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JOURNAL OF THE SOCIETY OF MOTION PICTURE ENGINEERS

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JOURNAL OF THE SOCIETY OF MOTION PICTURE ENGINEERS

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No. 1

RECENT DEVELOPMENTS IN THE FIELD OF MAGNETIC RECORDING*

S. J. BEGUN**

Summary.—New magnetic recording media have been developed during recent years which will widen substantially the field of application for magnetic recording equipment. Probably most outstanding among the new recording media is the non-ferrous wire or tape, plated with a thin layer of nickel-cobalt alloy, and the paper disks and tapes coated with a dispersion of magnetic powder.

It might be of particular interest to the motion picture industry that the coated recording media can be perforated to obtain synchronization between picture and sound. It is also possible to apply the magnetic coating directly to the film base.

When Valdemar Poulsen, in 1898, built the first magnetic recording instrument, he named it the "Telegraphone," a name which has since been used to identify all types of magnetic recording equipment.

In the January 1917 issue of the magazine *Machinery* an article appeared under the title "The Telegraphone." In the light of recent developments, one paragraph of this article merits special attention:

"Another application which is being developed is the use of the telegraphone in connection with the motion picture machine. The talking picture has never been made a success because of the difficulty of obtaining perfect synchronism between the pictures thrown on the screen and the recording of the voice. With the telegraphone, perfect synchronism is possible. This is accomplished by depositing a strip of pulverized iron filings directly on the film itself. The sound waves are thus carried directly on the same film as the pictures. In reproducing, an amplifier can be located behind the curtain and connected telephonically with the motion picture machine."

It was optical recording which was accepted later as the proper method for providing a sound track on motion picture film, but in other respects the statement which was made 30 years ago has cer-

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

** Brush Development Company, Cleveland, Ohio.

tantly a prophetic note. It is only now that recording media are available which use a coating of finely dispersed magnetic powder applied to a plastic or paper base.

It was in 1928 that Pfeumer, in Germany, made the first practical attempt to apply a magnetic coating to paper or plastic material for use as a recording medium. The A.E.G., in Germany, took over the Pfeumer patent and developed in co-operation with I. G. Farben a coated recording medium and recording equipment which was marketed in 1935 under the name of "Magnetophone." The Magneto-

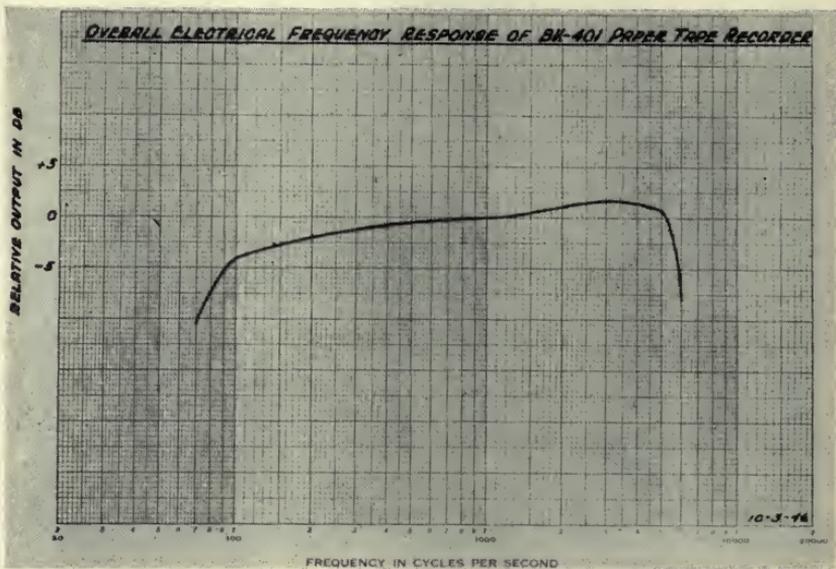


FIG. 1.

phone equipment, manufactured even as late as 1939, had a poor signal-to-noise ratio (about 20 db), but the instrument served quite adequately as a dictating machine. During the war the Germans made considerable further progress in developing recording media of this type, but information about these improved media became available only lately.

In this country little attention had been given to the development of coated magnetic recording media until, in 1939, the Brush Development Company started experimental work in this field. This activity was greatly accelerated during the war since it became clear that such

coated recording media would be relatively inexpensive to manufacture. This war development, which was conducted under the auspices of the National Defense Research Committee, seems to be one of the most potent factors which will bring magnetic recording from the scientific backstage into the commercial forefront.

Only about ten years ago it was considered necessary to have the recording medium move with a speed of two to three feet per second, to cover a frequency band wide enough for low, or possibly, medium



FIG. 2. The *BK-401* magnetic paper tape recorder.

quality sound recording. With the coated recording materials it is now possible to go up to about 5000 cycles with a speed as low as 7.5 in. per sec. In Fig. 1, the frequency response of a so-called paper tape recorder is shown, in which the recording medium moves at 7.5 in. per sec.

The recorder itself, which was designed for home use, is shown in Fig. 2. The design is of some interest to the motion picture engineer, since its mechanical arrangement is very similar to that of a motion picture film projector. It uses two 8-mm reels with a 7 in. diameter.

To simplify the mechanism, three motors are used. The shafts of two motors serve also as reel shafts. The third motor drives through a simple mechanical filter a capstan which propels the tape with a linear speed of 7.5 in. per sec.

In Fig. 3 a top view of the unit is shown, with the tape moving from one reel through the magnetic head over the capstan drive to the other reel.

Depending upon the direction of the tape motion, either one or the other reel motor is energized. For fast forward and fast rewind, the tape is removed from the capstan. Half an hour of recording can be stored on a 7 in. reel and can be rewound within less than one minute.

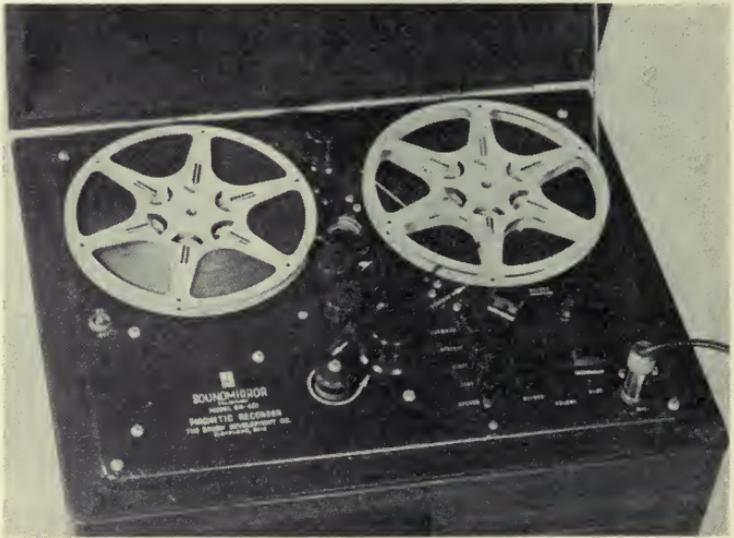


FIG. 3. Top view of the *BK-401* magnetic tape recorder.

Fig. 4 shows the capstan drive and its mechanical filter arrangement. The motor shaft drives the capstan flywheel through a rubber-tired idler.

Magnetically coated recording media, when used with the proper recording and reproducing heads, not only have an excellent frequency response characteristic when considering the slow operating speed of the medium, but they also have a remarkable dynamic range. Under carefully controlled experimental conditions, a signal-to-noise ratio of better than 60 db has been measured and, in fact, no final

data are at present available on what signal-to-noise ratio could be obtained under ideal conditions. The major difficulty which confronts the experimenter is the low output level on the terminals of the reproducing head, which in many cases makes the amplifier noise the limiting factor. To obtain such a dynamic range, it is necessary to have powder particles of extremely uniform size. Furthermore, these particles must be of small diameter, not exceeding one micron. In Fig. 5 an electron-microscopic picture of the powder particles is shown.

The level of reproduction depends upon the thickness of coating upon the concentration in the coating and upon the magnetic proper

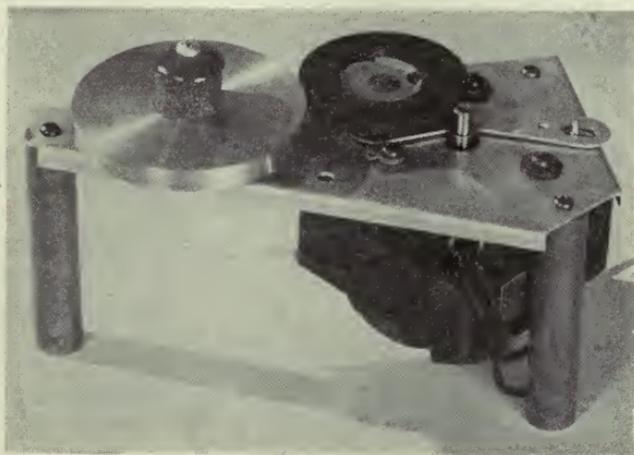


FIG. 4. Capstan drive and mechanical filter of the BK-401 magnetic paper tape recorder.

ties of the powder particles. Unfortunately, the pigment concentration in the coating cannot be increased beyond a certain limit without interfering with the making of a good dispersion. To secure good frequency response the thickness of the coating must not substantially exceed 0.6 mil. Powdered materials with better magnetic characteristics are under development.

