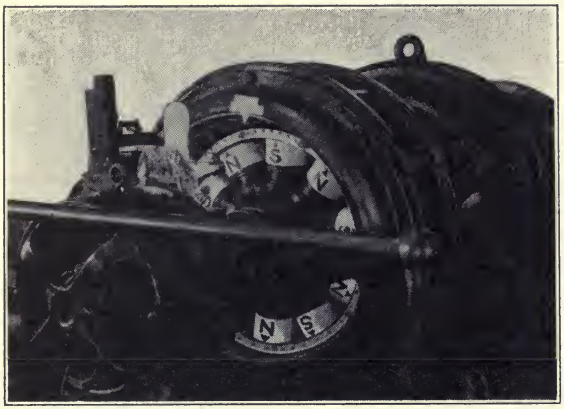


FIG. 2. Photograph of a large synchronous motor arranged with a thyratron source of intense stroboscopic light for taking motion pictures of the angular transients of the rotor.

One of the remarkable properties of this type of light is that it can be made to give a flash in less than ten microseconds. Another is that the instantaneous intensity is a great many times that of the normal rating of the tube so that the average light compares with that of continuous operation. A fourth property is that the time between the flashes is easily controlled by means of a grid. These characteristics give the mercury-arc thyratron some interesting possibilities

* A spectroscopic study of the time distribution of the radiation by means of Professor D. C. Stockbarger's synchronously rotating drum spectrograph (described in the *Review of Scientific Instruments*, April, 1930) shows that the majority of the actinic light is between 3660 and 4348 Å for the flash.

as a practical intermittent light source. "Thyratron" is the name that has been given by the General Electric Co. to gas-filled arc discharge tubes that have control grids.

The elements of an intermittent mercury-arc thyratron light source are sketched in Fig. 1 together with a plot of the variation of light against time. The condenser, C, builds up a charge through the resistance, R, from a d-c. supply while the grid is negative with respect to the cathode. At the moment the switching arrangement, S, makes the grid positive the anode begins to conduct and the tube practically acts as a short circuit to the condenser. The time for this discharge is determined by the characteristics of the thyratron and also by the resistance and inductance of the wires that connect the condenser to the tube. From a practical standpoint the time for the discharge is negligible for most purposes. When the switch, S, opens, the grid gains control and the condenser accumulates a charge for the next flash. The time between flashes, marked T on Fig. 1, is determined entirely by the speed or frequency of the switching or tripping arrangement and is adjustable over rather wide limits. The switching arrangement may be either a mechanical make-and-break or a source of alternating voltage such as a vacuum tube oscillator.

STROBOSCOPIC MOTION PICTURES OF SYNCHRONOUS MACHINES

The particular problem to which the use of flashing intermittent light has been successfully applied is the stroboscopic photography of the angular displacement of a synchronous motor. Motion pictures of the rotor were taken while a motor pulled into synchronism after having been started as an induction motor.

The rotor of a running synchronous motor, when observed with intermittent light of the same frequency as the alternating current which drives the motor, appears to be stationary, since the poles are in exactly the same position when the flash of light occurs. However, when the load on a synchronous motor is changed the poles must drop back in phase to supply the required torque and this angular shift is observed when the rotor is illuminated by means of stroboscopic light. The rotor usually oscillates about its final steady operating angular position, eventually stopping there.

Observations of such motional transients of synchronous machines have been made by means of neon stroboscopes but accurate readings of the position of the rotor cannot be made when the rotor is rapidly changing its position. The intense intermittent light of the mercury-

arc thyratron tube that has been described has made it possible to take such readings by means of motion pictures.

Fig. 2 shows a synchronous motor together with a thyratron tube so that stroboscopic motion pictures can be taken. The poles are surrounded with white cardboard in order to be photographed more easily. This motor rotates at 720 rpm. and its rotor is about four feet in diameter, so that the periphery is traveling at a speed of about 9000 feet per minute or approximately 100 miles per hour. The camera is placed about three feet from and perpendicular to the rotating periphery. For a satisfactory photograph the rotor must not move more than 0.02 inch for the exposure. Knowing the velocity of the rotor, it is possible to calculate the necessary duration of the light, thus:

$$0.02 \div \frac{9000 \times 12}{60} = 11 \times 10^{-6} \text{ seconds}$$

or about 10 microseconds. If the film is to be properly exposed in this short time the mercury-arc tube must produce a powerful light. As a very approximate calculation consider that a 50-watt incandescent lamp would give an equivalent exposure if placed in the same position while operating continuously. The stroboscopic illumination necessary in ten microseconds to give the same average light is that of an 83,000-watt lamp. For this calculation the frequency of the light flashes has been taken to be sixty times per second.

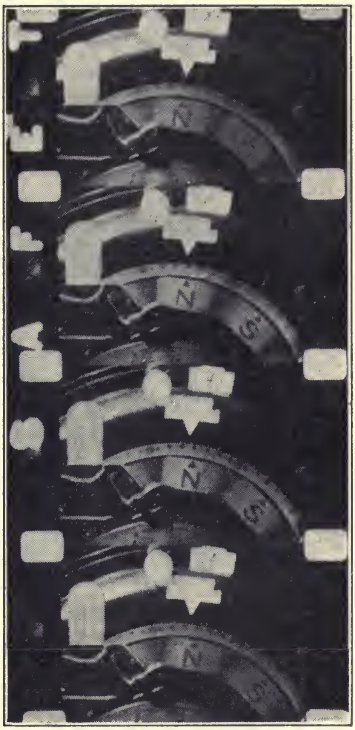


FIG. 3. Four enlarged 16 mm. motion picture frames taken while the motor was running. A change in the phase of the pole is noticeable between frames.

The switching arrangement for these stroboscopic tests was a transformer connected to the stator. The secondary voltage of the

transformer was made sufficiently high so that the discharges were regularly timed.

The ideal way to take motion pictures by means of intermittent light is to synchronize the light and the camera so that the flash of light occurs when the shutter is open. Such an arrangement requires for this problem a camera driven by a synchronous motor at 60 frames per second. However, it is possible to take satisfactory pictures at 16 frames per second and depend upon the random coincidence of an open shutter and a light flash to occur at the same time. Actually the shutter for this case is open about 0.033 second and during this time the light will flash once or possibly twice. Since the angular period of the synchronous motor is slow, about one cycle per second,

FIG. 4. A still photograph of the motor while running at synchronous speed (approximately 100 miles per hour on the surface) to show the definition that is possible by the rapid exposure of the light flashes. The accurate timing of the light flashes by means of the grid is also demonstrated in the photograph since several hundred flashes were used to expose the plate.

a double exposure on one frame shows the pole in practically the same position for both. The double exposure does not result in enough difference in density to cause any appreciable effect upon the projected pictures.

Four enlarged 16 mm. frames are shown in Fig. 3. They were taken on panchromatic film with an Eastman Ciné Kodak having a lens speed of $f/1.9$. The synchronous motor was rotating 720 revolutions per second when these were taken and the change in phase of the rotor between successive frames is clearly shown. From the

sharpness of the pictures, the exposure must have been less than about ten microseconds. These movies were taken from a 100-foot reel that recorded the pulling-into-step transients of a synchronous motor just as it reached synchronous speed following the starting period. They were used to illustrate a paper upon the pulling-into-step problem that was presented to the American Institute of Electrical Engineers at New York in January, 1931.

THE PHOTOFLASH LAMP*

R. E. FARNHAM**

Summary.—*The first part of the paper discusses the general design of the Photoflash lamp, its operating characteristics, and the quality of its light. The second part deals with the design of reflectors for efficiently utilizing and directing the light. The manner in which the lamp is used, number of lamps necessary, and their placement are explained. The application of the Photoflash lamp to the motion picture industry is discussed briefly.*

To secure an adequate quantity of photographically active light, of such a nature as to permit relatively accurate control, has been an outstanding problem of the photographic profession. Daylight, the only source available during the earlier period of photographic history, still serves the art well. Artificial light sources such as incandescent lamps, carbon arcs, and gaseous conductor lamps, which have been subsequently developed, give the photographer more flexible lighting facilities, and have made him independent of weather conditions and time of day. However, they impose upon him the need of an adequate supply of power. To give the photographer an absolutely self-contained light source advantage has been taken of the large amount of light evolved during the rapid oxidation of certain forms of magnesium and aluminum as well as some other substances. Since this combustion process occurs with great rapidity, one-tenth of a second or less, these flash sources usually take care of the timing of the exposure as well as furnishing the necessary light. When the action being photographed is so rapid that the flash duration is incapable of "stopping" it, devices which synchronize the operation of a high speed shutter and the flash are employed.

THE PHOTOFLASH LAMP

The Photoflash lamp is a recent development in sources of the flash type. In its present form it is similar in shape and size to a 100-watt incandescent lamp. The clear glass bulb contains several sheets of

* Presented at the Fall, 1930, Meeting at New York, N. Y.

** General Electric Co., Cleveland, Ohio.

thin aluminum foil and a quantity of pure oxygen, which constitute the elements entering into the combustion. A short incandescent lamp filament of 1.5 volt rating, covered with an ignition material, is placed within the mass of the foil and serves to start the flash when heated by an electric current. The purpose of the ignition material is to accelerate the start of the flash and assure the operation of the lamp, whether or not the foil is in contact with the filament. Fig. 1 shows the lamp before flashing and Fig. 2 shows it after flashing, the aluminum oxide covering the interior of the bulb.

As the usefulness of the lamp is limited to a single flash, it matters little whether or not the filament is burned out, hence the lamp can

FIG. 1. The Photoflash lamp before flashing.

FIG. 2. The Photoflash lamp after flashing.

be operated on any voltage from 1.5 volts to 125 volts. To prevent the possibility of an arc forming when lamps are flashed on 115-volt circuits, a fuse has been incorporated within the base. Since the light given off depends on the amount of foil and oxygen, it is unaffected by the voltage employed to flash the lamp.

Fig. 3 gives an approximate representation of the light output during the period of the flash. It will be noted that the greater part of the light is given off during a relatively small part of the total flash duration. Ninety-five per cent of the light is emitted within a period of about one-fiftieth of a second. Although the light intensity reaches a peak value of between four and one-half and five million

lumens, the average rate of emission of light is about 2,250,000 lumens.

The shape of the light-output curve lends itself particularly well to use with high-speed camera shutters operating synchronously with the flash and the present commercial flash lamps are sufficiently uniform in their performance to insure reasonable success with these devices.

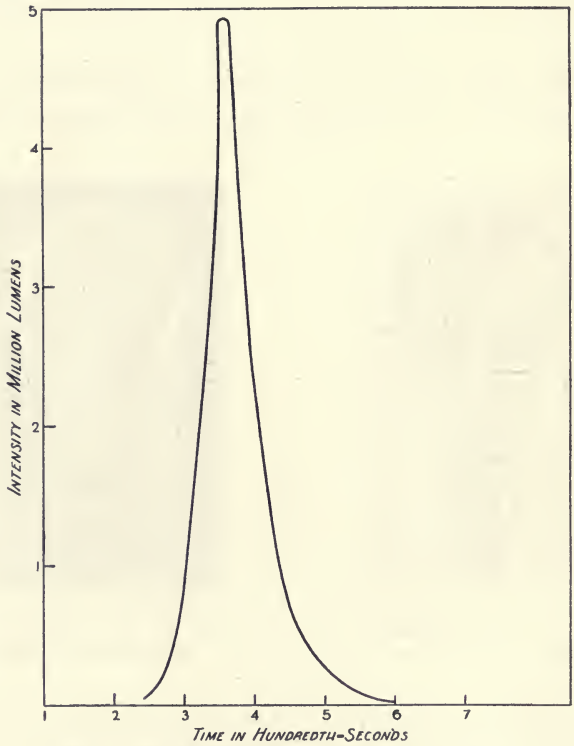


FIG. 3. Time-intensity distribution of radiation from Photoflash lamps.

Where the light of a single lamp is insufficient, any number required to secure adequate light may be operated simultaneously on the same electrical circuit.

The visible and infra-red energy emitted by the lamp is sufficient to flash other lamps immediately adjacent. Advantage has been taken of this phenomenon in several commercial equipments where it is desired to increase the light output from a single reflector above

that available from one lamp. The additional lamps are attached to the rim of the reflector by means of special socket clips so that the bulbs are within one-half inch of the lamp at the center of the reflector, but have no electrical connection with the flashing circuit. When the center lamp is flashed the others flash as well. The light output of a lamp operated in this manner is the same as if it had been flashed electrically.

Preliminary measurements of the spectral energy distribution of the light of the Photoflash lamp show that its spectrum is a continuous one through the near ultra-violet and visible range, and approximates a black-body radiator at 5000°K. Since the high efficiency filament lamps operate at a temperature of 2950°K. to 3150°K., the light of the flash lamp contains relatively more violet, blue, and green than the same amount of light from incandescent lamps. There is an increasing amount of yellow, orange, and red components so that, while the light of the Photoflash lamp is very effective with photographic materials of limited sensitivity, it is particularly well adapted to panchromatic emulsions.

PHOTOFLASH EQUIPMENTS

As the combustion which produces the light flash is confined entirely within the bulb, the flash lamp can be considered a spherical light source approximately three inches in diameter. This makes it particularly applicable to reflecting equipment both from the standpoint of light control and freedom from corrosive action on the reflecting surface.

An analysis of various camera lenses shows that all, except the wide-angle types, include a field of forty-five degrees or less. As the lighting equipment is usually placed approximately the same distance from the subject as the camera, we are primarily interested in the light distribution within a spread of sixty to seventy degrees, allowing a factor of safety in aiming the reflector.

Fig. 4 illustrates the desirable light distribution of reflectors for the majority of Photoflash lamp applications. The "spill" light, or light outside of the sixty-degree spread, is of secondary importance as it can only reach the subject by reflection from the walls and ceiling. Hence its intensity is low as compared to that coming directly from the lamp and reflector. Furthermore, the walls and draperies are usually of warmer tones so that the reflected light is of reduced photographic value.

When wide-angle lenses are employed the area being photographed is usually of such size that several lamps are necessary and the greater spread of light is obtained by aiming the reflectors so as to uniformly illuminate the field covered by the lens.

Because of the relatively large size of the light source of the Photoflash lamp, polished reflecting surfaces in the smaller reflectors

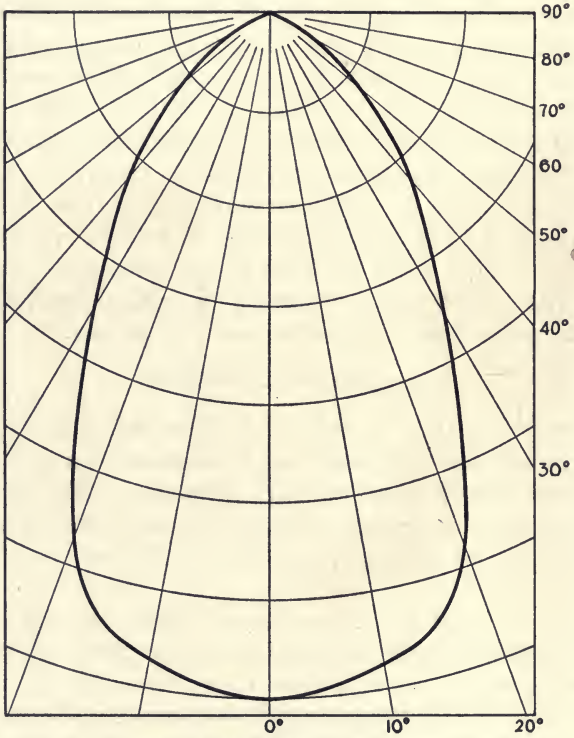


FIG. 4. Desirable light distribution from Photoflash lamp reflectors.

(up to 12 inches) and semi-matte surfaces in the larger reflectors (beyond 12 inches diameter) are necessary to give the desired light control. Polished and semi-matte aluminum and polished chromium plate have proved to be very satisfactory. They are relatively inexpensive to produce, rugged, light in weight, and they maintain their initial reflection efficiency over long periods.