There is also the possibility of obtaining a higher output level by making the tape wider but then one is confronted with difficulties of mechanical nature. With a speed of 7.5 in. per sec., the wavelength of a recorded 5000 cycle signal is only 1.5 mils. If the position of the gap of the magnetic recording head with respect to the sound track

on the recording medium deviates ever so slightly from the position of the magnetic gap of the playback head, the level of reproduction for high frequencies will drop substantially. This is a problem with which the sound motion picture engineer is quite familiar. It is, in many respects, similar to the results which one obtains when one reproduces a variable density recording with a slightly shifted light slit.

To obtain an essentially flat frequency response up to 5000 cps, with a recording medium moving at a speed of 7.5 in. per sec, extreme care must be taken in the design and construction of the recording and reproducing heads. These magnetic heads are formed of two

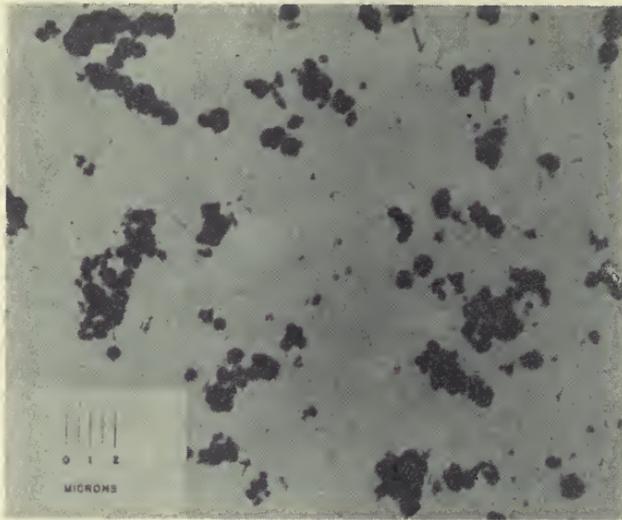


FIG. 5. Electron micrograph of magnetic powder particles.

identical pole pieces, assembled so that their ends are separated by extremely small gaps, which should not exceed 0.0005 in. This small gap is required during the recording process in order to focus the magnetic flux in almost a geometric line perpendicular to the motion of the recording medium; and it is also required in reproduction, since the output level drops substantially when the gap length approaches the dimension of a recorded wavelength.

In Figs. 6 and 7, two different types of recording heads are shown. In the first recording head, the pole pieces consist of a number of stacked laminations. In the other head each pole piece is formed of a

single sheet-metal portion, bent to proper shape. In both heads the pole pieces are symmetric with respect to the gaps. A coil is placed on each pole piece. This symmetry reduces substantially the effect of external magnetic flux disturbances, and yet maintains high effi-

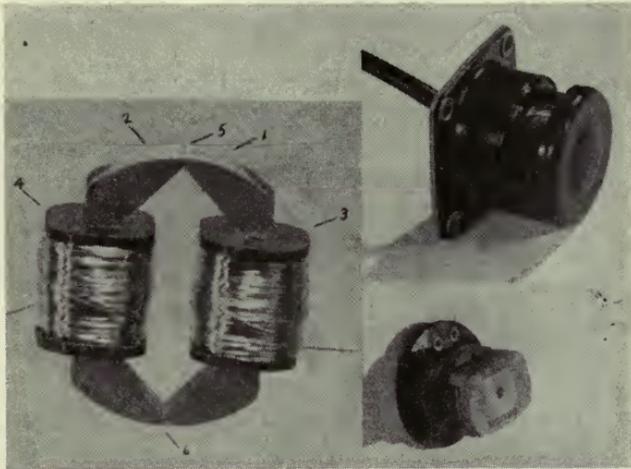


FIG. 6. Laminated recording head.

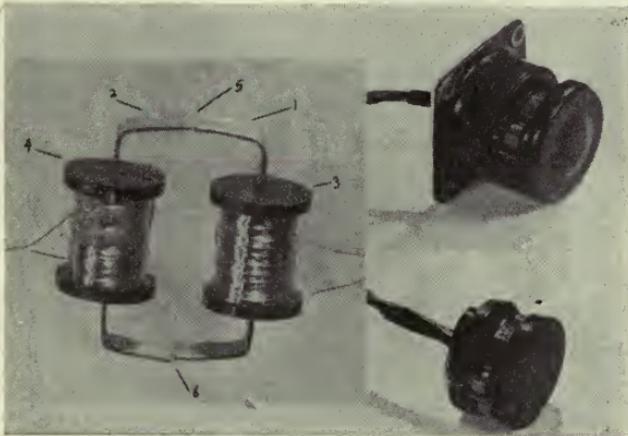


FIG. 7. Single sheet-metal recording head.

ciency in picking up the magnetic signal from the recording medium. The head which employs pole pieces made of a single piece of sheet material is more susceptible to permanent magnetic fields and should

not be used where strong magnetic fields could permanently magnetize it. The laminated head has higher losses but cannot as easily be permanently magnetized.

In the completed state, each of these heads is preferably provided with magnetic shields. As the output level is low at low frequencies, the addition of the shield is very important, since the hum bucking feature in itself would not be effective enough to give a good signal-to-noise ratio at low frequencies.

As do motion picture films, magnetically coated paper or plastic tapes vary in length as the result of temperature and humidity. If it is desired to synchronize a picture with sound, special provisions have to be made. The use of perforations in the magnetically coated tapes provides one well-established method. In a typical motion

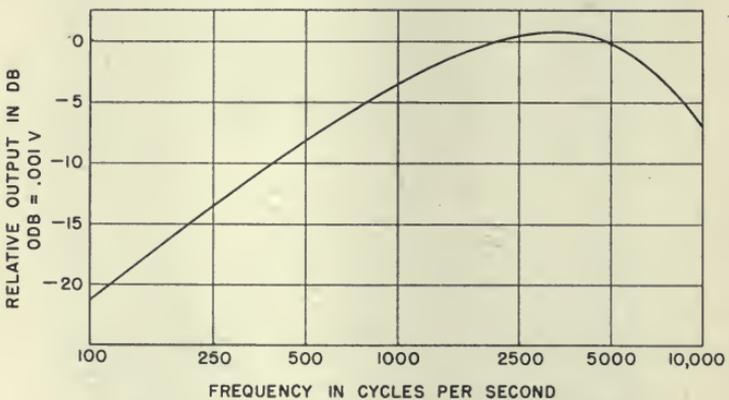


FIG. 8. Unequalized frequency response of paper tape at 18 in. per sec; recorded at 0.3 ma, max current = 0.8 ma, bias 1.7 ma at 30 kc.

picture sound recorder, a 35-mm magnetically coated perforated tape can be substituted for the 35-mm light-sensitive film, and the light valve can be replaced by a magnetic recording head. If desired, a number of sound and signal channels can be recorded simultaneously. Electronic methods to obtain synchronism as an alternative to the use of sprocket holes are under consideration at present and might lead to a practical system.

The coating can be applied to the film base directly. A film provided with a magnetic sound track might be extremely useful for the sound motion picture amateur because of the erase feature. While

projecting the film, recordings can be made over and over until a satisfactory sound arrangement is obtained.

Fig. 8 shows an unequalized frequency response of a paper tape moving with a speed of 18 in. per sec, the same as that of 35-mm sound film. It is fairly easy to equalize such a magnetic recording system up to 13,000 cps, which is certainly comparable to the best which has been done in film recording.

Up to this time it has been considered impossible to obtain any worthwhile sound recording on 8-mm film. The speed of 8-mm film, assuming 24 frames per sec, is a little better than 3.5 in. With magnetic recording a quality can be obtained which is good enough for speech intelligibility and it appears that for amateur applications 8-mm sound film is now in the realm of possibility.

Of course, if a magnetic recording track is provided on 16-mm film, the quality of reproduction is certainly adequate for amateur use and most likely even for professional applications.

Because of the low speed of the recording medium, it has for the first time become possible to design a practical magnetic disk recorder. The idea of recording on magnetic disks is certainly not new. In a newspaper article (*Springfield Republican*, Sept. 15, 1912), the following statement was made:

"By substituting small steel disks for the customary steel wire, it is plain that records may be taken by magnetic impression as they are now taken mechanically on the wax disks of a phonograph. The disks can then be sent by mail as letters, with no danger that anyone can read them except the one for whom they are meant, for the blank steel tells no tales till it is put on another Telegraphone and repeats the message it conceals."

When these words were written, the field of magnetic recording was yet in its infancy and it would have been entirely impossible to design equipment of any commercial value. But because of the development of the magnetically coated recording media, what used to be a dream has now become reality.



FIG. 9. Disk-type magnetic paper recorder.

In Fig. 9 a disk-type recorder is shown. A three-minute voice recording can be made on a coated paper disk, starting from an inner

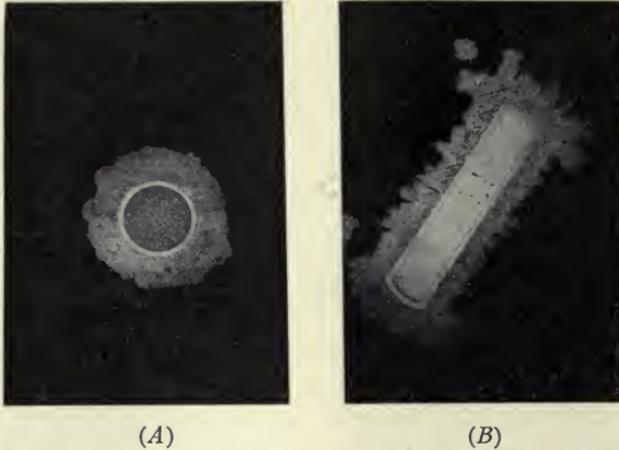


FIG. 10. *A*—Cross section of plated wire; *B*—Cross section of plated tape.

diameter of 5.5 in. to an outer diameter of 8.5 in. The sound track is 14 mils wide and the spacing between sound tracks is 11 mils, thus

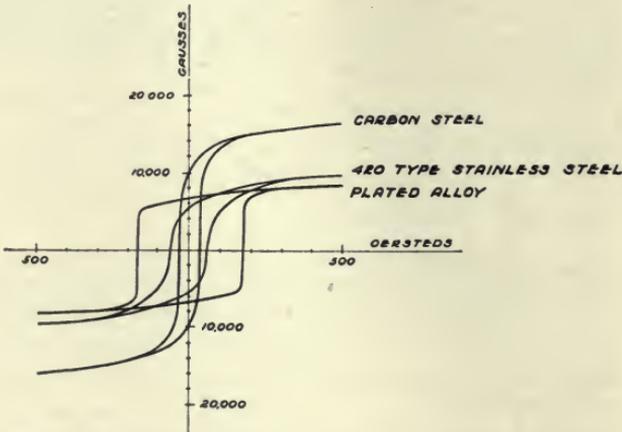


FIG. 11. Representative hysteresis loops of various recording media.

allowing for 40 tracks per in. The turntable rotates at only 20 rpm. To guide the pickup properly along the helical sound track a grooved

guide disk is placed on the center of the record and is, by an appropriate pin, brought into a definite relationship with the record.

During the war the Brush Development Company, under the auspices of the National Defense Research Committee, developed another new recording medium which also will have its place in the magnetic recording field. A ductile nonmagnetic nonferrous wire, such as a brass wire, is used as a base material on which a thin layer of a highly magnetic nickel-cobalt alloy is plated.

To draw a material which has uniform magnetic characteristics with a high coercive force and a reasonable remanence is a fairly ex-

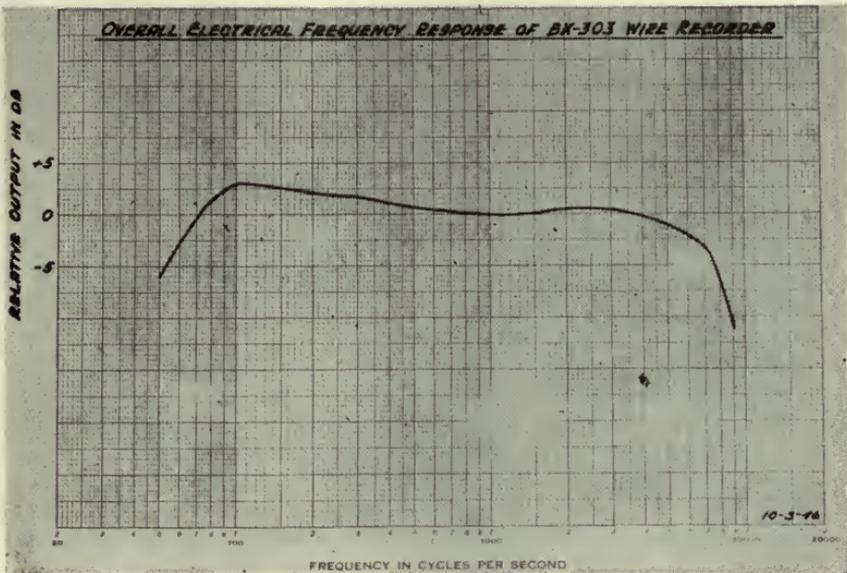


FIG. 12.

pensive process. It is true enough that substantial gains have been made in producing better solid magnetic recording media, such as wire and tape. However, the basic idea underlying the use of the plated recording medium was that it would be possible, with little expense, to draw a fine brass wire with high dimensional accuracy and then plate this wire inexpensively to secure a magnetic alloy deposition of excellent dimensional and magnetic uniformity. In Fig. 10 the cross section of such a plated wire is shown. Fig. 11 shows the hysteresis loops of carbon steel wire, which was used in the 1930's; the stainless steel wire, which was used particularly in military equip-

ment during the war; and the plated wire which now will become available on commercial wire recording equipment.

In Fig. 12 the frequency response of a Brush *BK-303* wire recorder is shown, in which the plated wire moves with a speed of 2 ft per sec.

The question might be raised, "Why should wire be used at all in the future, since from all available indications the coated magnetic recording materials seem to have so many advantages?" The answer is fairly simple. Though the coated materials can be operated with slower speed than the solid or plated wires or tapes to obtain an equivalent frequency band, the tapes have a substantially bigger cross section, and thus more space is required to accommodate them. Particularly for applications where a long playing time is needed, wire recording, probably in preference to any other method of recording, will have its place.

DISCUSSION

MR. R. J. TINKHAM: I wanted to ask what coercivity can be obtained with these plated materials.

DR. BEGUN: The coercivity of the plated wire as produced commercially is between 200 and 220 oersteds. It has been found possible to plate material with a coercivity as high as 300 oersteds.

MR. A. SHAPIRO: What linear speed per minute was the tape running through the machine during the demonstration?

DR. BEGUN: There were two magnetic paper tape recorders demonstrated; one model, which soon will be available on the market as a home recorder, has a paper tape speed of 7.5 in. per sec. The tape of the other unit moves with a speed of 18 in. per sec., a speed equal to that of 35-mm film.

DR. J. G. FRAYNE: What is the order of the distortion that is possible? What is the minimum distortion that can be obtained under well controlled conditions in either of these types of machines?

DR. BEGUN: Unfortunately, there is still not sufficient information available to supply data on distortions.. From the experiments we have made to date, it seems that for a dynamic range of 40 db, the intermodulation product does not exceed 5 per cent.

MR. L. HOLMES: There has been a lot of discussion about signal-to-noise ratio and signal-to-noise measurements on magnetic recording. We have heard some claims of 80 db for the captured German equipment. I would like to ask if Dr. Begun could explain how the signal-to-noise measurement of 60 db was measured, whether it is for the medium alone, or whether it is the medium plus equipment, whether it has any pre-equalization or post-equalization.

DR. BEGUN: Unfortunately, the Chairman has limited the time of discussion so that I am not able to go into all the details of how signal-to-noise ratio has been measured. However, I would like to summarize briefly the arbitrary test procedure which was followed:

First, a curve is plotted which relates the input current to the recording head

for a 1000-cycle tone to the output voltage. The system is considered to have a linear transfer characteristic as long as a current increase in recording results in a proportional voltage increase in reproduction. The point where the output voltage deviates more than one decibel from the linear input-output relationship is designated as overload point. The ratio of the overload voltage to the noise voltage (distributed over the complete frequency range) is considered the signal-to-noise ratio. In the measurements referred to in my presentation, special care had to be taken in selecting the first tubes.