A modified paraboloid gives the most uniform distribution through

the 60-degree spread and the deep type of reflector, such as shown in Fig. 5, is recommended because of its high utilization efficiency.

Fig. 5 illustrates a portable hand unit with medium-sized reflector. Two standard flashlight cells contained in the handle operate the lamp. The switch employed with all Photoflash units should be of the spring type so that it is not possible to leave them turned "on" and thus flash a lamp as it is being screwed in the socket.

There are also available semi-portable Photoflash equipments for general applications both in and out of the studio which employ a

FIG. 5. A portable hand unit of good design, operated by flashlight cells.

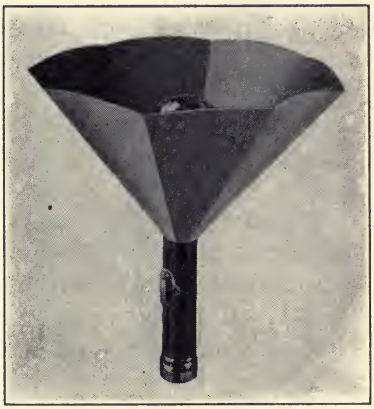


FIG. 6. An inexpensive flash lamp reflector, of good efficiency that can be folded into a small space, designed particularly for the amateur photographer.

reflector similar in general design to that shown in Fig. 5 but mounted on a light-weight folding tripod. This unit can be operated singly or any number of them can be flashed simultaneously by closing a single switch. The power can be obtained from the 115-volt lighting circuit, storage battery, or dry cells. Reflectors similar to that shown in the illustration, but with suitable provisions made for hanging them on the walls or balcony rails of assembly rooms, are employed to photograph large groups and assemblies. A connecting cable with suitable outlets spaced ten to twelve feet apart permits

simultaneous flashing of all of the lamps by means of a push-button held by the operator at the camera.

Photoflash equipments designed particularly for portrait work both in and out of the studio should include a standard filament lamp to permit the photographer to judge his lighting of the subject and to focus. In addition to this, several equipments incorporate a device that opens the camera shutter and flashes the lamps by a single pressure on the bulb or cable release.

APPLICATION OF THE PHOTOFLASH LAMP

The Photoflash lamp is used in a manner similar to any other artificial illuminants in making pictures. For photographing individuals or small groups a single lamp in a reflector is held above and to one side of the camera. A reflecting screen or a second lamp farther from the subject than the first and placed on the shadow side serves to illuminate the shadows and soften the contrasts.

Large groups covering a greater area require several lamps. A good rule that is well borne out by experience is to use one lamp in a reflector for every 200 square feet of floor area. This assumes the lens operating at $f/16$, medium colored walls and ceiling, and normal panchromatic film. The negatives obtained are of good average density. If the lens can be operated with larger aperatures fewer lamps will be required, and, conversely, where a smaller stop opening is necessary the number of lamps must be increased. The faster panchromatic films recently made available permit the number of lamps to be reduced by one-half.

In photographing large assemblies such as banquet groups, with the camera in an elevated position, the lens can be tilted so as to sharply focus both the front and rear parts of the group. This permits lens apertures as great as $f/8$ and hence 800 square feet of floor space per lamp.

Newspaper photographers usually operate under such conditions that a lens aperture of the order of $f/4.5$ is practical and, with the fast plates employed for their work, one lamp supplies ample light for the majority of their pictures.

Similarly, in portrait work, both in the studio and outside, where lens apertures of $f/6.3$ to $f/4$ are common, a single lamp provides sufficient light although two lamps are often desirable to create proper modeling of the subject.

Nearly every branch of photography has found the Photoflash

lamp a valuable accessory to their lighting equipment and in a number of fields, such as banquet photography and in newspaper work, it has largely displaced older artificial illuminants. The amateur photographer, who seldom made pictures outside of daylight hours, now makes them when and where he chooses.

The Photoflash lamp finds several applications in motion picture work. The "still" photographer must frequently make pictures away from the studio, or under circumstances in which the regular studio lighting facilities cannot be employed, and the flash lamp proves particularly adaptable.

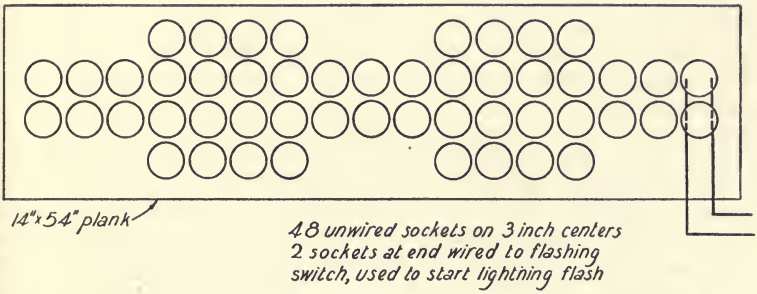


FIG. 7. A suggested arrangement of lamps to produce a lightning flash of a greater duration and intensity than a single lamp.

Artificial lightning of any intensity can be created by the flashing of a cluster of lamps. If a single lamp of the group is flashed electrically and the others by the energy received from the first lamp, the flash can be given greater duration and the chances of the camera shutter being closed at the time of the flash is eliminated. The lamps operate silently so that voices or other sounds can be recorded at the time of the flash. They may also be flashed under water.

The characteristics of the flash are such that the lamps may be used for signaling. A single lamp at the focus of a 24- or 36-inch diameter, polished mirrored reflector gives a concentrated beam of light of sufficient power to photograph objects several hundred feet from the lamp.

The Photoflash lamp has made it possible to take pictures in places heretofore forbidden to the photographer because of the element of danger or the general objections to the older flash sources.

DISCUSSION

MR. ROSS: Do you have data on the life of these lamps?

MR. FARNHAM: A number of lamps made a year ago performed as well as new lamps. Our experience covers only about a year and we don't know how lamps older than that will behave.

PRESIDENT CRABTREE: What happens if air is allowed to enter the bulb through a crack?

MR. FARNHAM: That has been very carefully investigated. As with all lamps there is a possibility of air finding its way into the bulb. If there is a limited amount of air in the bulb the lamp may fail. Air dilutes the oxygen and and the foil burns slowly.

We have a method of testing lamps by means of a high-frequency discharge device, which unmistakably shows the presence of air. Lamps are tested for slow leaks at the time of manufacture and several days later. Lamps showing the presence of air are destroyed. Cracks occurring in the lamps during shipment and subsequent handling are apt to be such as to admit enough air to make the lamp flash slowly.

MR. PORTER: One of the problems which has bothered photographers for some time is that of photographing high-speed machinery. While this has been done in the past with neon lamps, which are not very brilliant, it might be done by synchronizing the flashes with the object to be photographed.

DR. GAGE: If a lamp is flashed on 440 volts, would there be danger of arcing?

MR. FARNHAM: We've never tried flashing the lamp on 440 volts, but I believe the fuse wire in the base would function satisfactorily in case an arc tended to occur.

MR. EDWARDS: What is the cost of the lamps in comparison with that of flash powder?

MR. FARNHAM: The cost of the lamp is somewhat higher than that of flash powder for an equal quantity of light.

PRESIDENT CRABTREE: Are these lamps on the market? What is the price?

MR. FARNHAM: The lamps have been on the market since Sepetmber 1, 1930. The list price is twenty-five cents apiece.

MR. CUMMINGS: Has the lamp the same actinic quality as an open flash would have? Have any tests been made directing the flash against a strong light to prevent halation? For many years pictures have been made of individuals in offices and it is the practice to have strong daylight back of the object to obtain round lighting instead of full lighting.

MR. FARNHAM: I have seen a number of pictures taken toward windows and doors with strong daylight coming in and the lamps have given sufficient light to produce good high-lights on the sides of the objects away from the daylight. Good detail has also been obtained underneath tables, chairs, and in corners.

MR. CUMMINGS: What effect has the glass envelope on the light emitted by the lamps?

MR. FARNHAM: The glass used for the flash bulbs has a uniform transmission throughout the entire visible spectrum. Below 3500 Å, when the bulb glass no longer transmits, there is of course no light given off.

HAND-COLORING OF MOTION PICTURE FILM*

GUSTAV F. O. BROCK**

Summary.—This paper deals with the advantages of selective hand-coloring, as distinguished from more or less complete coloring and covers briefly the use of hand-coloring in educational, commercial, and theatrical pictures. Finally, a description is given of the equipment used for hand-coloring.

The most beautiful coloring for motion pictures, and the only coloring which will satisfy the audience is the imaginative coloring which each onlooker unconsciously adds to the perfected black-and-white picture of today. Any process of producing what is generally termed "natural color" and which up to the present time has been publicly demonstrated, has substituted for the beautiful imaginative coloring some more or less perfect color combinations, all of which are far from perfect and which detract considerably from the original beauty of the black-and-white picture, producing results comparable with those we were accustomed to see in the motion picture "stone age."

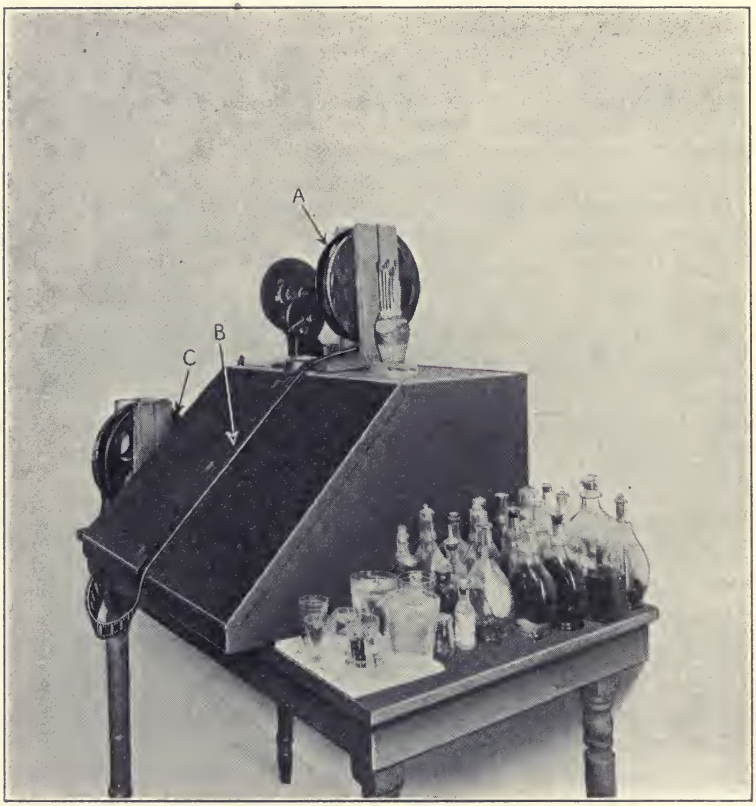
Until "natural color" processes shall have been perfected and until nothing, whether in beauty or realism, will have been sacrificed on substituting it for the perfect black and white, the use of color in motion pictures should be in accordance with the ideas expressed on coloring in general by S. R. Kent:[1] "It is a great thing if not overdone; it can only be applied to certain films. I would use all color in pictures only as an exception. Color should be used to enhance values only."

The greatest advantage of hand-coloring is that it can be applied to the finished production, of which various portions can be enhanced and important contrasts emphasized by coloring. For example, following the players from a frosty out-door scene into a heated room, the contrast between the two temperatures and the coziness of the room may be strongly emphasized by coloring the flames in the fire-place in the same manner as a Broadway scene at night is very much enhanced by the coloring of the electric signs. The

* Presented at the Spring, 1931, Meeting at Hollywood, Calif.

** G. O. Brock Organization, New York, N. Y.

advantage of not having to consider the question of color before the picture has been finished can be easily understood and appreciated by every producer from an artistic angle as well as from the commercial and economic angles. Another great advantage of hand-coloring is that it does not interfere with the beauty and perfection



Apparatus used in hand-coloring.

of the black-and-white picture. Aiding the black and white, the coloring serves to sustain and partially replace the imaginative coloring originally required.

Hand-coloring is equally useful and of value in educational, commercial, and theatrical motion pictures. To be brief, it is of interest to call attention to the advantages of showing in color the

safety device on a machine, the difference in the appearance of two or more families of birds or insects in an educational picture, or the exact color of a product, packing, or trade-mark demonstrated in a commercial picture. The advantage of hand-coloring as selective coloring in these instances is too obvious to demand further explanation. Yet, it is equally obvious that the use of hand-coloring may be of still greater importance in the theatrical motion picture as a means of sustaining the onlookers' imaginative coloring of the black-and-white picture.

Many things in life depend upon color for their complete conception. In order that screen pictures of these things may retain their realism and that the lack of color may not lead to an incomplete illusion or inaccurate imaginative coloring of the black-and-white picture, it is of great importance that certain of these things should be colored.

We may first mention flames which, by means of their colors, always impress themselves so dominatingly on our sense of sight that all other surrounding colors are reduced to half-lights and shadows. We see nothing but the flames and their colors, and on the screen white flames can never furnish the proper illusion. Here hand-coloring is imperative, because only by this means can a real illusion of flames be obtained.

It is obvious that the showing of an uncolored danger or stop-light only brings confusion to the audience, which, without the aid of color may imagine the white light as green indicating "go ahead," and misunderstand the whole story. Close-ups of the national colors, signal flags or where the text specifies "the green mask," "the famous sapphire," *etc.*, are but a few examples where color can be successfully used in order to emphasize or enhance the action in a picture.

None but light-emitting or reflecting bodies have color at night; it follows that the conception of color is much stronger at night than by day and night scenes showing light effects need color for realism (Broadway at night, torch parades, fire-works, bonfires, *etc.*).

In some instances hand-coloring may be used solely for artistic purposes. In these cases a combination of tinted or tinted-and-toned film with hand-coloring is preferable to black-and-white film, except for night scenes.

Hand-coloring of motion picture film is, as the expression indicates, the process of coloring motion picture film by hand, using special

brushes and water-diluted dyes. The brush must be large enough to hold sufficient paint for covering several frames at a time and for avoiding changes of color tone from one frame to another due to the evaporation of the water. At the same time, in order to properly take care of detail work, the brush must have the finest point imaginable. It must be sufficiently stiff not to bend when touching the film, permitting the artist to make the smallest point visible to the eye. For coloring larger surfaces other brushes are used, which should be soft enough to make an even spread quickly so that the film does not have time to absorb the paint in spots.

The dyes should be acid dyes and it is sometimes preferable to add citric acid or ammonia to the dilution in order to make the dye "take." Acid seems to be preferable to ammonia, which often reduces the force and brilliancy of the dye. Red, orange, and yellow colors are very easy to handle; green and greenish-blue demand more care in application; violet-blue and violet are difficult to apply; finally, as purple approaches the red it becomes easier to handle.

The coloring is applied to the emulsion side of the dry positive print, which can be processed and waxed before coloring. From a reel, *A*, placed on top of an enclosed box with an inclined front on which is a glass-covered opening, *B*, the length of the front and the width of the film, the latter is drawn over the glass, where it is colored and then drawn toward and rewound on another reel, *C*. Inside the box is an incandescent lamp, furnishing illumination which is diffusely reflected to the film by a white plane parallel to the glass-covered opening. A magnifying glass completes the equipment, although a projection machine using cold light, permitting single frames to be examined without overheating the film, is most valuable.

The most important feature to be considered in producing successful hand-colored pictures is the personnel. Without an excellently trained organization of responsible and skilled helpers, willing to contribute the utmost of skill in handling the brush, their nerves, their eyes, and all the stamina which the work in a half-darkened room with strong light reflected directly into their eyes through the film demands from the man who often has to work ten and twelve hours a day, the idea of coloring film by hand is a useless dream.

The time required for coloring film by hand naturally varies with the different jobs, but experience seems to show that 15 feet of film per hour is the average speed. Since the advent of the talking pictures, each color job contained in each reel of a picture has been delivered

for coloring in a thousand-foot reel. In order to color a scene twenty feet long in a picture of a release of 200 prints, the hand-color man will have to wind and rewind 200,000 feet of film and carry the responsibility for the proper handling of all that film, in addition to having to color it.

The main responsibility of the leader of the organization lies in judging instantly, from a preview of the picture, what could and should be done by means of hand-coloring so that the expected improvement due to the coloring can be obtained in the best, quickest, and most economical way, and so that the producer will get the most intelligent service for his money and be able to get the work done when he needs it. The leader also must color a print to be used as a sample for the helpers, and instruct the latter very minutely as to the details of the job.

At the present speed of releasing a picture the use of hand-coloring must be restricted to the most effective sequences in order to limit the footage to be colored. The coloring of a few hundred feet of film in each print is the limit for the average picture in order to keep up with the distribution. Consequently, the price for coloring of each print is negligible, compared with what is paid for all-color picture prints. The principal argument for the use of hand-coloring lies in this restriction; when intelligently used, there will be just enough coloring to permit the color to "talk," "explain," emphasize, and enhance the illusion which the picture is intended to create.

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RECORDING, RE-RECORDING, AND EDITING OF SOUND*

CARL DREHER**

Summary.—This paper deals with problems bordering between the artistic subject of editing sound film and the technical fields of recording and re-recording. The topics discussed are: characteristics of effective sound recording; functions of re-recording; sound effects—analogy with special-process photography; equipment for re-recording; choice of sound tracks in editing; sound dissolves; common faults of re-recording; personnel and organization for re-recording and sound editing. The purpose of the paper is to show how sound engineering, re-recording, and editing must be closely coördinated to give the desired emotional and artistic effect in the finished picture.

CHARACTERISTICS OF EFFECTIVE SOUND RECORDING

The principal characteristics of good recording in the motion picture field may be classed under two heads: (1) intelligibility of dialog; (2) naturalness, or acoustic fidelity to the original rendition.

Broadly considered, naturalness of recording and reproduction might be considered the sole aim of sound technic. From this viewpoint, naturalness would require intelligibility at least as good as in the original spoken rendition. Likewise, naturalness would require faithful reproduction of music. Actually, however, the problem of effective recording and reproduction of sound is not as simple as this. Since the reproduction of sound is an artificial process, it is necessary to use artificial devices in order to obtain the most desirable effects. For example, it is normal procedure to reproduce dialog at a level higher than the original performance. This may entail a compromise between intelligibility and strict fidelity. We may find it necessary to drop out some of the lower frequencies of speech when the volume is raised in reproduction in order to avoid "boominess," or the predomination of low-frequency tones. This is an artificial device to preserve intelligibility; properly used, however, it may enhance the illusion of natural sound reproduction for the audience.

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* Presented at the Spring, 1931, Meeting at Hollywood, Calif.

** RKO Studios, Hollywood, Calif.

In general, good reproduction requires a loudness level approximately equal to what a normal auditor would expect on the basis of his experience. It also requires reproduction of a band of essential frequencies. Finally, it requires freedom from distortion, such as frequency variations (flutter), generation of spurious harmonics through overloading, *etc.*, both in recording and reproduction.

Normally the latter requirements are well taken care of by high-grade, film recording equipment. The film runs through the machines at sensibly constant speed, obviating frequency irregularities. The microphone and amplifier transmission characteristics are such as to admit the desired frequency-band without permitting undue emphasis of any particular frequencies. Attenuation of high or low frequencies is effected in a purposeful manner and under controlled conditions.

There is, however, one factor in natural recording about which there is still a difference of opinion, namely, sound "perspective," or the correspondence of sound quality with the picture shown on the screen. It is agreed that a close-up picture requires close-up sound, that is, sound such as one is accustomed to hear from a nearby source without intervening obstacles. But as the source of sound in the picture recedes to a greater distance, there is no general agreement on the proper variation of sound quality at the same time. Some critics believe that close-up quality should be maintained even with a long-shot picture. More discerning observers are inclined to the view that the sound should in general follow the action, so that the loudness will decrease with increasing distance in the picture, but that, even at its minimum, the sound must be loud enough to be clearly understood if the action of the play requires it. (There are, of course, instances when a mere murmur of voices or certain intelligible lines standing out above unintelligible material are all that is required.)

For example, the use of sound perspective is indicated in a scene in which a woman overhears dialog which causes her to leave a room hurriedly. The camera, following the woman, travels around two corners, and at the same time the voices which frightened her are heard dying away as she gets farther away from the room. It would be natural for the recordist to drop the level rather sharply as the actress turns each corner, since such a variation in sound corresponds with reality. This would be taken care of automatically if the microphone dollies with the camera, but if this effect is not secured in the original recording, it may be simulated in re-recording.

Generally speaking, natural conditions on a set take care of a good deal of sound perspective and other artistic devices. For example, if the recordist attempts to get close-up quality with the average long-shot pick-up, he will run into excessive reverberation, camera noise, *etc.* He is, therefore, practically forced to drop to a lower sound level, thus minimizing these sources of interference and at the same time preserving a natural sound perspective.

It should be noted that in some cases failure to utilize sound perspective definitely weakens a production. A recent picture contained a scene in which a man addressed a large crowd from a high tower. A close-up track was made with the microphone at a distance of a few feet, and a long-shot track was made from a point in the crowd. Both tracks afforded good sound at the respective distances, but the cutter, lacking comprehension of the principles involved, matched the close-up track with portions of the long-shot picture. Thus the producer, who had spent a large amount of money in erecting a high tower, got the effect of magnitude only in the picture, and failed to secure it in the sound. As far as the sound was concerned, the tower might have been 10 feet high instead of 100 feet high. Had the long-shot sound track been used, the sound would have added to the effect of the picture and the money would have been that much better spent.

The elimination of film ground noise which is now in progress promises to be a powerful force in promoting natural recording.[1] With ground noise eliminated or materially reduced, it is possible to decrease the levels considerably without losing intelligibility. Noiseless recording thus tends to do away with the reckless gain control manipulation which has ruined the artistic effect of a good many well played scenes. Moreover, as explained under "Equipment for Re-recording," noiseless recording permits much greater flexibility in re-recording than has been possible heretofore.

FUNCTIONS OF RE-RECORDING; SOUND EFFECTS

Re-recording has been discussed in previous papers and need not be defined here.[2] Aside from such purely mechanical functions as transfer of sound from film to disk, re-recording may be resorted to for two general purposes: (1) to improve the quality of an original recording, as by change of levels; (2) to introduce sound material with greater effectiveness, or at less expense, than would be possible during the original recording.

Under the first heading we may include such changes as lowering levels that are too loud for pleasing reproduction, raising levels where the original track has been under-modulated, and reducing undesirable characteristics, such as boominess, *etc.* The technic of these operations is treated in greater detail later.

The addition of sound effects to a dialog track by re-recording is analogous to special-process photography. In special-process photography, foreground action is shot against a blank backdrop, a film background being supplied by artificial means. The artificial background does not appear until after the film is developed. The blue cloth against which the foreground action is photographed corresponds to the silent background of dialog in sound. In re-recording, any desired sound background may be supplied, just as in special-process photography any desired visual background may be supplied. In both cases, the device is primarily a matter of economy; the special process is justified by the lower cost. In sound re-recording an additional justification is found in higher quality than could be readily obtained by an original recording of the desired sounds.

In some cases, the special audible background can be secured *only* by re-recording. Assume, for example, that it is desired to introduce the call of a meadow lark behind open-air dialog between two lovers. It is readily possible to engage lovers for the purposes of the screen, but it would be difficult to secure the song of the lark at the proper time and place. It is easy, however, to obtain a meadow lark sound track and to re-record it back of the dialog at the precise intervals desired and with the exact loudness which will be most appropriate.

It is clear that the value of sound effects injected during re-recording depends largely on the availability of a complete library of sound-effect films. Such a library is collected in the normal course of work in any large picture studio. Railroad noises, music, traffic noises, door slams, shots, glass crashes, screams, animal noises, automobile noises, and almost every other conceivable sound are available, properly catalogued and filed for use when the demand arises. Sometimes synthetic sounds must be devised. An amusing instance occurred in a current picture in which it was required to imitate the noises of prehistoric animals. No one knew what noises these animals made, but it was left to the sound-effects man to put in something which would be interesting and plausible.

EQUIPMENT FOR RE-RECORDING

In the articles previously cited the quality requirements of re-recording equipment, such as freedom from flutter, inadequate frequency transmission characteristics, overloading, and other causes of distortion, have been emphasized. Constant progress is being made in improving the equipment in these fundamental requirements.

Certain special adjuncts are very useful in high-grade re-recording. Some of these devices are already available and others will be developed as the art progresses. Among the adjuncts already in use, we may mention the following:

(1) *High-pass filters*, cutting off as sharply as design will permit at 100, 200, 300, 400 cycles, *etc.* These are very useful in re-recording material containing a preponderance of low frequencies. The optimum cut-off depends on the nature of the pick-up, the type of voice, *etc.*

(2) *Peak filters* emphasizing the upper frequency range (say, above 2000 cycles) for the purpose of overcoming high-frequency losses in projection.

(3) *Automatic shutter for reducing ground noise in re-recording from variable area track.* It is well known that any attempt to raise levels in re-recording from a standard track immediately involves addition of ground noise, often to a prohibitive extent. This effect is, of course, much less pronounced with "noiseless recording" and presents one of the principal arguments in favor of ground noise reduction in the original recording. A so-called "noiseless" track may often be raised 6 db. in re-recording without showing an appreciable amount of ground noise in the final production. When, however, the recording is done on a standard track, the addition of an automatic shutter of the type invented for recording by McDowell,[1] which shuts off the excitation light in the re-recording projector to the maximum degree allowable without cutting off modulation peaks, presents a practical solution to the problem. The McDowell shutter has been successfully applied to a re-recording projector by J. V. Maresca of RKO Studios in Hollywood, permitting the raising of levels on variable area tracks which have inadvertently been undermodulated in re-recording.

(4) *Limiting devices of the automatic volume control type.* These are effective in re-recording a track in which, for example, a woman's voice is below the level desired, while the voice of a man in the same scene is adequately loud. If the general level were raised, the

man's voice would become too loud, but by means of an automatic volume control device, utilizing thermal or other means to limit the output without introducing distortion, the level of the woman's voice may be raised without affecting that of the man's. This usually could not be done smoothly by manual means, but is readily accomplished by using an automatic electric adjunct to the re-recording channel.

(5) *Footage-counting devices.* In re-recording, it is customary to project the picture, which is marked to indicate points where certain operations such as changing levels, introducing sound effects, *etc.*, are to be started. A useful adjunct in this connection is a footage-counter near the re-recording mixer panel, interlocked with the footage-counter on the re-recording projector. Starting from a given mark on the film, it is then possible for the re-recording operator to arrange a cue sheet calling for certain operations at various footages. This is more accurate than relying solely on marks in the picture frame.

Aside from equipment design, such matters as securing clean prints for re-recording and keeping them clean during successive runs are of great consequence. Attention to detail is as important in re-recording as in other branches of motion picture technic.

It is possible that in the future re-recording will become largely an automatic operation. The automatic volume-limiting device mentioned above may be merely a precursor of future developments. It is possible that volume will be changed and sound effects, music, *etc.*, introduced into the track through automatic devices similar to printer-light controls in film laboratories. For example, a given notch on the edge of the film may result in an automatic increase in the re-recording gain, *etc.* Such equipment can, no doubt, be worked out; whether it will be worked out is merely a question of convenience and economy.

CHOICE OF SOUND TRACKS IN EDITING

Effective choice of sound tracks, where a number of takes are available, requires an ear which can distinguish between natural and unnatural sounds. This is, to some extent, a matter of training, but some people have a natural aptitude for it, whereas others are lacking in this quality, just as some people have a spontaneous sense of pitch in music, while others are almost devoid of it.

For example, a picture was made showing a trout fisherman wading

in a turbulent mountain brook. Some of the shots were made with an ordinary microphone suspended in the air out of range of the cameras, while others were made with the reflector microphone described by the writer previously.[3] The quality of the concentrator pick-up under these conditions proved superior for dialog, but it was noticed that the unaided microphone gave a more natural reproduction of the sound of running water than the concentrator turned upstream. The reason for this is, as every trout fisherman will recognize, that a man wading in a pool hears principally the noise of the water in the rapids immediately above. Rapids farther upstream are scarcely heard at all, particularly when the water at the entrance to the listener's pool is very turbulent. A contributory factor lies in the relatively high acoustic absorption of the stretches of quiet water in the stream. A concentrator microphone, with its beam effect and long-range pick-up acts in a manner contrary to this natural experience. When pointed upstream, the concentrator picks up not only the closer rapids, but also the series of waterfalls and ripples for a considerable distance. This results in a continuous rush of sound quite unlike the noise of a single cascade. In order to pick the best track in this case, one must not only have the subjective idea of how a stream sounds to a man wading in it, but one must be prepared to reject tracks which do not have natural characteristics. As in other branches of film editing, wide experience and acute observation are the bases of correct choice.

A simpler case is that of the sound produced by beating a man with a stick. There are two distinct sounds—the swish of the stick through the air and the impact of the stick against the man's body. These may or may not be in the original track. If a dubbing job is done, only the impact may be inserted. In that case, the scene will not have the emotional force of the combined swish-thud sound. The audience may not consciously note the absence of the swish, but the blow will simply not seem as real and painful as it should.

Sometimes sounds which are natural in a given scene do not appear to be so to the average auditor. For example, in an Arabian desert picture, one of the camels uttered its characteristic whinny during an otherwise silent interval. The effect would have been acceptable to persons familiar with camels, but the noise sounded too much like a human scream to be used. Had it been left in, it would have confused the average European or American audience.

SOUND DISSOLVES

Sound dissolves are in general effective only when a diminution in volume appears natural and in accordance with common experience. For example, a sound dissolve corresponding to a train disappearing in the distance, with the noise of the train, the locomotive whistle, *etc.*, dying away, might be highly effective, whereas the fading of voices corresponding to a picture dissolve, with the speakers stationary, might be meaningless. The first case is one which agrees with experience, whereas the second is an evident artificiality. It is true that a picture dissolve is also artificial, but it happens to be an effective visual device in dramatic psychology. It does not follow that it will be equally effective in the aural field.

One precaution that is usually necessary in sound dissolve work is to guard against "tinny" quality as the volume is lowered. Since the ear is much more sensitive in the treble range than in the bass, when the volume is lowered the threshold of hearing is reached first in the lower octaves. The ear is no longer sensitive to the bass, whereas the treble range is still clearly perceived. This results in the unnaturally high-pitched quality of sound tracks reproduced with progressively lowered recording or reproducing gain. A partial remedy is to attenuate the higher frequencies in recording, by means of networks, as the volume is lowered. This is of particular importance when the action of the photoplay requires reproduction of music from a distant room, *etc.*

COMMON FAULTS OF RE-RECORDING

The above note on the need for frequency correction in sound dissolves illustrates one common fault in re-recording. Others may be cited. Where music accompanies dialog, as in carbaret scenes, *etc.*, the dialog is usually recorded without accompaniment and suitable music re-recorded behind it later. Even when the music accompanies the dialog in the original recording, it is a good idea to make one bare dialog track as a "protection track," in case the musical accompaniment turns out to be too loud. The latter is a common fault. It may also occur when the music is re-recorded later, and it is well on this account to run through a number of re-recordings with different music levels and then to pick the best "take" in the projection room. This may be done at small expense, since the staff and overhead involved in re-recording are both very moderate. Excessively high-level music accompaniments are perhaps the most frequently en-

countered fault of re-recorded sequences of this class. This is one of the arguments for entrusting re-recording to a specialist who learns the characteristics of the apparatus and the special requirements of different types of scenes. The average recordist engaged on a job of this kind usually produces music 4 db. too high, interfering seriously with the intelligibility of the dialog. The same fault is frequently found in traffic noises, *etc.*, accompanying dialog.