MAGNETIC SOUND FOR MOTION PICTURES*

MARVIN CAMRAS**

Summary.—A magnetic sound track on motion picture film is convenient and economical. The final recording can be monitored while it is being made and requires no processing. All or part of the sound track can be erased, and a new record put on; or the film can be edited in the usual manner. Apparatus for making high-quality records is described, including the sound head, constant speed drive mechanism, amplifier equipment, and the magnetic track. Over-all performance, frequency response, dynamic range, and distortion are given.

Three fundamentally different sound recording methods can be used with motion pictures. For a long time the mechanically cut or embossed recording was the most highly developed, and the first talkies used a phonograph disk synchronized with the picture. An optical sound track, however, is so satisfactory for most sound on film work that it is now used almost exclusively. Magnetic recording apparently has been neglected, although it has some unusual advantages over the conventional systems.

Fig. 1 illustrates the three sound recording methods. Similarities between the optical and the magnetic methods suggest that they may be used interchangeably, provided certain mechanical and electrical modifications are made. To compare the two systems we might list some advantages and disadvantages of each:

Optical Recording Advantages

- (1) Better resolution—better high-frequency response at a given speed;
- (2) No direct contact of recording head with the film—no wear or clogging problems;
- (3) Ease of duplication—direct contact printing.

Optical Recording Disadvantages

- (1) Requires developing before record can be played back;
- (2) Relatively expensive;
- (3) Cannot be monitored immediately;
- (4) Film technique—must be handled in the dark—expiration dates—processing skill required.

* Presented Oct. 22, 1946, at the SMPE Convention in Hollywood.

** Armour Research Foundation, Chicago, Ill.

Magnetic Recording Advantages

- (1) Simplicity;
- (2) Low cost of the magnetic system;
- (3) Immediate monitoring if desired;
- (4) No processing;
- (5) Magnetic record medium can be erased by demagnetizing and used over again (economy of material);
- (6) Parts of sound track can be edited by erasing, and dubbing in new sound;
- (7) No serious distortion with overmodulation.

Magnetic Recording Disadvantages

- (1) Head contacts the record—possibility of wear;
- (2) Technical performance not quite equal to the best possible with advanced optical methods.

It should be pointed out that the above lists are based on the present state of the art. In the last decade work done with film recording has been outstanding, especially with the advent of fine grain films and ultraviolet optics. It appears that film recording techniques have approached closely to theoretical limits of perfection, and there is no reason to expect revolutionary changes in the near future. On the other hand, we have by no means reached the ultimate in magnetic recording heads or media. Theoretically a magnetic track can be at least as good as an optical one, and the magnetic record should give a greater dynamic range without resorting to artificial noise reduction schemes.

Mechanical Drive.—In constructing a recording machine for studio work, 35-mm equipment was chosen because excellent wow-free, rigidly built film machines are available. These can be converted to magnetic recorders with a minimum of trouble. A sound-on-film recording machine built up from standard equipment is shown in

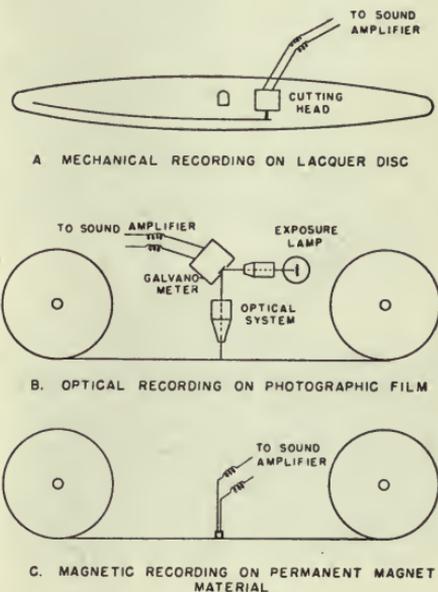


FIG. 1. Sound recording methods for motion pictures.

Fig. 2. The magnetic film, stored on the upper reel, is pulled into the sound head by sprockets of an old Simplex projector from which the intermittent mechanism was removed. The sound head is the latest Motiograph type. From this the exciter lamp, photocell, and optical systems were removed. In their place was mounted a plate containing three magnetic heads as shown in Fig. 3. These heads contact the film while it is against a rotary-stabilized drum. The film then feeds over a sprocket and on to a take-up reel in the conventional manner.

Magnetic Heads.—The magnetic head assembly is illustrated in

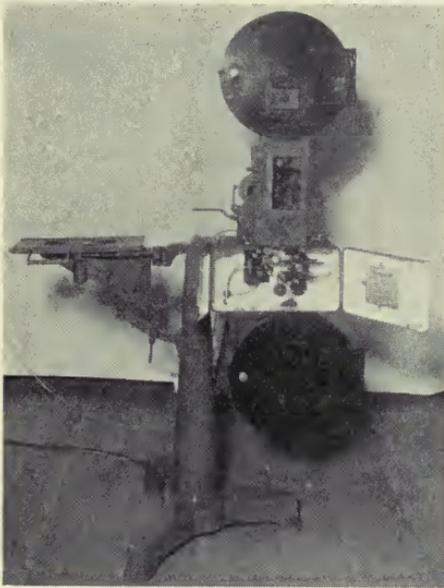


FIG. 2. Magnetic film recorder.

Fig. 4. A rigidly mounted adjustable plate holds three heads. Each head has an individual arm, spring biased against the film while the latter rides against the stabilized brass drum. The upper head is for erasing; it clears the magnetic track from any previous record and prepares it for receiving a new record. The erase coil is fed with high-frequency energy at 40 kc. Although a half ampere of current is sufficient for demagnetization, approximately one ampere is used to ensure perfect cleaning.

Recording is accomplished by the center head, which contains a main audio winding and an auxiliary high-frequency coil. The auxiliary coil is connected in series with the erase coil to secure proper high-frequency excitation. The audio winding is energized with signal current from the audio amplifier.

Below the recording head, and spaced from it, is the monitor or playback head. This is surrounded by a mu-metal shield to isolate it from direct pickup of magnetic flux from the recording head. The pickup head feeds through an amplifier, and reproduces the sound which has been recorded on the film 50 milliseconds before. It is thus possible to monitor the record as it is being made. Distortion,

etc., caused by improper adjustment is detected immediately, and steps can be taken to correct any faults without delay.

For best results it has been found advantageous to use "graded" sizes of magnetic heads. As seen in Fig. 5 the erase head is 0.240

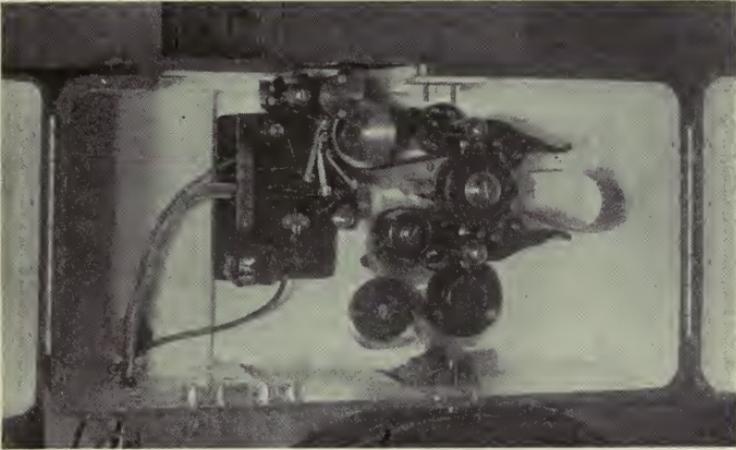


FIG. 3. Close-up of sound head.

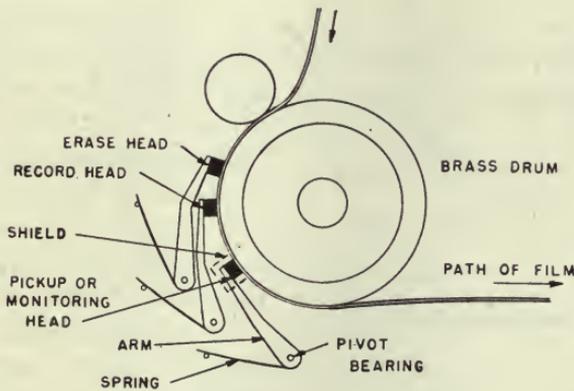
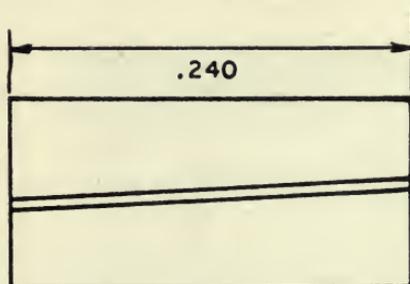


Fig. 4. Magnetic head assembly.