In many cases, it is necessary to exercise a certain amount of license in order to avoid sacrificing intelligibility of important lines. For example, if speech occurs during a battle scene, it may be necessary to space explosions in such a way as to leave lulls at the critical points of the dialog. The effect may not be strictly natural, but if it is carefully done it will not attract undue attention, and is certainly preferable to losing the essential dialog.

Addition of ground noise as a fault in re-recording has already been discussed under "Equipment for Re-recording."

ORGANIZATION AND PERSONNEL

Experience shows that re-recording is most effectively done by a sound technician who specializes in this field. A first recordist, or mixer, who possesses particular aptitude for judging quality of dialog and music may be given charge of re-recording operations on all pictures in a given studio, or, where enough work is involved, a number of such men under a supervisor may be employed. This arrangement gives better results than allowing each recordist to re-record his own picture. The individual recordists may render valuable consulting service in connection with their pictures, but re-recording is such a specialized function and requires such accurate knowledge of the characteristics of the equipment and the technical peculiarities of its operation that the best results are secured by specialization.

One or more sound cutters should be attached to the sound department to handle tracks and, in general, for *liaison* between the cutting and sound departments. It is necessary for such men to be in general contact with the progress of individual pictures and to know which portions will require re-recording, dubbing, *etc.;* then, at the proper time, to collect the necessary footage, thus obviating delays. (In this connection it may be pointed out that synchronizing and splicing machines should be available in close connection with the re-recording equipment to avoid delay.) The regular cutter on the picture may furnish consulting service, much as the recordist does to the re-record-

ing specialist. Of course the producer of the picture, the director, and others concerned must be in close touch with what is being done, since the success or failure of a picture often depends, to a considerable extent, on the quality of the re-recording, and this condition will become more marked as the sound picture art develops.

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TREATMENT FOR REJUVENATING AND PRESERVING MOTION PICTURE FILM*

J. A. NORLING** AND ALBERT P. RIPPENBEIN†

Summary.—*The paper briefly describes a method of treating positive and negative motion picture film for eliminating abrasions and scratches and improving its elasticity. There are two treatments: (a) the rejuvenation or regeneration process, by means of which worn and damaged negatives and positives are restored to good condition and (b) the impregnation-preservation process, by means of which new negatives and prints are given a longer life in service or in storage. The processes do not involve the use of lacquers or coatings, but depend upon the swelling and contraction of the film and the glazing of the surface in order to resist scratching and accumulation of surface dirt.*

A photographic film contains colloidal systems which tend to change as the film ages. This change develops serious symptoms: the film shrinks and tends to become dry and brittle. The mechanical strains and stresses to which dry and brittle films are subjected during use soon cause a breakdown of perforations.

The nature of the photographic emulsion, and likewise, of the base, makes it a receptive medium for accumulating moisture, oil, and dirt. The substances of which the emulsion is composed are not highly resistant to abrasion and scratches appear in a short time under normal use. These scratches become receptacles for dirt. The dirtier a scratch, the worse it appears when projected. Therefore, when a film becomes scratched during the first run, which may occur on poor equipment or on good equipment improperly operated, subsequent use of the film will make these original scratches more and more apparent. In addition, new scratches will be added constantly, and by the time the print arrives in the smaller theaters, it has acquired the "rainy" appearance which has been a source of much perturbation to conscientious projectionists throughout the country.

Any process that will reduce scratching, wearing, and absorption of

*Received by Editor April 24, 1931.

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dirt will be of great benefit to the industry. Many processes have been used which involve the use of lacquers and varnishes. The Recono processes differ from these in that they do not employ any lacquers or coatings whatever.

These processes for treating film were developed by Frederick J. J. Stock, of Munich. They have been in successful use in Germany for the past eight years, and in this country since the beginning of 1930. They provide two distinct treatments: (*a*) the rejuvenation or regeneration process, by means of which worn and damaged negatives and positives are restored to good condition; and (*b*) the impregna-

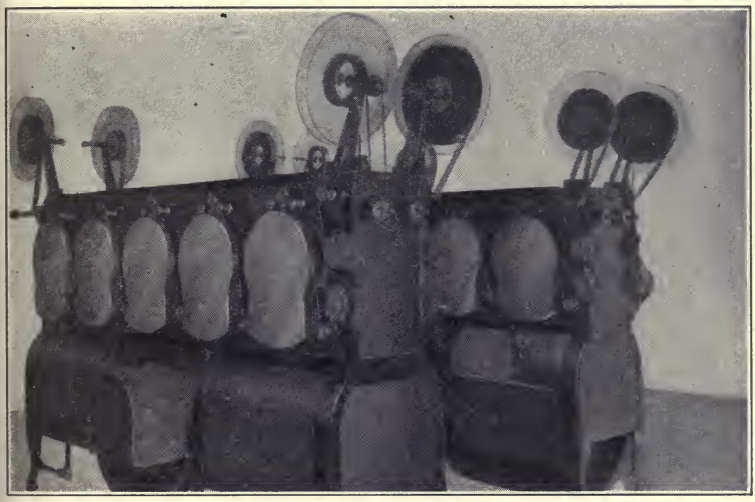

FIG. 1. Film-cleaning machine.

tion-preservation process, by means of which new negatives, black-and-white and color prints, and prints made by the different color processes, are given a longer life in service or in storage. The treatments are similar in the following respects:

(1) They are both essentially chemical treatments which effect definite physical and chemical changes in the film.

(2) Both treatments involve an impregnation of chemicals into the emulsion layers and, in the case of the rejuvenation treatment, into the celluloid as well. The emulsion layers and celluloid are made to swell and are partly liquefied in order to permit them to readily absorb the chemicals required in the process.

By the rejuvenation process, scratches and abrasion marks on both the emulsion and celluloid sides of negatives and positives are almost entirely removed. Dry, brittle film is restored to an elastic condition, and warped film is straightened. The removal of scratches is effected by causing a temporary swelling of the celluloid and emulsion layers, thus bringing together the walls of the scratches. After the swelling is reduced by drying, the walls of the scratches adhere. Elasticity is restored by impregnating the celluloid with material to take the place of the material that has evaporated. Neither distortion of the

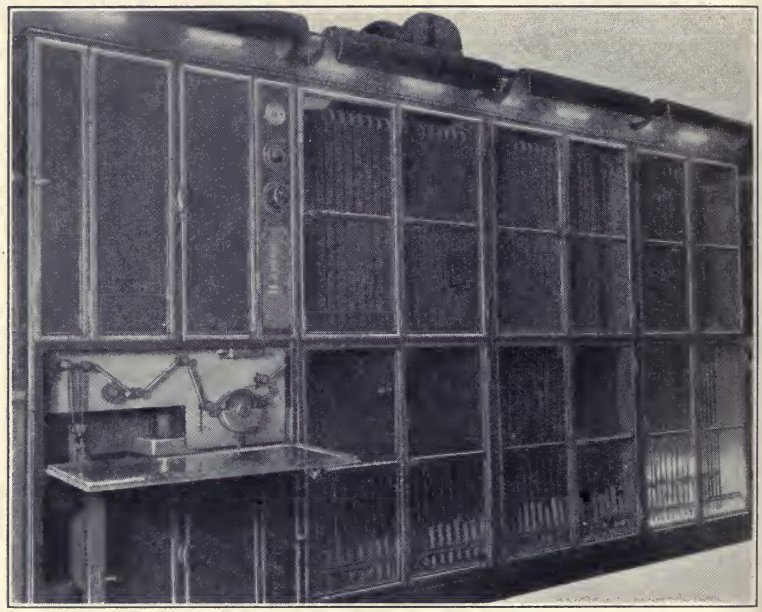

FIG. 2. Film-treating machine, including applicator and drying cabinet.

film nor disturbance of the relative positions of the silver grains results from this treatment. The impregnation-preservation treatment is applied only to the emulsion side of negatives and positives, with the following results:

(1) The surface of the emulsion is increased in hardness, making it more resistant to scratching. This advantage is obtained not only without the accompaniment of dryness and brittleness, but with an actual increase in the film's elasticity, amounting to as much as 15 per cent when measured at the breaking point.

(2) The emulsion surface is given a high gloss which has a beneficial effect in resisting scratches and accumulation of surface dirt. This gloss makes waxing unnecessary.

(3) The emulsion layers are made resistant to the absorption of oil and moisture, and the original moisture content of the emulsion is sealed in. The film therefore tends to retain the moisture necessary for preserving its elasticity and its tendency to resist buckling or warping under excessive heat.

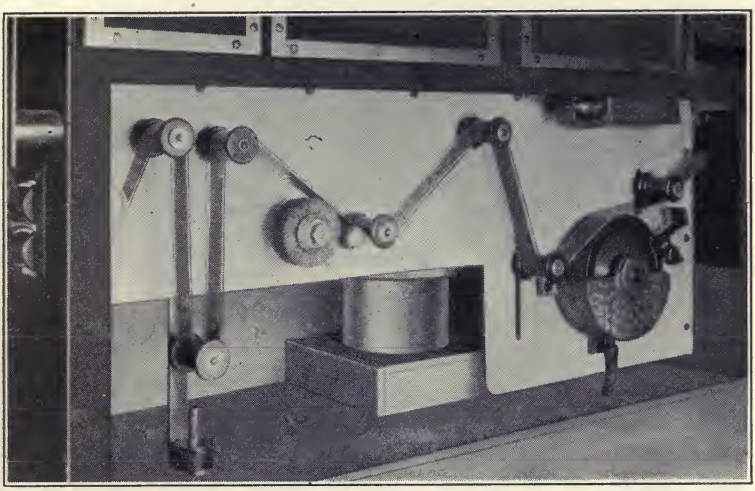

FIG. 3. Close-up of applicator.

(4) Perforation checking and damage are reduced because of the greater permanent elasticity imparted to the film.

The first step in the rejuvenation process is the cleaning of the film. This cleaning is done on machines such as are shown in Fig. 1.

The film first passes through a cleaning solution such as trichlorethylene and is then brushed thoroughly, first on one side, then on the other. The brushes penetrate to the bottom of the scratches and remove dirt particles.

The second step is a chemical treatment based on the swelling of the colloidal substances, and the liquefaction of the surface to a certain degree which permits the substances to penetrate into the picture layers. The swelling of the material thus effected varies from 21 to 36 per cent, depending on the type and make of film.

FIG. 4 (*a*). Scratched film-frame before treating.

FIG. 4 (*b*). Same film-frame after treating, showing the scratches and abrasions removed.

The swelling, which at the beginning diminishes rapidly, only amounts to about half the quoted value after 48 hours; the loss of the liquid by evaporation then proceeds very slowly, so that even after a year a slight swelling may be in evidence.

The chemical treatment is given in the machine shown in Fig. 2. The close-up, (Fig. 3) shows details of the applicator cabinet. The applicator wheel is shown at the right. It serves to carry to the film the correct quantity of solution, which can be regulated within close limits. Both negatives and positives are treated in machines of the same type, the solutions differing according to the nature of the film. In Fig. 4 (*a*) and Fig. 4 (*b*) is shown an illustration of the result obtained by applying the rejuvenation treatment to a scratched negative.

Condition	Thickness in Mm. (Average of 15 Tests)	Test No.	Per Cent of Elongation at 7.5 Kg./Cm.	10 Kg./Cm.	Breaking Point	Tensile Strength (Breaking Weight in Kg. per Cm. Width)
Not Treated	0.146 mm.	1	2.2	3.2	36	15.65
		2	1.8	3.0	33	14.30
		3	1.8	3.0	28	13.95
	Average		1.9	3.1	32	14.60
Treated	0.148 mm.	1	2.0	3.4	33	14.35
		2	1.8	3.2	37	15.15
		3	2.2	3.5	40	16.15
	Average		2.0	3.4	37	15.20

In the impregnation treatment for preserving new film, the emulsion layer is subjected to a similar colloidal process. By means of this process suitable substances are introduced which form, with the gelatine, colloidal complexes of increased resisting power which retard the tendency of new film to shrink and which harden and make glossy the emulsion surface so that it can better resist mechanical attacks. This treatment also increases the elasticity of the film, particularly at the perforations, resulting in longer life. There is a very slight increase in the thickness of the film amounting to less than $^1/_{20}$ of one per cent (about 0.002 mm.), a negligible amount. There is, however, no coating over the emulsion.

The application machine is similar to the one shown in Fig. 2 and Fig. 3. Tests have indicated certain improvements when the film

is impregnated. Elongation and tensile strength comparisons are shown in the table.

These tests were made by the Prussian Government Material Testing Bureau. Film strips 10 cm. long were used. The perforations along each edge were cut off, making each strip 2 cm. wide. Standard testing apparatus was used to obtain the data for elongation and tensile strength. As can be noticed, a distinct improvement in elastic quality is characteristic of the samples of impregnated film.

STORAGE AND HANDLING OF MOTION PICTURE FILM*

E. W. FOWLER** AND L. B. NEWELL†

Summary.— *Several serious fires in film exchanges early indicated the need of careful attention to methods of storing and handling motion picture film. Many tests were made to determine proper methods of storage. Film requires special consideration in storage and handling because of its low ignition temperature, rapidity of combustion, and capability of decomposing with little air, evolving poisonous, inflammable gases. Fundamental safety precautions include: elimination of means of starting fires, adequate provision for control of fire, minimizing quantity of film subject to one fire, and ample means of exit. More important provisions of Regulations of the National Board of Fire Underwriters, based on above considerations, are discussed.*

As against the relatively few serious fires involving motion picture film of recent years, the considerable number and frequency of such fires in the earlier days of the motion picture industry present a vivid contrast. In spite of the extremely rapid developments in this industry, with vast changes in methods, past experiences in the storage and handling of motion picture film have proved to be very valuable lessons, expensive as many of them were.

The often-mentioned Ferguson Building fire which occurred in a film exchange in Pittsburgh on the morning of September 7, 1909, was one of the early lessons in the high potential hazard of motion picture film. It was this severe fire and explosion, injuring approximately 30 persons, which brought about the development of the necessary precautions for safely storing and handling film. The Fire Underwriters, being anxious to obtain a scientific report of this explosion, were fortunate in obtaining the United States Geological Survey to make a thorough investigation.

It was upon the basis of the experience gained and investigations made of this fire that the National Board of Fire Underwriters in 1910 first issued regulations for the storage and handling of nitrocellulose film. Later fires indicated the need of a more extensive investigation of proper methods of film storage, and about 1915 a long

* Presented at the Spring, 1931, Meeting at Hollywood, Calif.

** National Board of Fire Underwriters, New York, N. Y.

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series of tests was begun on the various features of vault design and protection. These resulted in the promulgation in 1919 of a revised edition of the regulations on motion picture film based upon the results of these tests.

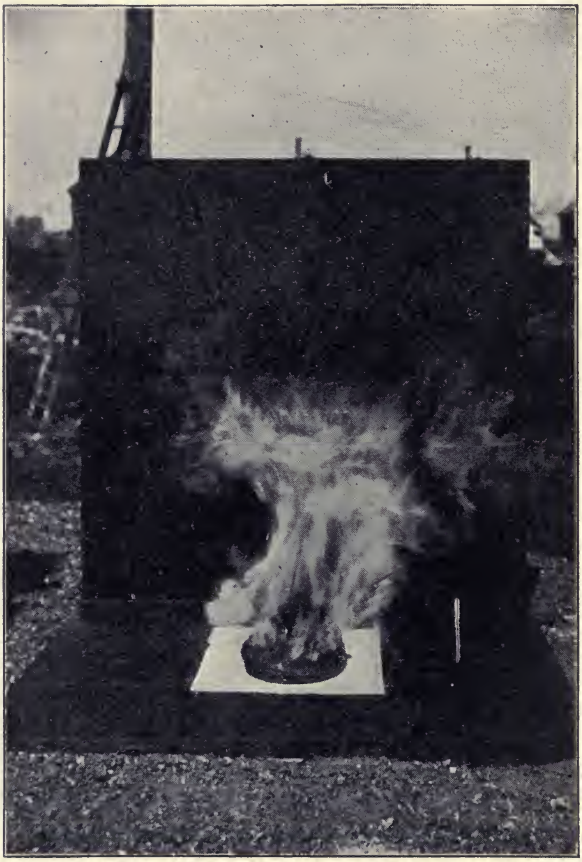

FIG. 1. Film decomposing. Note large volume of gas evolved.