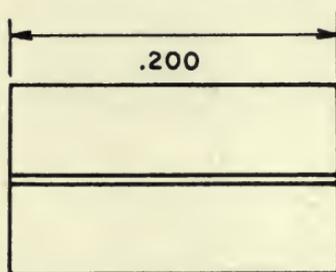
in. wide; it clears a track almost $\frac{1}{16}$ in. wider than the pickup channel space needed. The recording head is 0.200 in. wide. The pickup head is made 0.187 in. wide, and does not cover the entire recorded track. With an arrangement such as this, slight errors in lateral alignment are not serious, and do not result in distortion or cross talk.

Magnetic Film.—The recording film itself is a new product of

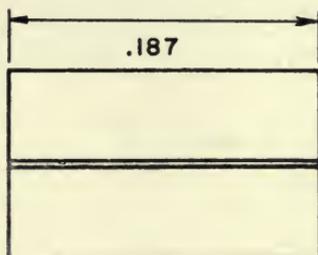
special interest. A cross section through a piece of 35-mm magnetic film is shown in Fig. 6. Standard acetate or nitrate stock is used for base material. Instead of the usual emulsion (or in addition



ERASE HEAD



RECORD HEAD



PICKUP HEAD

FIG. 5. Magnetic head dimensions.

to it) a half-mil coating of special magnetic material is used. The magnetic material is very finely divided, having a particle size of one micron or less, dispersed in a binder which gives a good bond to the base material.

Approximate magnetic properties of the coating in its final form are:

Coercive force	$H_c =$	350
Residual magnetization	$B_r =$	500
Maximum field for above readings	$B_m =$	1,000

It is noteworthy that high magnetic properties can be attained with peak fields as low as 500 or 700. This means that the material not only can be magnetized easily but also can be erased readily. Complete erasing by the high-frequency method has always been difficult with previous, high-coercive materials because of the high saturation fields required. As has been noted in previous work¹ a high B_r contributes to low frequency output, while a high H_c gives good high frequency response. Also a high H_c ensures that the record will be less influenced by stray magnetic fields which could cause

deterioration, especially of the high frequencies.

Dimensions of the sound tracks are given in Fig. 7. The useful working space on a 35-mm film coated all the way across is approxi-

mately an inch. Four sound tracks, each $\frac{3}{16}$ in. wide and spaced $\frac{1}{16}$ in. apart can be accommodated. Ordinarily, only one channel is

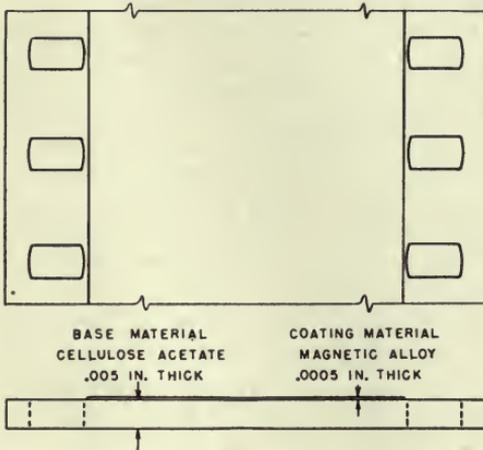


FIG. 6. Thirty-five millimeter magnetic recording film.

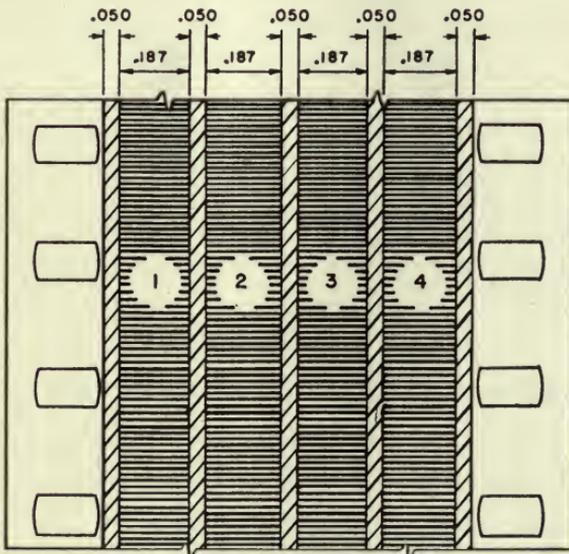


FIG. 7. Four-channel 35-mm sound system.

used, but the availability of the other channels offers some interesting possibilities:

- (1) Microphones might be placed in several positions, each pickup recorded

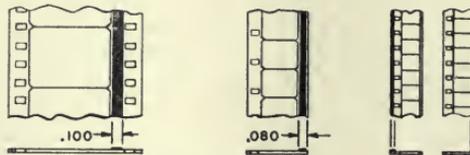
on its own channel, and the best "take" chosen. This might be important for new events where everything must be right the first time.

(2) Binaural or Stereophonic recordings are possible.

(3) One or more tracks can be used for control purposes.

(4) In editing, background music, sound effects, and control signals can be put on the side tracks. These can be erased, changed, or rearranged as many times as needed. When a satisfactory composition is made, all of the tracks are blended together in the rerecording process. By this process, the main record is rerecorded only once, thus minimizing noise and distortion.

(5) For some types of work the film spools can be interchanged and the film can be run through again, thus eliminating rewinding, and doubling the recording time without the need for extra heads or other apparatus. A binaural system has been made in which channels 1 and 3 are used with the film running in one



35-, 16-, AND 8-MILLIMETER PICTURE FILMS
WITH MAGNETIC SOUND TRACKS



8-MM FILM WITH FULL
WIDTH TRACK FOR SYN-
CHRONIZED WORK



COATED PLASTIC OR PAPER
TAPE FOR NON-SYNCHRO-
NIZED WORK

FIG. 8. Magnetic films and tapes.

direction; and channels 2 and 4 are picked up when the film is run in the reverse direction.

(6) By using narrower tracks, eight, sixteen, and even more channels can be accommodated. The quality is of course sacrificed when very narrow tracks are used.

Experiments have been made also with a wide variety of bases carrying a magnetizable material. Some of these are illustrated in Fig. 8. Excellent results have been obtained with a magnetic sound track on 16-mm picture film, and a paper describing this work is now in preparation. An 8-mm sound system shows promise; although the quality is poor, it may be adequate for amateur work.

Amplifier Equipment.—The amplifier equipment needed for magnetic recording is conventional in most respects. Ordinary

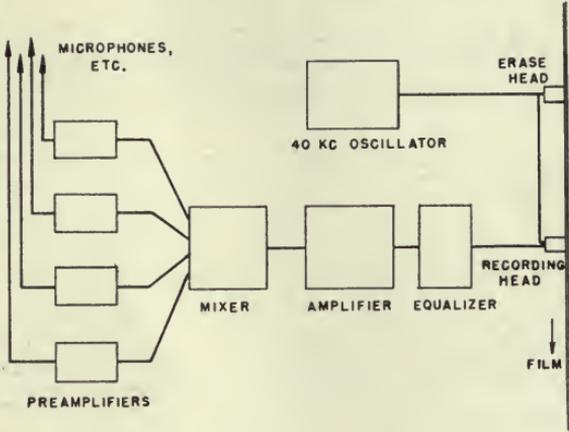


Fig. 9. Recording system.

sound-on-film amplifiers can be modified readily for magnetic sound. Fig. 9 is a block diagram of a typical recording system. Pre-equalization is used for the high-frequency end of the spectrum to

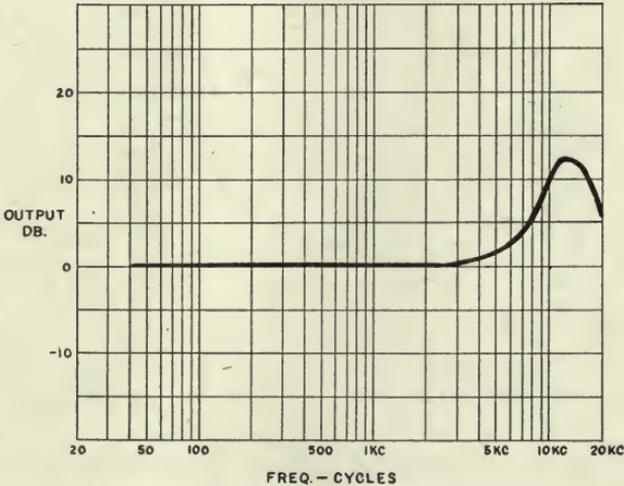


FIG. 10. Response of recording equalizer.

compensate for slit-loss in the recording head and for the inefficiency of short magnets in the record medium. The extent of these losses is indicated by the response curve of Fig. 10. Except for the boost at

high frequencies the recorded flux is proportional to the input voltage of the system. This may be expressed by

$$\phi_r = K_1 V_{in},$$

where ϕ_r = the recorded flux,
 K_1 = a constant of proportionality,
 V_{in} = the input voltage to be recorded.

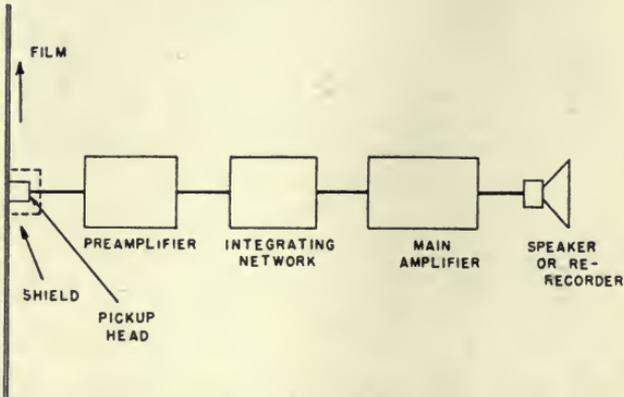


FIG. 11. Playback system.

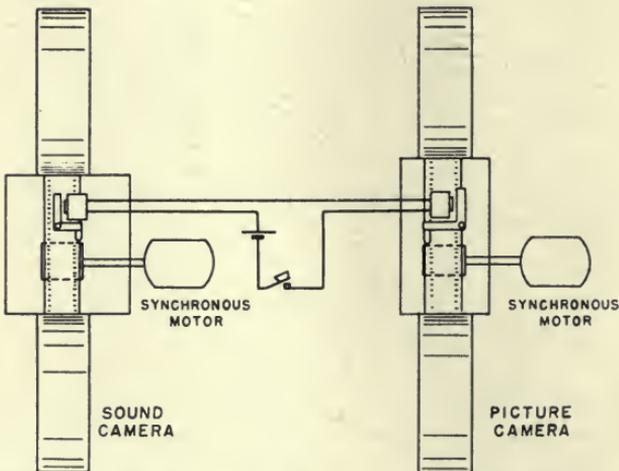


FIG. 12. Synchronization of sound and picture cameras.

In playback, the voltage generated by the head is proportional to the rate of change of flux, so that

$$V_{out} = K_2 \frac{d\phi_r}{dt} = K_1 K_2 \frac{dV_{in}}{dt}. \quad (K_2 \text{ a constant}).$$

This equation indicates that the playback voltage is proportional to the derivative of the original signal, which not only causes a phase shift, but also gives a rising frequency characteristic. For proper reproduction an integrating network is necessary. It is advantageous to place this integrating network in a later stage of the voltage amplifier where it will also reduce tube noise. The playback system is diagrammed in Fig. 11.

Operation.—Magnetic film recorders may be used in the same way as optical recorders. A recorder using synchronous motor drive is illustrated in Fig. 12. The sound camera and the picture camera are brought up to speed, and reference marks for synchroni-

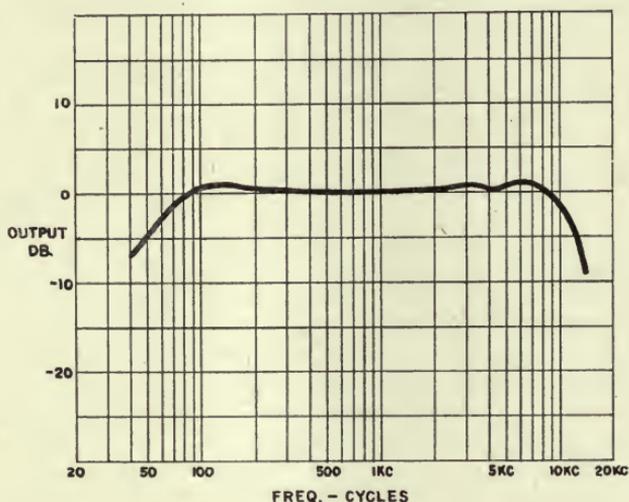


FIG. 13. Over-all frequency response of 35-mm magnetic recording system.

zation made by clapping boards together in the usual manner. The recorded noise is as sharply defined on the magnetic track as it is on an optical one; naturally it cannot be seen, but it can be located easily by exploring with a pickup head in the editing machine.

A synchronizing system as in Fig. 12 may be convenient. Here a pair of relays are mounted, one in the motion picture camera, the other in the sound camera. Energizing these relays puts a scratch or a dab of paint on each of the films. These marks are later used for synchronization or for reference. Since the magnetic film is driven at a standard speed of 90 ft per min, it will fit directly into editing,

rerecording, and printing machines, these being provided with magnetic pickup heads.

Over-all response of the experimental system is given in Fig. 13. The frequency characteristic is flat from 50 to 12,000 cycles within ± 3 db. Intermodulation distortion was measured by recording a combined 100-cycle and 7000-cycle signal, the 7000-cycle component being 12 db below the 100-cycle tone. Wave analyzer measurements showed a total intermodulation distortion of 4 per cent at normal recording levels. Variation of intermodulation distortion with recording level is given in Fig. 14. Dynamic range measurements indicate that a maximum signal-to-noise ratio of about 45 db is attained.

Conclusions.—A 35-mm magnetic sound recorder has been developed which has a number of novel and desirable features for

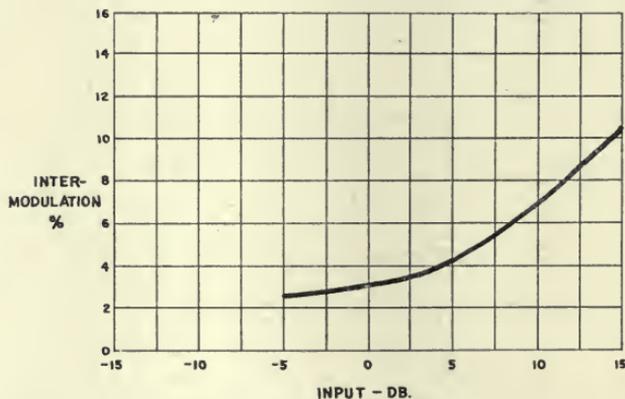


FIG. 14. Intermodulation distortion versus recording level.

motion picture work. The system can be used as an alternative to present photographic methods, and should be more flexible and economical. Laboratory measurements indicate that further improvements are probable.

The writer wishes to thank R. T. Van Niman and the Motiograph Company for their help in setting up the sound head. Acknowledgment is also due R. E. Lewis of Armour Research Foundation for his valuable help and consultation.

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DISCUSSION

MR. R. C. HOLSLAG: Is the magnetized track transparent or opaque?

MR. CAMRAS: The magnetized track is opaque. I do not know of any transparent material that is available.

MR. J. I. CRABTREE: I would like to ask two questions: How long does the magnetism last? Second, in the case of the paper record, how many feet are on a reel?

MR. CAMRAS: As far as we know, the record life would be determined by the base on which it is put, rather than by the magnetic material. The records are quite permanent with respect to time and with respect to repeated playbacks. They can be run thousands of times. In fact, experimental records have been played back hundreds of thousands of times, and I think the deterioration was in the order of 5 or 6 db.

In our film records, of course, the amount of film is exactly the same as for optical recording. A paper record has about 1000 ft of paper per reel of about 7 in. in diameter. At a speed of 7 or 8 in. per sec, it will last for half an hour.

MR. CRABTREE: How complete is the wipe-off?

MR. CAMRAS: The erasing is perfectly complete because the material is demagnetized, provided the peak erase field is considerably greater than the peak recording fields used.

MR. GEORGE LEWIN: In the use of this method, is the track put on before or after the picture is developed?

MR. CAMRAS: It can be put on either way. With existing pictures, sound can be added by a coating process. The film we have here had the track put on after. The possibility of adding a sound track to films which are already on hand is attractive. On the other hand, the track is quite waterproof, and we have made tests to see if it would stand the normal developing solutions. We can make a magnetic sound track directly as we make the picture, and the track will go through all the film processing and be retained.

MR. LEWIN: If you want to release this in theaters, each individual print will have to be recorded.

MR. CAMRAS: Of course, each release has to be run through a printer anyway. In that printer the magnetic track could be picked up and rerecorded.

MR. CRABTREE: Is there any offsetting of the magnetized record onto another convolution of film? In other words, does the record on the paper or film offset a magnetic image onto the portions of the tape adjacent to it on the reel?

MR. CAMRAS: Yes, we call that effect "transfer." There is no appreciable transfer with anything that is spaced by the thickness of the film which is about 6 mils or so. There is some transfer effect in wire recording where the convolutions of wire are in direct contact with each other, but even those can be kept in the order of 40 db or less, as compared to the recorded signal; and it is no problem at all with film recording.

DR. J. G. FRAYNE: Are these films available commercially, or are they just experimental films made up for your development work?