The present standards for motion picture film storage are still substantially the same as were issued at that time. Of the many film fires which have occurred, some of serious consequence, never has a single one—as far as the writers have been able to determine—ever demonstrated the need for departure from these standards, nor have

any fires ever reached uncontrolled proportions in storages protected in compliance therewith.

Anyone, who has seen a considerable quantity of film burn unrestricted, realizes the need of proper precaution in its storage and handling. There are three important reasons why nitrocellulose motion picture film needs special consideration, and why it differs from other ordinary combustible materials. These are:

(1) low ignition and decomposition temperatures;

(2) rapidity of combustion and resulting high temperatures;

(3) property of decomposing with little or no air supply, resulting in evolution of poisonous and inflammable gases.

Wood and paper when heated rapidly do not ignite until a temperature in the neighborhood of 600°F. to 700°F. is reached, while nitrate film will decompose when exposed to temperatures around 300°F., and on prolonged exposure at temperatures as low as 230°F.

The heat of combustion of nitrocellulose is about the same as that of wood but the rate of combustion is 12 to 18 times as fast, so that the temperature attained by burning film is extremely high in comparison with most other common combustible materials.

Cellulose nitrate contains in itself sufficient oxygen to maintain a condition of decomposition with little or no air supply. Such decomposition, once begun, proceeds very rapidly, with the evolution of extremely poisonous and readily inflammable gases which, when mixed with a sufficient supply of air, form an explosive mixture. It is the ignition of such gas-air mixtures that explains the explosions which have so many times accompanied serious film fires.

With such peculiar properties it is obvious that nitrocellulose motion picture film presents an unusual fire hazard. Reasonable safety to persons and property from the fire hazards of this material in its storage and handling requires careful attention to certain fundamental considerations, which are as follows:

(*a*) the elimination, as far as practicable, of all possible means of starting a fire;

(*b*) the provision of adequate features for the control of and protection against the spread of fire, should it occur;

(*c*) the segregation of large quantities of film into small protected units and minimizing the quantity of film exposed, or otherwise subject to fire, in all rooms where persons are working;

(*d*) ample provisions for life safety, through the above-mentioned protective measures and by adequate accessible means of egress.

It is upon these fundamental principles that the Regulations of the National Board of Fire Underwriters are based. These regulations, first issued in 1910, have been kept in step with modern developments of the industry and the sixth edition will be issued some time this year.

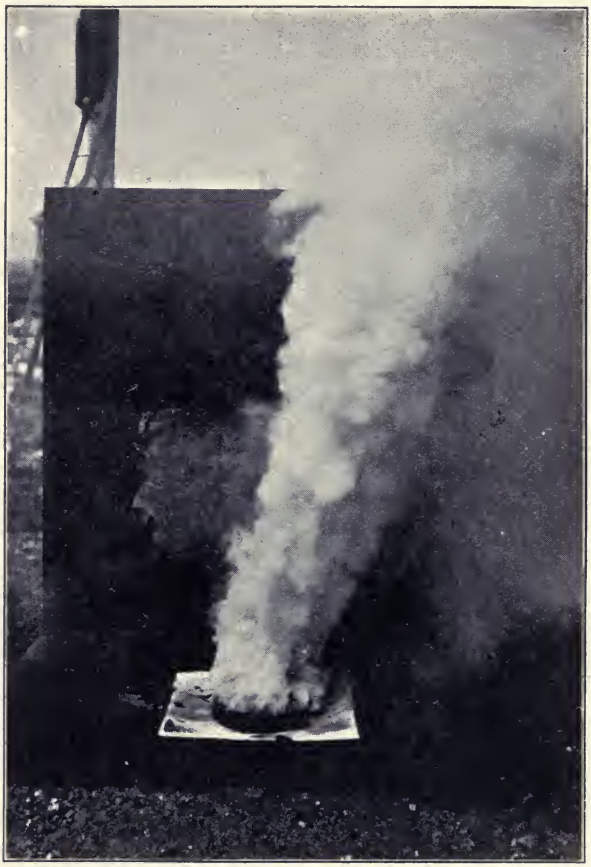

FIG. 2. Film burning; gases of decomposition give way to a sheet of flame if sufficient oxygen is available and material is not cooled by application of water.

Let us take the more prominent provisions of these regulations, study the reasons underlying them, and review some of the experiences of the past which have illustrated their need.

MOTION PICTURE THEATERS

The care and use of film in motion picture theaters in which many people are congregated is certainly worthy of careful consideration. The possibility of panic from a slight fire, or even a small amount of smoke, makes the proper care of film a matter of very great importance. For these reasons projection machines are always located in an enclosure or booth, and all film should be kept in the projection booth or other specially provided rooms.

Fires in projection booths occur with considerable frequency. For this reason the construction of the booth is of vital importance. The booth need not be of heavy construction, for the quantities of film allowed in a booth if ignited would all burn up in a very few minutes; it must, however, be of tight construction to prevent smoke issuing through cracks or crevices.

Openings in the booth necessary for the projection of the picture, the operator's view, and for color and effect machines and spot lights should be as small and as few as possible. Unless such openings are protected by automatic shutters which close in case of fire in the booth, fire and smoke may issue out into the auditorium, as has often been the case, and be the means of starting a panic. For similar reasons the door of the booth should be kept closed. With all openings closed up as much as possible and with the machines operating, ventilation of the booth is an important matter from the operator's viewpoint, and is also necessary to carry away the fumes of any burning film in the booth.

It is essential that the quantity of film in the booth should be kept at the very minimum. For this reason every booth should be provided with an insulated cabinet vented to the outside of the building so that a roll of film burning on the machine or any other place in the booth will not ignite other rolls of film. The cabinet should be of such construction that all the film in it will burn up without discharging fire and fumes into the booth.

Film can be safely rewound in the projection booth if enclosed rewinders are used, but a separate room for rewinding serves to lessen the amount of film in the projection booth. Rewinding rooms should be provided with ventilation direct to outside the building and should be suitably constructed to confine any fire therein entirely to this room.

Inspectors often discover operators smoking cigarettes in projection booths. How any intelligent person who is familiar with the proper-

ties of motion picture film could hold a roll of film in one hand and a lighted cigarette in the other is almost inconceivable, yet it has been done. Every operator of a projection machine owes it to himself, his employer, and his audience to exercise the utmost care in the handling of motion picture film.

The protection of projection booths in motion picture theaters by automatic sprinklers has not met with universal acceptance because of the practical difficulty that often exists in installing them. Projection booths are often located very high up in the theater building, and to furnish water supply for sprinkler protection would be a matter of considerable expense. Many projection booths, however, are protected by automatic sprinklers which have proved to be very effective in controlling fires and reducing losses.

If the quantity of film to be held in a projection booth is to be much increased over that generally found at present—and the quantity generally deemed necessary in the average theater today is several times that formerly required—there seems to be no more acceptable method for guarding against the fire hazard of the film than by the installation of automatic sprinklers. Furthermore, they serve to wash out a considerable portion of the toxic and inflammable gases from the fumes of burning film.

MOTION PICTURE FILM EXCHANGES

That fires in poorly managed film exchanges may become very serious was demonstrated in the Ferguson Building fire and in other exchange fires since then. Film exchanges should be located only in buildings that have superior construction features and which can withstand and retard the destructive forces of a severe fire. Of particular need is the protection of all openings, stairways, and passageways between floors, and the subdividing of the various parts of the exchange by fire partitions. All door openings in such partitions should be protected by standard fire-doors of the self-closing type. Doors should be kept closed at all times to prevent the spread of fire from room to room.

Rooms in which several people handle film should be provided with at least two exits so as to reduce the probability of persons getting caught in the room with burning film blocking a single doorway. Exits should lead directly from each room to a nearby enclosed stairway or to the street.

Automatic sprinkler systems of proper design and installation have

proved of inestimable value in preventing loss of life and serious property damage in film exchanges, and such protection is absolutely essential. The fact that no serious fire has ever occurred in a film exchange equipped with automatic sprinklers, and that a number of very serious fires have occurred in film exchanges not so equipped

FIG. 3. A Pittsburgh film exchange fire; exchange not sprinklered. Showing wreckage due to explosion, and spalled brickwork from intense heat when gases of decomposition reached outside air where there was sufficient oxygen to completely burn.

seems to be sufficient evidence that automatic sprinklers will control fires in film handling rooms. Obviously sprinkler installations must be properly designed and an ample water supply provided.

There is a limit to the amount of film which the ordinary sprinkler system will protect; for this reason unnecessary accumulations of

film in any workroom, such as an examining room, must be carefully avoided. Film should be permitted to remain outside of containers only while actually being worked upon, each person placing the film into containers as soon as the inspection or other operation is completed. A common practice is to use I. C. C. containers for holding the containers of film before and after each operation. Likewise the quantity of film in containers should be kept as small as possible, and vaults or cabinets should be convenient for ready use.

The receiving and shipping room of every exchange should be provided with one or more vaults or cabinets in which film should be placed when received and checked. It should not be taken out of shipping cases and stocked in the shipping room. Each shipment as handled should be put back immediately into shipping cases or into vaults or cabinets. Thus only a minimum amount of film will be allowed to remain exposed and the possibility of starting a fire will be greatly reduced.

But there is bound to be some exposed film in an exchange. Hence the requirement for automatic sprinklers, and the necessity for providing all rooms in which film is stored or handled with the proper vents, *i. e.*, windows or other thin glass areas which will open automatically in case of fire.

So much air is required for the complete combustion of film that in most rooms there would not be enough air to support complete combustion. The partial combustion produces large quantities of inflammable gases, which, passing into another room where there is sufficient air, form an explosive mixture. With adequate vents the gases will find their way to the outside of the building and there burn without the danger of an explosion. Not only will the vents eliminate gas-air explosions in the building but will also provide a means of escape for the poisonous fumes.

FILM VAULTS

The design and protection of vaults has been the subject of much study and many tests have been conducted to determine the various features necessary to produce safe storage conditions.

Vaults are limited in size to comply with one of the fundamental principles of all fire prevention engineering, *viz.*, that large quantities of burnable material must be segregated into small protected units. The present limit in size has proved to be a very reasonable one. Under arrangements of the vault interior for a maximum amount of

storage, the standard vault will contain about 2000 of the 1000-foot rolls of 35 mm. film. Not many vaults are arranged to hold this maximum quantity of film, but obviously sprinkler protection and vent areas must be based on the maximum storage capacity.

It is an interesting bit of history, that in the report of the U. S. Geological Survey on the Ferguson Building fire, which contained recommendations for vent areas based on studies made as a result

FIG. 4. The 1915 film vault test to determine proper vent area; no sprinkler protection. This small test vault contained 1900 pounds of film, mostly in containers. Vent area was standard. Blow torch flame shown was 8 feet in diameter, extended 70 feet, and lasted about 90 seconds.

of that fire, an error in a decimal point was made in converting the figures from the metric to the English system. This resulted in a recommendation for a vent area only one-tenth of that intended. The error remained unnoticed for some time.

As a result of later fires it was deemed advisable to conduct more thorough tests regarding the necessary vent area; there was some feeling that even a larger vent area was necessary. Accordingly in 1915 a committee of the National Fire Protection Association demon-

strated that the vent area of 140 square inches per thousand pounds of film was sufficient to prevent any but a very slight pressure to be built up in a vault.

In the burn-out of this test vault, flame issued from the vent as a torch 70 feet long and lasted about 90 seconds. This clearly demonstrated the fact that such vents might be a very serious menace to surrounding property. It also indicated the necessity for sprinkler protection in the vault and the need of a thorough investigation of the

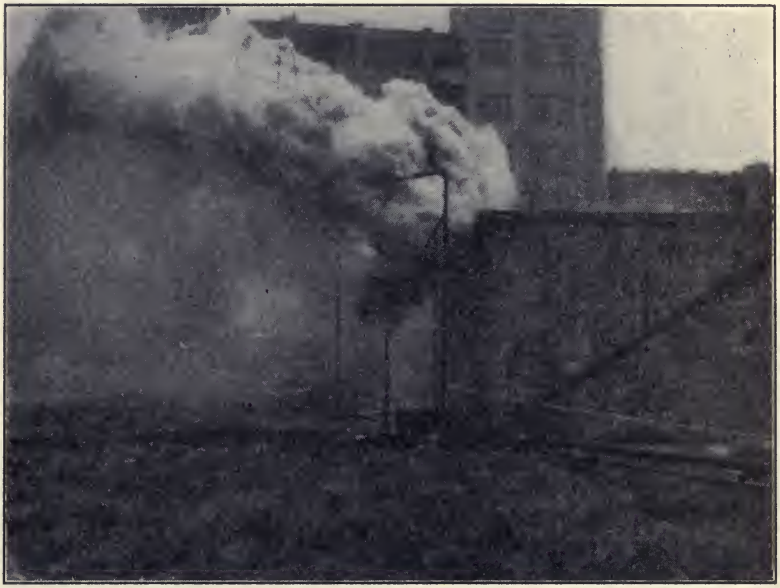

FIG. 5. Film vault test to determine proper sprinkler protection. This vault had standard vent area and was protected by standard number of sprinklers. Note difference in emission of gases from that shown in Fig 4.

value and extent of automatic sprinkler protection. A series of tests was conducted to determine whether sprinklers could prevent the entire destruction of the film and lessen the hazard to surrounding property from the torch flame coming out of the vent.

Tests made on a half-size vault with 2, 4, and 6 sprinklers showed that, with sprinkler heads in the ratio of 12 to a standard size vault, loss of film could be reduced to a reasonable figure and decomposition controlled so that the vault would not constitute a severe exposure hazard.

These tests also indicated, in agreement with the report of the Chemical Warfare Service following the Cleveland Clinic fire, that sprinklers serve to reduce the amount of gases liberated and to render them less inflammable and hence less liable to produce an explosion. Further tests clearly showed the value of subdividing partitions in reducing the amount of film destroyed, and that these should be arranged so that each section will be protected by one sprinkler head.

Various types of sprinkler systems have been used for vault protection—dry-pipe systems, open-head systems, and others. The standard wet-pipe system, however, appears to offer certain advantages over all other types. If heat in the vault is necessary to prevent the sprinkler pipes from freezing, low-pressure steam or hot water under proper automatic control can be safely used.

For safe storage at least one of the vault doors must be kept closed, and should be of the swinging self-closing type. Light fire-doors have been found to be eminently satisfactory and are recommended in place of heavy vault doors.

The fires which have occurred in vaults of standard design have proved conclusively the correctness of the vault requirements. Fires have started in vaults in various ways, often in an unknown manner. Portable extension lights or other electrical equipment have often been the cause. Film decomposition may be started by electric sparks or by electric light bulbs coming in contact with the film; thus the necessity for using only fixed lights in a vault, located at the ceiling and operated by outside switches. Several fires in vaults have been started by sunlight entering through the vent. Vents must therefore be so arranged that sunlight will not reach the film.

Film in vaults should be kept in individual reel containers stored on racks on edge. There has been a tendency to place the containers flat but such an arrangement is unwise because water from the sprinklers will then fall only on the top container and on the edges of the lower containers; if stored on edge, water can find its way between the containers, as each of these has a corrugation on top and bottom, and can effectively reach and cool every container of film in the rack.

MOTION PICTURE FILM LABORATORIES

Recent developments in the field of sound pictures and other adventures into the use of extra wide film have been responsible for unsettled and at times very serious conditions in motion picture film laboratories.

All of the foregoing general principles for safe storage and handling motion picture film apply to laboratories as well as other occupancies. Because of the difference between the operations conducted in a laboratory and those in an exchange, however, certain of the principles of protection and fire prevention need greater elaboration than has been given.