MR. CAMRAS: These films were made by Armour Research Foundation especially for development work. They are not available yet, but should be in the near future.

MR. BRUNSWICK: Is there any effect from metallic sprockets, and such, in

running through ordinary projection equipment? Does that cause any deterioration of the magnetic image?

MR. CAMRAS: It will not if the material is not in direct contact. Is that what you mean?

MR. BRUNSWICK: In other words, if it ran through ordinary projection equipment repeatedly?

MR. CAMRAS: The only modification we made was to take off the hardened stabilizer roller which became magnetized, and to substitute a brass roller. We have not put any hard surface on the brass roller, but it could be chrome-plated. That is the only change we have made. Otherwise the equipment is standard.

MR. WALTER SILVERS: If you have a can of film and drop it, will that demagnetize and erase the image?

MR. CAMRAS: No, it will not affect the recording at all.

MR. CRABTREE: In your 16-mm demonstration there was a ground noise on this side of the room.

MR. CAMRAS: I think you will notice the noise persisted even after the film had run off the head. This "vibrator hash" is caused by contact points on the motor governor. Otherwise the noise level should not be much worse than what you heard on our 35-mm equipment.

MR. E. W. KELLOGG: There has been reported in plenty of tests the fact that a very satisfactory magnetic rerecording on coated paper, narrow strip, works out very well. But, personally, I would anticipate some mechanical trouble in putting it on anything that is as stiff as motion picture film. I would expect you would have a kind of self-aligning mounting of your recording and playback head. Is that correct?

MR. CAMRAS: That is right. It seeks its own position.

MR. C. A. LINDSTROM: You mentioned ground noise. What in magnetic recording would cause a ground noise at all?

MR. CAMRAS: There is noise in every recording system that has so far been used. Of course, we try to keep it at a minimum. I think the noise would depend upon the particle size of the material, when you get irregularities which approach the gap size in order of magnitude. That would correspond to grain noise in a photographic recording.

MR. C. R. SKINNER: What is the relative output of this system? Is it less sensitive than optical recording?

MR. CAMRAS: I do not know what the optical recording systems give, but I believe the head plus matching transformer of the 35-mm job gives as much as $1/4$ -v peak output to the first grid.

MR. GEORGE TALLIAN: I would like to ask two questions: First, did you make any splices, and what did those splices sound like as they went through?

MR. CAMRAS: I do not think you heard any splices. They sound just like a click. If you have a continuous magnetic coating, then you should have a minimum of noise. You can hear a thud, or you can hear a slight click, depending on how skillfully the splice is made. I think it would correspond very closely to optical systems.

MR. TALLIAN: The second question is, did you put your magnetic material on the emulsion side or the celluloid side of an already developed picture?

MR. CAMRAS: We have done both. I believe it comes out that in order to re-

produce the sound on 16-mm film properly, and get the head located on the outside, we have to put the track on the back side of the film, not on the emulsion side; which is an advantage, I think, if we have to coat after the film has been made. But we have done it both ways, and obtained satisfactory coatings.

MR. STANSEL: Could you give a little more information on the network used in the playback? (Fig. 11.)

MR. CAMRAS: The recorded flux is proportional to the signal. In other words if we mapped the flux we would find that it was in direct proportion to the input signal. In order to play back, we have to use a magnetic device which is sensitive not to flux, but to the rate of change of flux. Therefore, if our record was a sine wave, we would find that we got a cosine wave on the reproduced signal; and also the output would be directly proportional to frequency. When we differentiate a sine wave, we have a frequency term appearing in the coefficient.

MR. STANSELL: Is that just an RC network?

MR. CAMRAS: Yes, it can be an RC network. We use a slight modification but an RC network can be perfectly satisfactory.

MR. F. C. SPIELBERGER: I would like to know about the volume range. You have said you do not have distortion as in film. Do you have saturation at high volumes?

MR. CAMRAS: Yes, it corresponds to saturation but is much smoother. It sounds like an overloaded amplifier rather than the harsh sound of an over-modulated galvanometer.

MR. SPIELBERGER: What is the volume range you get without distortion?

MR. CAMRAS: I think it is in the order of 45 db, if we record at the level corresponding to 5 db on Fig. 14. I think the 5-db level corresponds to something like 5 per cent distortion.

MR. J. W. THATCHER: Could you tell me at what speed you were running those films?

MR. CAMRAS: The 35-mm film is run at the standard speed of 90 ft per min. The 16-mm is run at 24 frames, which comes out to be somewhere between 7 and 8 in. per sec.

MR. P. E. BRIGANDI: In studio practice we record a negative and then we make prints which we use for editorial purposes, and preserve that negative so it will not be scratched or marked. What is your method, using one of these original tracks? How do you propose to copy it to use it in editing?

MR. CAMRAS: If we wanted to copy it, we could copy it magnetically, and record it on another magnetic track, provided we wanted to use magnetic systems all the way. We can use the original film and record or rerecord various sound effects and other things on adjacent tracks without in any way affecting the original track. And then, when we get the proper music, sound effects, etc., at the proper levels, we can rerecord the original track plus all the other tracks mixed together, onto an optical track, if we wished a release print to be used in conventional projectors.

MR. BRIGANDI: I was thinking of the earlier steps; as you are editing, you want to cut a little bit of the scene and add another piece from another scene together. Would you rerecord the track to use in the cutting rooms for that purpose, to assemble dialogue track, for instance, in continuity?

MR. CAMRAS: I do not see any alternative except rerecording unless you wish to edit the original track as it came.

MR. BRIGANDI: You mentioned the saving in the studio. We still would have to use another transfer for editing purposes.

MR. CAMRAS: I would say that is so if you wanted to do actual cutting and wanted to preserve the original. At any time, though, you can record it onto an optical system. You could have a magnetic original and do all your cutting on the optical tracks, if you wished.

MR. LEWIN: You mentioned the 40-kilocycle erasing current as going through the recording head as well.

MR. CAMRAS: The theory of that is rather involved. I believe it has been written up in several articles, but in short we need a bias, or you might say an exciting current in recording, in addition to the audio signal. This straightens out hysteresis effects of the magnetic material, and allows linear recording.

A MAGNETIC SOUND RECORDER OF ADVANCED DESIGN*

R. J. TINKHAM** AND J. S. BOYERS†

Summary.—Recent developments in magnetic recording have led to practical use of this art as a high-fidelity recording system. The particular apparatus described is the result of a need for wire recording equipment of professional caliber. It is characterized by good frequency response, low distortion, freedom from "wow" and flutter, and lock-in synchronous drive. The electrical and electromagnetic portions are the result of experience gained by research during the war. The mechanical portions have many parallels in motion picture equipment design. This apparatus is suitable for many motion picture recording applications.

Magnetic recording is about 50 years old. The first magnetic sound recordings were made by the Danish scientist, Vlademar Poulsen, just before the turn of the century. He recorded sound magnetically on heavy steel wire, but the reproduction was poor.

Because greater amounts of acoustical energy were available from mechanical recording systems than from magnetic systems, the mechanical systems were developed to a very high degree throughout the later years. However, with the advent of the vacuum tube and certain other techniques, it became possible to make practical magnetic recordings.

Following Poulsen's original efforts, work was done in Germany, and later in this country by Bell Telephone Laboratories, Brush Development Company, and others. Recently Marvin Camras, of the Armour Research Foundation, discovered principles and added refinements which have made magnetic recording both practical and economical.

A professional recorder of any type should incorporate as minimum requirements good frequency response, wide signal-to-noise ratio, low distortion, ease and economy of operation, and adaptability to existing auxiliary equipment.

Magnetic recording possesses certain advantages not found in other types. Among these are its long playing time with compact and light-

* Presented Oct. 22, 1946, at the SMPE Convention in Hollywood.

** President, † Chief Engineer, Magnecord, Inc., Chicago, Ill.

weight records, and its property of being unaffected by extremes of heat and cold. Mechanical shocks and vibrations are no problem during either recording or playback. The wire may be reused an unlimited number of times simply by erasing the previous material. Instantaneous reproduction is possible because the recording medium requires no processing. Repeated playbacks result neither in an appreciable increase of background noise nor in a noticeable deterioration of the recorded material.

The mechanical design considerations of a wire recorder have much in common with those encountered in motion picture equipment, plus a few more. It is difficult to grab hold of the wire mechanically. It is extremely difficult, if not impossible, to put sprocket holes in a 0.004 in. diameter wire. This led initially to a spool drive type of machine wherein the takeup spool pulled the wire past the recording and playback heads. As the spools were driven at a constant angular velocity, the wire traveled faster and faster as more wire was wound on the take-up spool. This had obvious disadvantages, the chief one of which was the variable frequency response resulting from the variable wire speed. Spool driven systems cannot be made to give the smooth wire drive demanded in professional type equipment because of the rapid instantaneous changes in the spool radius caused by the random piling up of the wire across the face of the spool. This gives rise to a random type of flutter.