Automatic sprinkler protection throughout is, of course, most essential. The fire in 1929 in a Hollywood laboratory clearly showed what could happen in an unsprinklered laboratory. The report on this fire reads: "Immediately upon discovery of the fire, the alarm was given and employees hurried from the building. The fire spread so rapidly that several girls suffered slight burns; no attempt could be made to extinguish the flames.... Eight minutes after the first alarm the entire building was involved." If the fire had occurred in the daytime rather than at night when few persons were working, a much greater loss of life would have been almost certain. As it was, only one life was lost.

Laboratories must be so arranged that employees have plenty of room and are not crowded; adequate aisle space is very important. By limiting the number of workers in a room and the amount of film which each worker may have, the quantity of film in any room becomes limited and each person is assured of space to make his exit in case of fire. With vaults and cabinets located conveniently, the amount of exposed film can easily be kept to reasonable limits.

The Hollywood laboratory fire not only emphasized the danger of large quantities of film in workrooms, but also brought out the danger of having buffing and other processing machines in rooms where other operations are performed. All special processes which present unusual possibilities for starting a fire should be well cut off from other rooms.

Printing machines, especially multiple print machines, present a rather unusual condition. Last February the National Board of Fire Underwriters conducted tests, simulating printing room conditions, to determine the possibility of fire communicating from one machine to another under ordinary sprinkler spacing. These tests clearly demonstrated that a considerably wider spacing of machines is necessary than is usually found in printing rooms to assure that fire originating in one machine would not jump to the others in advance of sprinkler operation. As a result of these tests partitions between machines are deemed desirable for safety in a printing room where the machines are closely spaced.

Laboratory film dryers of the drum type are being replaced by the generally less hazardous cabinet dryers. Such dryers should be heated by heaters that are thermostatically controlled to keep the temperature from reaching a dangerous degree. Heating elements should also be protected so that no film can come in contact with them.

The care and handling of scrap film in laboratories, as well as in exchanges and elsewhere, is a matter of vital importance. The only safe place to keep scrap film is under water. Its form renders it very

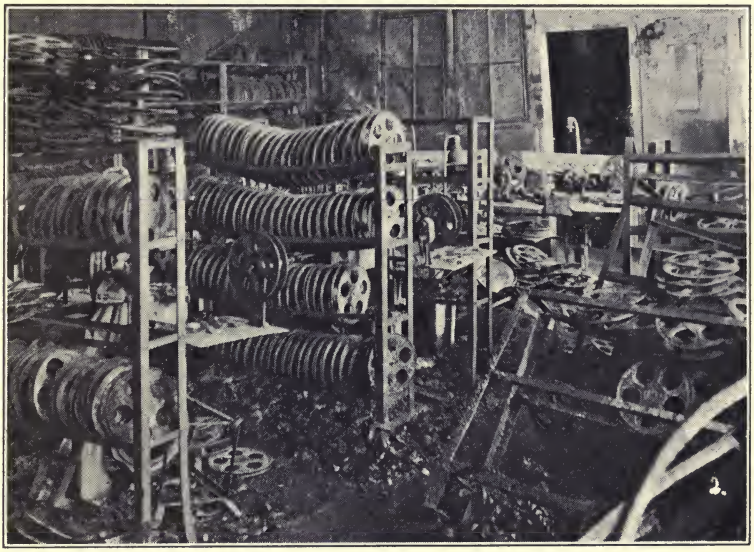

FIG. 6. Portion of positive assembly room in Hollywood laboratory after fire. Racks shown against wall contained 750 reels of film. Small racks each had capicity of 100 reels. This laboratory was not sprinklered.

liable to ignition, and wax and other coatings on the film appear to make it more hazardous than new film.

Room heating systems in laboratories, *etc.*, may cause ignition of the film. Heating systems should be of the low-temperature type, steam or hot water. It is possible that even at the temperature of low-pressure steam heating radiators, film will become ignited upon long-continued contact. Hence all steam or hot water pipes and radiators must be protected by guards to keep film from touching them.

Hand extinguishers or other first-aid appliances employing water or water solutions are most effective for use on incipient film fires. Other types of extinguishers may be of as much benefit and more desirable from other standpoints in certain special circumstances, but as a general rule water is the safest extinguishing agent for general use.

MOTION PICTURE STUDIOS

The storage and handling of film in studios presents little additional hazard over that found in exchanges and laboratories. The problem is slightly different, however. On the studio stage, there may be many people and much light combustible material, such as curtains, drops, and all kinds of scenery.

The studio fire which occurred in New York in 1929 and took a toll of 10 lives occurred in an unsprinklered building. Since that date another fire occurred in a studio in New York which was equipped with automatic sprinklers. Although this other fire happened under very similar circumstances, there was no loss of life and the opening of four heads soon controlled the fire, all of which clearly substantiates the requirement that motion picture studios should be equipped with automatic sprinklers.

Film handling and storage rooms should be separated from the studio stage by fire partitions. The hazard on a studio stage, due to the necessary large quantities of combustible material, as hangings, scenery, and other materials making up the sets, is great enough without adding to it quantities of film. Furthermore, it is a basic rule of safety in handling film not to have any more film where people are congregated than is absolutely essential.

One safety precaution in a motion picture studio which is not directly concerned with the handling of film but which is very important from the safety-to-life standpoint is concerned with reducing the probability of a quick, sweeping flash fire involving the whole of a stage. While automatic sprinklers with adequate supply properly installed will undoubtedly control a fire of this type, there is a serious possibility of a quick flash fire involving the whole or a large portion of the stage area before all persons would have a chance to get out. It is therefore necessary that all inflammable material, such as drops, hangings, wall coverings, and similar materials, be rendered fire retardant by painting, spraying, or other process, whenever such can be done without destroying the usefulness of the material.

COMMITTEE ACTIVITIES

IMPORTANT COMMUNICATION FROM THE PAPERS COMMITTEE

The Papers Committee takes this opportunity to thank the members of the Society for the hearty coöperation it has received in preparing and in presenting the papers program at the Spring Convention.

The Committee feels that this program was a very good one from many standpoints. Nevertheless it believes that even better programs are practicable. It is the aim of the Committee that each papers program shall show improvement over the preceding one and it seeks your continued support to this end. It should be borne in mind that the Fall Convention is but a few short months away—a very short period, because allowance must be made for vacations.

Each member is asked to review the work he is doing and make plans for the presentation of a paper this fall. The chairman should be notified at once of the subject to be discussed, and given a brief résumé of the ground to be covered.

Some papers were planned for the Hollywood Convention which for one reason or another could not be presented. The Committee asks that these papers be followed up and prepared for the next convention.

As was pointed out in the March issue of the JOURNAL, much information of interest and value to the members of the Society is withheld by individuals simply because it is familiar material to them and to the small group engaged in the particular field of activity. It should be kept in mind that all phases of the motion picture and affiliated industries are represented in the membership of the Society and that most of us are pretty much interested in the other fellow's job and in its reaction on the Big Job we are all doing together. If any member is doubtful about the suitability of any material he should give the Papers Committee an opportunity to advise with him.

The Committee would be very glad to hear from members of the Society in reference to changes in the general plan of the papers program and to receive suggestions for topics to be treated in single papers or to be the subject of symposiums. Everyone must have ideas about the kind and character of programs which would interest him most. Why not tell the Committee about it?

The Committee looks forward to an early reply from each member of the Society.

O. M. GLUNT, *Chairman*

SOUND COMMITTEE

At a meeting held in New York, N. Y., April 27th, most of the subcommittee reports were discussed and passed upon as suitable material to be included in the final report to be presented at the Hollywood meeting. This report concerns itself primarily with a consideration of present-day practice in sound recording and reproducing, the possibilities of standardization, and items which the Committee believes warrant further investigation by the industry.

PROJECTION SCREENS COMMITTEE

At a meeting held April 16th, in New York, N. Y., Mr. Whiting submitted a report dealing with measurements on screens, which included a description of the method used and comments as to desirable screen brightness. Mr. Little was assigned the task of securing laboratory data on the distribution of light from laboratory screens with the light incident at varying angles. He proposed a method for defining and measuring total reflection factors, which the Committee accepted. Mr. Raven proposed that the Committee submit recommendations on the types of screens suitable for houses of different widths. Mr. Tuttle suggested that the Committee consider screens suitable for rear projection, and volunteered to obtain data relative to deterioration of screen surfaces. Mr. F. H. Hopkins agreed to submit an analysis of acoustic properties and requirements for screens. In order to guide the activities of the Committee, a complete outline of the proposed work for the coming session was drawn up.

PROJECTION PRACTICE COMMITTEE

At a meeting held April 22nd, in New York, N. Y., the full report of the Subcommittee on Projection Room Lay-Out was read by Mr. Goldberg. After some discussion concerning various details of this report, and in which it was pointed out that the report should deal primarily with the lay-out of the projection room and not with accessories for it, the report was accepted by the Committee to be included in its final report which will be presented at the Spring Meeting. This report is to include several suggested plans for the lay-out of projection rooms for large, medium, and small theaters.

In the announcement concerning the Projection Practice Committee published in the April, 1931, JOURNAL, the statement was made: "Chairman Rubin read a communication from Mr. Chauncey Greene suggesting that arrangements be made to close off the balcony when not occupied, in order to avoid excessive reverberation from the ceilings and upper walls of the theater auditorium." This should have read ". . . that arrangements be made to close off the *sound distributed to* the balcony whenever the balcony was not occupied."

STANDARDS AND NOMENCLATURE COMMITTEE

At a meeting held at the Pennsylvania Hotel, New York, N. Y., May 2nd, the report of the Subcommittee on Wide Film to be presented at the Spring Meeting of the Society was read by Chairman Hardy, and accepted by the Committee. A great deal of work was done by the Subcommittee on Nomenclature on the glossary which it is expected will be submitted to the Society in the near future.

ABSTRACTS

Sound and Image. CH. W. VAN DER PYL. *Technique Cinemat.*, **2**, Feb., 1931, p. 11. In the technical development of equipment for optical and sound reproduction purposes the principal attention should be directed toward life-like reproduction instead of abstract technical perfection. As an example, the author states that psychological considerations show that camera objectives which give better depth of focus would be preferable to those giving critical sharpness in a limited plane. In this connection he calls attention to a lens devised by F. Diedrichs with which a reasonable degree of sharpness is obtained in all planes from a near object to infinity. This result is produced by shifting the central elements of the objective during the exposure. Application of this principle to motion picture purposes would be difficult because of the frequency of oscillation of the moving parts necessitated when pictures are made at the usual rate. The improved results, however, would be well worth the trouble. C. E. I.

New Air-Blast High Intensity Lamp. *Film Daily*, **55**, March 15, 1931, p. 7. A new high intensity projection lamp has been marketed by a Hollywood concern. Features of this lamp are: two equalized contacts on each side that cannot oxidize or pit; a powerful and dependable automatic, fully enclosed striker; an arc image visible from both sides of the lamp; a pyrex mirror cooled by circulating air; a carbon release operating outside the lamp house. The entire mechanism is removable by sliding it out with the rear housing. The air-blast in the cooling system is generated by a silent, powerful blower operated by the arc control motor. The air stream is diverted to all parts of the lamp housing, lowering the operating temperature to such an extent that a smooth running machine is maintained. Besides serving as a protective feature, the air blast insures an increase of illumination by allowing a greater amount of current to be carried in the same diameter of carbon. Heretofore, it is said, lamps of the high intensity reflector type were only designed to operate at 72 amperes when using a 9 mm. electrode. With this new type lamp, the normal current is 85 amperes and can be worked up to currents as high as 90 amperes. C. H. S.

Improved Metallic Surface Sound Screen. *Film Daily*, **55**, April 12, 1931, p. 30. A new and improved metallic surface sound screen, known as "silvers heet," has been designed primarily to meet the constant demand for more light. It is claimed that this screen will give three times more screen brightness than any ordinary white surface screen. Webbed with double reënforced webbing it can be laced in any present type lacing frame. C. H. S.

The High Output Incandescent Lamp in the Motion Picture Industry. A. SALMONY. *Kinotechnik*, **13**, Jan. 20, 1931, pp. 28–9. The lamps described are the Osram tungsten filament lamps of 10,000 and 50,000 watts, such as are used in motion picture studios. The total output of the 10,000 watt lamp is about 228,000 Hefner lumens and that of the 50,000 watt lamp, about 1,000,000 Hefner lumens. Curves are reproduced showing the distribution of the

light of the 10,000 watt, 220 volt lamp in both a horizontal plane and a vertical plane. M. W. S.

Third Dimension System Based on Screen Evolved by Bell Laboratories. *Mot. Pict. Herald,* **102,** Sect. 1, Mar. 7, 1931, p. 12. In this improved process of stereoscopic photography, a special screen, two feet square, is used composed of 200 solid celluloid cylinders set in a vertical position. A panoramic view and a different image is thus provided for each eye of a person viewing the picture. Recent developments include a single exposure and stationary camera instead of the moving camera. Either a large concave mirror or a large lens and a grating may be used to photograph the subject. Much research is considered necessary to perfect the process, however, and factors which are requisite include: (*a*) an extremely fine-grain, high-speed film, (*b*) a projection lens free of distortion and having excellent definition, and (*c*) elimination of all lateral movement of the film while passing through the projector gate. G. E. M.

Television Impractical for Wide Use in Its Present Stage. D. K. GANNETT. *Mot. Pict. Herald,* **102,** April 18, 1931, p. 12. Regular broadcasting of television images by the usual methods would require a frequency band 4,000,000 cycles wide, which is equivalent to 400 ordinary broadcast channels. Such a band is considered impractical as it would mean nearly complete monopolization of present transmitting channels. A scanning disk, having 125 holes, would be required compared with a 50 hole disk used in 1927, which transmitted about 2000 elements, making a very indistinct picture. The 125 hole disk would give images comprising about 12,500 elements. Good telephotographs contain about 250,000 elements. G. E. M.

Equipment Exports in 1930 Up $4,000,000. *Mot. Pict. Herald,* **102,** Sect. 1, Mar. 14, 1931, p. 18. Sound apparatus and arc lamps were not listed under export classification in 1929. Estimating the export value of these as $3,500,000 and adding listed exports of $1,442,803, gives a total of approximately $5,000,000 for 1929 exports of motion picture equipment compared with $9,172,824 for 1930. Partial compilation of equipment is as follows: 35 mm. projectors, 2160; 35 mm. cameras, 945; substandard projectors, 1634; substandard cameras, 1677; arc lamps, 967. Sound apparatus valued at $7,736,059 was exported during 1930, chiefly to Europe. The figures were supplied by the Motion Picture Division of the U. S. Department of Commerce. G. E. M.

Ground Noise Reduction—RCA Photophone System. R. H. TOWNSEND, H. MCDOWELL, JR., AND L. E. CLARK. *Mot. Pict. Herald,* **102,** Sect. 2, Mar. 14, 1931, p. 74. In normal variable width recording the sound track is always made up of equal portions of exposed and clear film. Dirt or foreign matter on the clear side intercepts the light normally falling on the photo-cell and produces noise which is very noticeable if the modulation of the recorded sound is low. The experiments of Hanna and of Hewlett have been extended by the authors and a method is described in detail whereby noise produced in this type of sound record is greatly reduced. A little of the output of the amplifier, before it is fed into the recording mechanism, is amplified and rectified, and the resulting direct current is used to furnish a secondary control over the vibrator. A moving shutter actuated by two voice coils is placed mechanically in the beam of light reflected by the vibrator of the recording system. This shutter moves in proportion to the amount of input to the two-stage amplifier. When no modulation occurs, the shutter

admits a beam of light onto the film approximately one-seventh the width of the beam used in the normal variable width recording system. Diagrams of circuits are included and 29 reproductions of different sound records. G. E. M.

Electron Tubes in Industrial Service. W. R. G. BAKER, A. S. FITZGERALD, AND C. F. WHITNEY. *Electronics*, April, 1931, p. 581. Discusses various circuits for the use of the thyratron tube in the production of alternating current of adjustable frequency from a d-c. source. The paper also discusses some special applications such as time-delay relays and telemetering systems. A. C. H.

Developments in Automatic Record Changers. FRANKLIN S. IRBY. *Electronics*, April, 1931, p. 584. A very complete discussion of the characteristics of seven commercial types of automatic record changers for phonographs.

A. C. H.

Variable Area Sound Recording. JOHN P. LIVADARY. *Electronics*, April, 1931, p. 587. A mathematical investigation of the distortion introduced in the variable area method of recording by the finite width of the recording slit.

A. C. H.

Progress in Two-Way Television. HERBERT E. IVES. *Bell Lab. Record*, **9**, February, 1931, p. 262. The television apparatus developed at Bell Telephone Laboratories has been further improved by the substitution of an incandescent lamp for the arc used in scanning and the addition of a red component in the scanning beam, with two caesium-oxygen cells added to the receiving equipment. A better design of neon lamp has also been applied. The final effect is an orthochromatic image which is much more faithful to the original and shows better definition than the earlier arrangement of the apparatus. A. A. C.

New Types of Photoelectric Cells. A. R. OLPIN. *Bell Lab. Record*, **9**, March, 1931, p. 310. Recent advances in photoelectric cells have been made by treating the surfaces of alkali metals with gases or with vapors of dielectrics such as sulfur or organic dyes. The response curves of these new types show that selective sensitivity to light of almost any color may now be obtained. A. A. C.

Measuring Reverberation. CARL F. EYRING. *Bell Lab. Record*, **9**, March, 1931, p. 315. The acoustical properties of a room cannot be accurately given by reverberation time alone. Oscillograms recording the loss of intensity at short intervals are presented to show that the rate of decay is the important factor, and that each rate, with the range of drop in intensity over which it applies, should also be given to characterize a room. A. A. C.

New Simplex Triple Lens Turret. *Mot. Pict. Proj.*, **IV**, April, 1931, p. 19. Projectors, as well as cameras, may now be equipped with a means for quickly interchanging prefocused lenses to suit whatever magnification the program demands. This turret provides space for three half-size lenses of standard dimensions, with adapters available for the quarter-size lens tube; it may be fitted to any standard Simplex machine. A. A. C.

Quality of Television Images. D. K. GANNETT. *Bell Lab. Record*, **9**, April, 1931, p. 358. The limit of detail available in a television image depends upon the number of elements which can be transmitted in the time allotted to each single picture, that is, upon the frequency band which can be sent from the sending to the receiving point. With the ordinary ten-kilocycle broadcasting channel the limit is 625 elements in one-sixteenth second, which corresponds to a picture of about 22 by 28 elements. By using two or more channels pictures of finer detail

can be obtained. The illustrations of this article, made by transmission as telephotographs, show the possibilities of pictures with the number of elements ranging from 625 to 12,500. Allowance must be made for the fact that coarseness of detail in a moving scene is less objectionable than in a still picture. A. A. C.

Talking Picture Equipment for Portable Use. JOHN DUNSHEATH. *Proj. Eng.*, **III**, April, 1931, p. 14. The growing field for portable sound projectors requires dependable, fire-proof equipment of limited size and weight; simplicity of operation is essential. The article describes a projector designed with these requirements in view. It has an automatic switch which turns the light on only when the mechanism has attained normal speed and cuts it off in case the film breaks or runs out. Film magazines are in enclosed compartments. The amplifier is in a separate case, designed to operate from either of two projectors, and is so placed that the light from the sound track, coming through an opening in the projector case, can fall upon the photo-cell. Half-size projection lenses are used, together with special condensers and a 1000 watt lamp, which are claimed to give a good picture at a screen distance of 100 to 125 feet. A. A. C.

Film for Home Record Reproduction. A. L. WALKER. *Proj. Eng.*, **III**, April, 1931, p. 16. The Austrian Selenophone Company is now making home reproducing equipment which embodies sound-on-film recording. The record is a paper strip one-half inch wide with four sound tracks printed side by side, thus giving about seventy minutes playing time to a single 300 meter strip. Modulation is by light reflected from the strip and a selenium cell is used with the variable area record, for the printing of which a special ink method has been developed. Quality of reproduction is said to be "not far less" than that of the commercial disk record. A. A. C.

Visual Fatigue and the Motion Picture. DR. LUCIANO DE FEO. *Mot. Pict. Proj.*, **IV**, February and April, 1931, p. 27. The author, who is director of the International Educational Cinematographic Institute, presents in this paper the results of an inquiry into visual fatigue conducted throughout twenty-seven Italian provinces. Analysis of replies to a questionnaire presented to thirteen thousand school children shows that 29 per cent normally experience visual fatigue after a motion picture performance. The effect appears more pronounced among the younger children.

Opinions are quoted from specialists on the subject, most of whom seem to agree that well-managed presentations do not cause eye-strain. There follows a long list of the common conditions in auditoriums, films, and projection methods which cause fatigue and a discussion of the regulations necessary for eliminating them. A. A. C.

A System for Suppressing Hum by a New Filter Arrangement. PALMER H. CRAIG. *Proc. I. R. E.*, **19**, April, 1931, p. 664. A new system for suppressing hum, either in the output of a rectifying system or the output of a generator, is discussed thoroughly. The mathematical design of the filter is given as well as the points of superiority of the proposed system over the usual capacity-inductance system are shown. The proposed system is based on the superposition of a current displaced in phase by a wave filter, on a current not so displaced.

A. H. H.

Improvement of Thin Film Caesium Photoelectric Tubes. S. ASAO AND M. SUZUKI. *Proc. I. R. E.*, **19**, April, 1931, p. 655. The sensitivity of photoelectric

tubes, specially treated by the application of a thin layer of gold or silver over caesium deposited on oxidized silver, is shown to be increased in the red and infrared. The process of making the tube and the laboratory set-up of apparatus used in testing the tube are explained. Curves illustrate the increase of sensitivity. A. H. H.

The French Solution of the Wide Screen Problem. P. AUTRÉ. *Cinemat. franç. Supp.*, **13**, Feb. 28, 1931, p. 1. One of the most attractive solutions of the wide screen problem is that involving the use of standard 35 mm. positives with cylindrical supplementary lenses for giving a uniform increase in the width of the projected image. Such an increase in one dimension during projection is possible without distortion of the picture if the positive has been produced by a printing process involving a corresponding reduction in width of the image from a wide negative. The economic advantage to the exhibitor is obviously great.

Successful application of this method depends on satisfactory optical devices for the purpose and photographic materials having sufficiently fine grain. As to the optical equipment, a highly corrected cylindrical lens has been devised by H. Chrétien which gives satisfactory results with the regular type of illumination system in the projector. This and the corresponding corrective lens used in the printing process consist of five elements having cylindrical surfaces. Recent progress in the direction of fine grain in photographic negative film gives assurance of satisfaction and since only the positive film which has fine grain is subjected to the unusual enlargement no trouble exists in that quarter.

Inasmuch as it may not always be required to produce an extremely wide screen image, the same principle can be turned to advantage in providing more width on the positive for the sound record. C. E. I.

A Study of Certain Photographic Reducers. G. ROBIN. *Science et ind. phot.*, 2nd Series, **II**, Jan., 1931, p. 24–6. Sensitometric studies of the action of the following photographic reducers were made using Lumière "Etiquette Blue" plates developed to a gamma of 1.5 in an elon-hydroquinone developer:

(1) Ceric sulfate and sulfuric acid.
(2) Potassium ferricyanide and sodium thiosulfate.
(3) Potassium permanganate and sulfuric acid.
(4) Ammonium persulfate and sulfuric acid.

The results obtained with the reducers prepared, using various concentrations of the constituents and by treatment for increasing times, are given in tabular form. The values D_o, D_a, D_a/D_o, D_o-D_a, and γ_a/γ_o are given, "D_o" and "D_a" representing the densities before and after reduction, respectively, and "γ_a/γ_o," the ratio of the gamma after reduction to the gamma before reduction. Under the conditions of the tests the author found that all of the reducers decreased contrast (as measured by gamma) more or less rapidly, depending upon the composition of the solution. The action of a dilute solution of permanganate with a trace of sulfuric acid was approximately proportional while still further decrease in the acid gave super-proportional results. The removal of fog without serious reduction of the middle tones was not possible with any of the formulas tested. Plates exposed from either the front or back gave similar results upon reduction.

L. E. M.

ABSTRACTS OF RECENT U. S. PATENTS

1,798,144. **Automatic Projection Lamp Adjustment.** H. A. DeVry. Assigned to QRS-DeVry Corporation. March 31, 1931. Automatic fire prevention means where the light-intensity of the projecting lamp in a motion picture projector is cut down when the film is brought to rest. The projector may be adjusted for projecting motion pictures or still pictures. When the motor and film are stopped the luminosity of the projection lamp is reduced to prevent overheating of the film while the film is stationary.

1,798,335. **Device for Indicating Speed Variation in Projection.** O. Messter. March 31, 1931. A device for regulating the showing of motion pictures to enable the operator to properly accommodate the speed of the successive pictures with respect to the scene being shown, that is to say, to prevent a too quick, as well as a too slow succession of the pictures during the entire showing, and, on the other hand, to finish the showing within the time predetermined for the respective play or performance. This is attained in a particularly simple manner, *viz.*, merely by regulating the running of the cinematographic apparatus in continual correspondence with the running of the seconds-hand of a clock. This can be effected, for instance, by having an additional hand driven by the cinematographic apparatus, the speed of the latter being then regulated according to the speed of the additional hand in such a manner that this hand and the seconds-hand (which may indicate tenths of seconds) always lie one over the other. If the hand which is driven by the cinematographic apparatus is leading, the speed of the apparatus must be retarded, whereas, when the seconds-hand is leading, the speed of said apparatus must be accelerated, in both cases in such a degree that the one hand again covers the other.

1,798,793. **Reciprocating Lens for Continuous Projection.** C. B. Hall. Assigned to Lorenz F. Muther. March 31, 1931. Film apparatus wherein the film is continuously moved across an optical axis instead of being intermittently moved. In lieu of the intermittent movement of the film, the lens is mounted for reciprocation back and forth along a path extending transversely of the optical axis. A cam follower is connected to the lens. A rotating cam engages the follower for reciprocating the lens. The position of the cam and follower are adjusted transversely of the cam axis and transversely of the optical path to vary the throw of the lens.

1,798,963. **System for Successively Scanning Juxtaposed Areas.** G. Valensi. March 31, 1931. A scanning system for television circuits where separate sources of light are provided and exploring means associated with each source. Optical systems are provided for each source for focusing beams of light on juxtaposed areas of the object. The exploring means sinuously explores the respective juxtaposed areas in succession. The advantages of the illumination sending scanning device according to this invention are: first, to concentrate a greater amount of light successively on the various points of the scanned object, because

the pencils of powerful sources of light are juxtaposed on said object through distinct and complementary portions of the circumference of the same scanning disks; and, second, the placing of the photoelectric cell in front of said object, and as close as possible, in order to collect in said cell the greatest possible amount of the light reflected by said object.

1,799,154. **Automatic Fire Shield for Projectors.** FREDERICK BROOK. April 7, 1931. A safety shutter or shield which is automatically and instantaneously interposed in the path of the rays between the projector and the film to prevent the film from catching fire in the event of a breakage in the film. A circuit closure is provided which is normally maintained open by the passage of the film between the pair of contact fingers forming the circuit terminals. When the film breaks, the circuit is closed through the spring fingers actuating an electrical circuit for interposing the fire shield in the path of the light rays from the projector. The intact film functions to hold the circuit open, the shield being normally held in inoperative or unobstructive position and is moved or permitted to move under the influence of a spring or gravity, or both, by the relay which is normally inactive but which is energized on the closure of the circuit due to the breaking of the film. The energized relay acts directly to move the shield, or to release a detent catch normally holding the shield in retracted position, and thus permit it to move into its functional position, when the relay circuit is automatically opened.

1,799,235. **Monitoring System for Recording Studios.** H. C. HUMPHREY. Assigned to Electrical Research Products, Inc. April 7, 1931. An acoustic system for use in sound recording in which the recording studio is equipped with a plurality of unilaterally conductive recording circuits energized by the amplified output of separate sound pick-up devices. A monitoring circuit is provided which may be automatically connected to the sound recording circuit. The monitoring circuit terminates in a monitoring room of such size and acoustical properties as to simulate the acoustic conditions of a sound picture theater of average size, and equipped with a sound radiator of the type used in the theater. An observer in the monitoring room is thus enabled to hear the sound reproduced under conditions similar to an average theater. Facilities are provided so that the circuit to the sound radiator may be connected to the output of the sound detector by switches to monitor on the modulated light transmitted through the film during recording. A visual indicator is provided in the monitoring room to indicate when the output power from the sound detector approaches the value at which the recording devices will be overloaded and a control device is provided by which the observer can reduce the sound power supplied to the recording devices.

1,799,378. **Phase-Displaced Multiple Sound Tracks for Improving Reproducing Sounds.** H. KUCHENMEISTER. April 7, 1931. A film is provided with a multiple number of sound tracks adjacent the picture record on the film. The sound tracks are displaced in phase by a time-interval of from $^1/_8$ to $^1/_{30}$ of a second. The phase-displaced sound record impressions are converted into sound by means of a single sound reproducing device excited a plurality of times at a predetermined time-interval according to the phase-displacement of the records on the film. The purpose of the invention is to improve the intensity and color of the sounds which are reproduced in a talking picture.

1,800,000. **Transmitting a Plurality of Facsimiles without Re-charging.**

VLADIMIR K. ZWORYKIN. Assigned to Westinghouse Electric & Manufacturing Company. April 7, 1931. A facsimile-transmitting-receiving system whereby a plurality of pictures or messages upon opaque surfaces may be transmitted without interrupting the process to re-charge either the transmitting device with new matter or stopping the receiving apparatus to place additional light-sensitive material therein. The light-receiving surface is moved and a plurality of angularly separated rays of light located in proximity to the moving surface so as to trace a plurality of paths thereon transverse to the direction of movement of the light-receiving surface, the paths overlying each other and providing greater illumination than is obtained with a single path of light.

1,800,031. **Continuous Facsimile Transmission Apparatus.** F. SCHROTER. Assigned to Gesellschaft Für Draftlose Telegraphie M. B. H. April 7, 1931. Apparatus for facsimile transmission where a cylindrical drum is provided for supporting the picture or surface to be transmitted and light applied to portions of the surface to be transmitted from light sources located at opposite ends of the drum and directed toward optical means within the drum which project the light through the picture surfaces. The light from each of the sources is alternately projected to each of the pictures carried on the surface of the drum. The light projected to each of the pictures is caused to traverse each entire picture surface. A plurality of photo-cells in the path of the reflected light from the pictures are controlled for correspondingly actuating a transmission circuit in accordance with with facsimile signals.

1,800,211. **Collimating Projecting Device.** R. P. DE VAULT. Assigned to Acme Motion Picture Projector Company. April 14, 1931. A light ray projector for motion picture projecting apparatus where a light filament is arranged transversely to the axis of a reflecting surface which is formed by the revolution of an elliptical arc about an axis which is oblique to the major axis of the arc. The light is projected in the form of a converging cone of rays. A lens is provided having angularly related surfaces adapted to project the light coming on in the form of a converging cone of rays, into a beam having a portion thereof in a substantially cylindrical form. The reflector is axially arranged on the trajectory of a projected beam, and substantially encompasses the frontal reflector comprising a distorted frusto-ellipsoid, the section of said frusto-ellipsoid being less than the rear parti-spherical reflector whereby rays from said rear reflector may be reflected from said ray conveying and collecting reflector.

1,800,357. **Multiple Gear System for Scanning Drum.** R. H. RANGER. Assigned to Radio Corporation of America. April 14, 1931. Rotary drum for carrying a picture to be scanned for facsimile transmission. A system of gears is provided for advancing the drum a predetermined amount for each longitudinal travel of the scanning system. The amount of rotation of the drum is varied in accordance with the number of paths of scanning thereon. A gear shift lever is provided so that the apparatus may be changed from the line-for-line type of scanning and reproducing into a cross-line or woven type of scanning and reproducing. The gear change also provides for shifting the operation of the apparatus from four channel, multiplex communication for operation on any number of communication channels. For example, if eighty lines per inch was the amount of detail desired and required in the transmitted and received picture with four channels in the communication system, the drum would have four-eightieths of

an inch of circumferential movement, with respect to each longitudinal movement of the scanning or reproducing system, imparted thereto, and for a similar in-increase or decrease in the number of channels, the line advance of the picture drum would be correspondingly changed.

1,800,410. **Automatic Safety Shutter for Motion Picture Projectors.** J. SEARS. April 14, 1931. A shutter which will automatically close off the light projection through the film in the event that the film breaks or should be brought to a stop or slowed down from its ordinary speed of travel to prevent ignition of the film. A mechanism is provided consisting of a rockably mounted mercury switch which is actuated upon the slackening or breaking of the film passed through the projector apparatus for energizing an electromagnetic device for effecting a release and closing of the shutter at the projection machine.

1,800,472. **Alarm for Indicating Completion of Facsimile Transmission.** R. H. RANGER. Assigned to Radio Corporation of America. April 14, 1931. An alarm for indicating when the transmission or reception of a picture has been completed in a facsimile apparatus. The rotating picture carrying drum which supports the picture surface has a disk on the end thereof which is notched to permit the operation of a lever which falls into the notch when the disk rotates to a given position. The lever operates a system of contacts for sounding an alarm whereby it is possible to indicate the time when a picture which has been transmitted or received is completed so that an operator may attend to the machine for recording and either stop its motion or insert a new picture for transmission or a new record surface for reproduction and thus avoid considerable waste of time in transmission, and avoid the need of constantly watching the reproduction and transmission to determine the time length of operation.

1,800,601. **Vibratory Mirror Arrangement for Television.** M. CENTENO. April 14, 1931. A vibratory mirror device where a mirror is mounted on a support for movement about a horizontal axis with electromagnetic means on the support having a link and lever connection with the mirror for vibrating the mirror at a given frequency. A separate electromagnetic means is arranged exterior to the support for oscillating the support in a different direction under control of a different frequency. The mirror is mounted for vibration in a horizontal axis under control of one frequency and for vibration in a vertical direction under control of a different frequency for moving a spot of light and tracing a light beam for reproducing an image.

1,800,627. **Portable Motion Picture Screen and Frame.** F. P. HECK. Assigned to Da-Lite Screen & Scenic Co. April 14, 1931. A portable motion picture screen which can be carried in a case and unrolled upon a spring operated roller. A slat member is provided serving as an upper screen support, the flexible screen being permanently secured at one edge to the slat member and at the opposite end to the roller. There are foldable spring arms hingedly supported within the carrying case and adapted to be projected into extended positions for stretching the projection screen in a taut position.

1,800,745. **Pneumatically Operated Fire Shutter for Projectors.** N. A. NICHOLSON. April 14, 1931. A pneumatically operated shutter control mechanism for fire protection in a motion picture projector. The motion picture projector is equipped with a shutter controlled by a valve which is supplied with air pressure through a tube. A fire shutter is normally held in inactive position

by an arm projecting into the control tube in which a vacuum is created. The condition of pressure or vacuum in the tube is controlled by the condition of the film strip. An abnormal condition of the film strip passing through the machine serves to release a fire shutter to cut off the light rays projected from the lamps of the machine and protect the film strip from the intensive heat of the lamps.

1,800,803. **Synchronous Automatic Talking Machine.** W. R. MOORE, JR. Assigned to Deca-Disc Phonograph Company. April 14, 1931. A continuous disk record sound reproducer adapted for synchronous operation with pictures where an induction motor drives a rotating record table adjacent a stack of records which are automatically shifted from the face of the stack and *vice versa*, whereby the talking machine may be operated continuously and a record supplied at the end of each successive record. An escapement is employed for selectively determining the number of records to be played and automatically governing the operation of the talking machine.

1,800,868. **Multiple-Winding Pick-Up for Improved Sound Reproduction.** T. H. MCCLAIN. Assigned to Roy G. MacPherson. April 14, 1931. An electrical sound reproducing system where a phonograph pick-up is provided with a multiplicity of windings each efficient on different bands of sound frequencies, the windings being connected in different sound reproducing circuits efficient over a corresponding range of sound frequencies for operating loud speakers efficient to corresponding ranges of sound frequencies thereby effecting the reproduction of sound efficiently over the entire frequency band.

1,801,061. **Double Reel Case for Automatically Rewinding Film.** H. M. THORTON. April 14, 1931. Film carrying apparatus which employs two spindles projecting through opposite ends of a casing. Each spindle carries a double-width, three-flanged reel. Two films of the same length are mounted side by side within the casing. The forward end of one film and the reverse end of the second film are attached to one double reel and the reverse end of the first film and the forward end of the second film are attached to the second double reel. The casing is symmetrical and may be removed from the projector, inverted end for end and re-inserted into the projector so that as one film is being exhibited the other film of the pair is being wound upon its second reel ready for exhibition when unwound therefrom.

1,801,123. **Self-Equalized Recording and Monitoring System.** L. A. TAYLOR. Assigned to General Electric Company. April 14, 1931. System for recording sound on a moving film and for monitoring the recording process where there is a sound pick-up device and a device actuated thereby for subjecting a film to illumination in accordance with sound vibrations. The recording apparatus is arranged to have greater response to the illuminating means at the higher frequencies of the sound than at the lower frequencies thereof. In the monitoring process there is a photoelectric device arranged to be actuated by the illuminating means. The photoelectric device responds more feebly at the higher frequencies than at the lower frequencies. The recording apparatus automatically compensates for losses in the higher frequencies. The operator of the recorder is advised at all times during the recording process exactly how the apparatus is functioning by means of the monitoring circuit operated from the illuminating means controlled by the sound pick-up circuit.

1,801,208. **Combined Phonograph, Radio, and Picture Projector.** E. RASMUSSEN. April 14, 1931. A cabinet which encloses a motion picture projector and a sound reproducing system. A sound reproducing horn connected to a loud speaker unit is arranged within the cabinet terminating immediately behind a motion picture projecting machine at the front of the cabinet. The motion picture projector has the projecting lens extending through the throat of the horn for projecting pictures on the screen at the front of the horn. A phonograph is mounted within the cabinet and the apparatus employed either as an entertainment device for the home or as an advertising device for the reproduction of motion pictures accompanied with a sound program.

1,801,430. **Triple Scanning System for Television.** C. E. HUFFMAN. Assigned to Jenkins Television Corporation. April 21, 1931. A scanning system in which there are three separate scanning devices. The devices are moved successively across a picture field. The separate scanning devices scan the subject or object in lines that mutually intersect. The invention provides a method of scanning an image or visual representation, wherein the entire object is first completely scanned over linear elements which extend across the image, or representation in one direction, and then is completely scanned over linear elements which extend across the object at an angle to the first linear elements.

1,801,472. **Drum Structure for Guiding Sound Film.** D. A. WHITSON. Assigned to Whitson Photophone Corporation. April 21, 1931. Structure for guiding a sound film comprising a cylindrical drum over which the film record operates. The drum has an extended flange beyond which the sound record can project. A stationary support extends within the drum beneath the sound record and forms with the drum an opening over which the sound record travels. A lens structure is arranged to pass radiations radially through the opening. The lens structure is mounted upon the projecting support. A reflector is provided on the projecting support for directing radiations from the light source through the lens. The direction of the light rays from the light source through the surface of the drum and the film carried thereon and through an optical system toward the light-sensitive cell in the sound reproducing circuit does not interfere with the rotative movement of the drum which drives the film.

1,801,756. **Double Disk System for Improved Scanning.** F. M. ROBB. April 21, 1931. A construction of scanning system where two separate scanning disks are journaled on a common axis but are individually driven at different speeds. One scanning disk is provided with radially disposed slots while the other scanning disk has a continuous convolute slot. The slots register under conditions of movement of the scanning disks to provide scanning apertures in alignment with a lens and photoelectric cell system. The objects of the invention are to overcome the limitations so far found practical in regard to the size of the image and to make use of every bit of light available so as to produce a much brighter image and therefore capable of considerable enlargement by lenses; to reduce the dimensions of the scanning disk required to transmit a fair-sized image by omitting the customary spaced holes in scanning disks and replacing these by an arrangement of slots applied in a particular manner in the operation thereof; and to limit the space required for apparatus used in television and lighten the same, and thereby obviate the necessity of operating the rotated parts at a comparatively low speed, which is essential in large wheels and

disks well-known in this art; to emphasize the details in the transmission of the images and give forth a much more pleasant effect.

1,801,867. **Translating System for Reproducing Sound Employing Monochromatic Polarized Light.** B. J. KROGER. Assigned to Westinghouse Electric & Manufacturing Co. April 21, 1931. A sound reproducing system in which a source of substantially monochromatic light is employed adjacent to which the sound record moves in a position for controlling the effect of the light upon a light-sensitive element. The area of the sound record exposed to the light is limited and a polarizing lens is interposed between the light structure and the limiting means whereby diffraction phenomena occasioned by the limiting means are lessened. A photoelectric cell is employed that is particularly sensitive to monochromatic light and which gives an output that bears a straight-line relation to the intensity of the light falling thereon. The monochromatic light source is provided with a continuously variable intensity-controlling device, such as a rheostat, and the light is plane-polarized before it is allowed to pass through a limiting device to the film.

1,800,057. **Double Disk System for Improved Scanning.** H. P. DONLE. Assigned to Radio Inventions, Inc. April 7, 1931. A scanning system in which two aligned scanning disks are employed, one scanning disk having spirally disposed apertures therein and the other scanning disk having spirally arranged slots therein whose angular length is less than 360 degrees. The two disks are mounted on the same axis and are driven at different relative speeds. The slots and apertures co-act for effecting a scanning in greater detail than is accomplished with a single scanning disk. There are four revolutions of the scanning disk for one cycle of shutter apertures. The result is that for a given diameter of scanning disk the observation frame can be approximately sixteen times the area of the corresponding frame of the usual scanning disk.

(Abstracts compiled by John B. Brady, Patent Attorney, Washington, D. C.)

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Cunningham, T. D.: Born October 16, 1902, at Alton, Ill. B.S. in E.E., University of Missouri, 1926; drafting department, Western Electric Company, summer of 1923; meter department, Kansas City Power & Light Company, summer of 1924; radio engineering department and broadcast station operator KDKA, Westinghouse Electric & Manufacturing Company, summer of 1925; broadcast station operator FKRU, Stephens College, Columbia, Miss., 1925–26; radio engineering department, Westinghouse Electric & Manufacturing Company, 1926–30; engineering department, RCA Victor Co., Inc., 1930 to date.

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Fowler, E. W.: Civil engineering, Worcester Polytechnic Institute. Engineer dealing with special hazards, Committee on Fire Prevention and Engineering Standards of the National Board of Fire Underwriters, 1928 to date.

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Norling, J. A.: Born August 6, 1895, at Tunis, Africa. Photographic division, U. S. Army Corps, 1917–19; producing technical animated motion pictures for soldier training, Columbia University and U. S. Army War College, 1919–23; Bray Productions, Inc., 1923–25; secretary and treasurer, Loucks & Norling Studios, Inc., 1925 to date.

Olson, H. F.: B.E., University of Iowa, 1924; M.S., University of Iowa, 1925; Ph.D., University of Iowa, 1928. Research assistant, physics department, University of Iowa, 1925–28; research department, Radio Corp. of America, 1928–30; engineering department, RCA Photophone, Inc., 1930 to date.

Plank, W. C.: Born 1881, at Baucari, Mexico. Superintendent and manager, San Juan Mining Company, 1900 to date. Experimenter with continuous projectors.

Rippenbein, A. P.: Born 1895, in Russia. American Recono, Inc. ,1927 to date.

SOCIETY ANNOUNCEMENTS

NEW YORK SECTION

At a meeting of the New York Section held May 8th at the Westinghouse Lighting Institute in New York, a paper by Mr. A. F. Victor was read by Mr. J. Norling, describing the design and operation of the 16 mm. projector designed by the Victor Animatograph Corp. for home use. This was followed by a paper by Mr. Vesper A. Schlenker entitled "Acoustic Reverberation between Horns and Sound Screens," which described tests made on the acoustic properties of screens primarily with regard to reverberation occurring between the horn and the screen placed in front of it. The paper was illustrated by a number of oscillograms. Following this paper a film showing scenes in Berlin, produced by Europa, was projected for the entertainment of the members.

PACIFIC COAST SECTION

At a meeting held at the Pathé Studios, Culver City, on May 7th, the following papers were presented: "Frequency Control of Photophone Sound Track," by D. G. Tilton; "Transition from Rack to Machine in the Development of Picture Negative," by Michael Leshing; and "Some Practical Applications of Sensitometry," by Emery Huse.

LAPEL BUTTONS

There is mailed to each newly elected member, upon his first payment of dues, a gold membership button which only members of the Society are entitled to wear. This button is shown twice

actual diameter in the illustration. The letters are of gold on a white background. Replacements of this button may be obtained from the General Office of the Society at a charge of $1.00.

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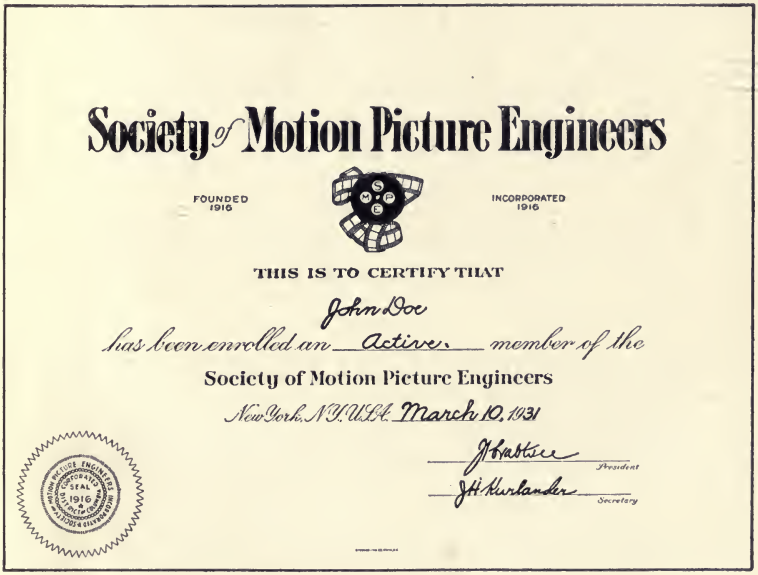
Society of Motion Picture Engineers

FOUNDED 1916

INCORPORATED 1916

THIS IS TO CERTIFY THAT

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New York, N.Y. U.S.A. March 10, 1931

President

Secretary

In the preceding issue of the JOURNAL it was announced that copies of the membership certificate, illustrated, could be secured by all associate members upon sending to the general office a request accompanied by a remittance of $1.00. Certificates for associate members will bear the seal of the Society impressed directly in the body of the certificate, omitting the gold seal. Certificates are at the present time being mailed to all active members *gratis* in accordance with a previous ruling of the Board of Governors.

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Prior to January, 1930, the *Transactions* of the Society were published quarterly. A limited number of these *Transactions* are still available and will be sold at the prices listed below. Those who wish to avail themselves of the opportunity of acquiring these back numbers should do so quickly, as the supply will soon be exhausted, especially of the earlier numbers. It will be impossible to secure them later on as they will not be reprinted. The cost of all the available *Transactions* totals $46.25.

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1920	10	1.00	1925	21	1.25		32	1.25
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Beginning with the January, 1930, issue, the JOURNAL of the Society has been issued monthly, in two volumes per year, of six issues each. Back numbers of all issues are available at the price of $1.50 each, a complete yearly issue totalling $18.00. Single copies of the current issue may be obtained for $1.50 each. Orders for back numbers of *Transactions* and JOURNALS should be placed through the General Office of the Society, 33 West 42nd Street, New York, N.Y., and should be accompanied by check or money-order.