To overcome these difficulties, it is obvious that the wire should be driven and the spools used merely to pay off or take up the wire at the necessary rate in the same manner as motion picture film is spooled. A capstan drive of some sort is in order. There are three general classifications of capstans: multiple wrap, in which the wire is passed around the driving member several times; pinch drive, in which the wire is held against the driving member by a pressure roller, usually rubber; and the jam drive, which has a wedging action on the wire.

The elimination of "wow" and flutter is as important in this type of recording as in any other and is solved in much the same manner by the use of rotating mass with suitable mechanical filters and dampers.

The spooling problem is similar to that in motion pictures with a couple of extra heartaches thrown in. The wire must be level-wound bobbin fashion, requiring added mechanical devices. An additional problem lies in the high speed forward-winding or rewinding of the recording medium. For certain practical reasons this must be accomplished on the same machine.

In professional use, where the reproduction must be repeatable within very narrow time limits, or where the record is to be used in synchronization with other equipment, some sort of synchronous drive is a necessity in addition, of course, to driving the wire with a nonslipping capstan. Where timing is important only with respect to total length of recording, as in the broadcasting industry, a synchronous motor, driven from a stable power supply, is sufficient. Where the device must be locked in synchronization with parallel acting devices, such as film cameras, projectors, or other recorder-reproducers an interlock type of motor is applicable.

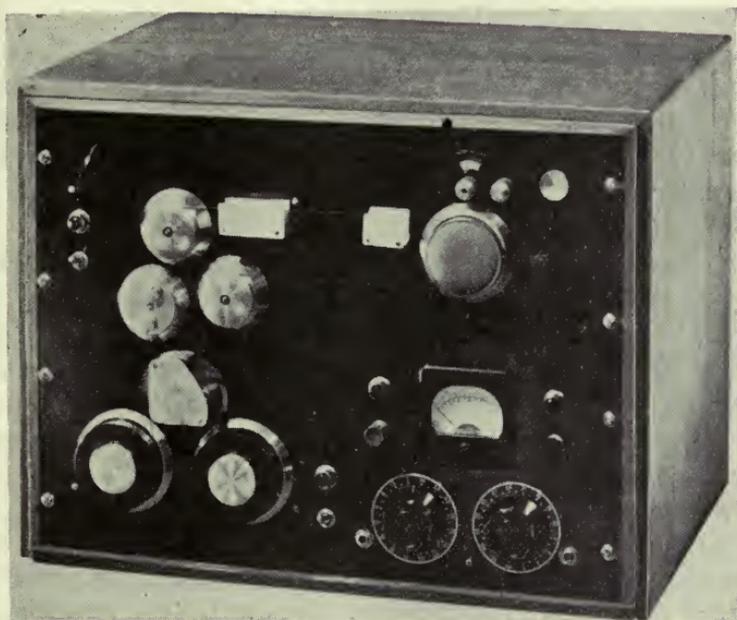


FIG. 1. Front view of Magnicorder Type *SD-1*.

Most of the above-mentioned mechanical features are incorporated in the design of the Magnecorder, Type *SD-1*. The jam-type capstan is machined to close tolerance after mounting it on the flywheel shaft. This shaft runs in sleeve bearings and is driven through suitable speed reducers by a synchronous motor. A timer calibrated in minutes and seconds is provided. This could also be calibrated in feet, if desired. Appropriate reversible spooling and level-winding mechanisms are driven from the capstan shaft. The wire has a slip in the capstan of less than one part in 5000 which corresponds to about one second in

one hour and 23 min of recording. At the wire speed of 4 ft per sec, used in this machine, that is the same as saying about a mile of wire must pass through the machine before there is a total slippage of one foot.

The unit is furnished in a cabinet (Fig. 1), or it may be mounted in a standard 19-in. rack. Console mounting is also available. Remote starting, stopping, recording, and playback may be incorporated if desired.

To damp out flutter caused by the spooling system, the wire passes through an antflutter set of spring loaded pulleys before entering the open type combination erase-record head. Following the recording head the wire passes over the playback head, then around the capstan, over an idler, the level-wind arm, and onto the take-up spool. The electrical apparatus is so arranged, that the pickup head may be used for either playback or monitoring purposes simultaneously with the recording operation. There is a delay of a fraction of a second between the recording and playback, caused by the distance between the two heads.

It is often desirable to hasten on to a later portion of the record, or to rewind the record rapidly. A mechanical control knob with suitable electrical and mechanical interlocks, shifts gears to drive the wire in either direction at a speed ratio of 4:1. Rewind to playing speed ratios as high as 30:1 have been used on auxiliary spooling units. However, it is not feasible to include such apparatus in the present Model *SD-1* Magne recorder where accurate wire measuring control is desired.

Operation of the unit is simple. The wire follows a well-defined path and is easily threaded up. Separate switches are provided for both the motor and amplifier power. To start the recording operation it is necessary only to push a red push-button switch which links up the proper electrical circuits to turn on the high-frequency erase and bias oscillator. The recording process may be stopped by either pushing the playback button or changing the direction or speed of the wire. Electrical interlocks mentioned previously provide this feature.

A "Volume Unit" meter is included to indicate the correct recording level. Separate gain controls are provided for the separate recording and playback (or monitor) channels. These controls utilize the bridge *T* configuration and are of the step-by-step type.

The magnetic recordings made by Poulsen utilized a recording system which might be called the direct current method. In this

system the recording medium was premagnetized to place it on a linear portion of the $B-H$ curve and the magnetization of the record was then changed in accordance with the recorded signal. This system suffered from inherent difficulties in signal-to-noise ratio and distortion.

The magnetic recordings of today are generally made using a supersonic bias to provide the linear characteristic necessary for a large signal-noise ratio with low distortion.¹ Several types of wire have been developed but one of the most satisfactory evolved to date is composed of solid stainless steel and is 0.004 in. in diameter. This wire is manufactured with close tolerances as to both mechanical and magnetic characteristics and is available in quantity. Using this medium, and with proper selection of the wire speed, machines have been made which reproduce from less than 10 cps to over 30,000 cps. Signal-to-noise ratios of better than 40 db are regularly achieved in production with low distortion in the recorded signal. Signal-to-noise ratios in excess of 55 db have been produced under laboratory conditions.

The Magnecorder Model *SD-1* requires an input signal of approximately zero VU level. The signal is fed through a recording amplifier utilizing a single stage of amplification. The output of this amplifier is fed through a transformer to the high-frequency pre-equalizer. This equalizer introduces a high-frequency boost to compensate for the reduced response of the recording heads in the upper portion of the frequency range. The recording head has two coils, one for the signal frequency and the other for the high-frequency bias current. The inductance of the signal frequency coil is approximately 2 millihenries while the inductance of the bias coil is only a few microhenries.

The supersonic oscillator utilizes a conventional Hartley circuit and supplies power for both bias purposes and erasing the wire. It is quite important that the erase field be powerful enough to eradicate completely the strongest signal which may be recorded on wires having high coercivity.

The playback head is similar to the recording head but lacks the bias coil. The output from this head is approximately 80 db below a zero VU level. Its frequency response rises approximately 6 db per octave from a low frequency to approximately 1000 cycles. The high end of the frequency response begins to fall off at approximately 5000 cycles, and at 12,000 cycles it is about 15 db down.

The reproduce amplifier has incorporated within it a low-frequency

equalizer which boosts 50 cycles approximately 22 db with respect to 1000 cycles. This compensates for the output of the reproduce head and in combination with the pre-equalizer mentioned above results in a frequency response which is flat within ± 2 db from 50 to 12,000 cycles, and is down 6 db at 15,000.

The output signal coming from the reproduce amplifier is approximately zero VU in level across a 600-ohm load. Distortion in the reproduced signal is kept at a low point by careful factory adjustment of the operating conditions. The total rms distortion is less than 1.5 per cent at 1000 cycles. This distortion is not seriously different throughout the audio range.

Numerous applications of wire recorders to the motion picture industry have been suggested. The inherent factors of low cost of the recording medium, ease of operation, portability, and ruggedness lend this system to many operations where other methods have serious deficiencies.

It has been suggested that a wire recorder might be used to record the original sound while making the picture. The wire could be edited in much the same manner as the movie film is edited and finally incorporated with other wires to form the final wire. The sound could then be dubbed to the final negative used to print the release. Savings in film through the use of this system for intermediate recording would be tremendous without any sacrifice of sound quality.

Editing is done merely by snipping the wire with scissors, splicing it with square knots, and then trimming off the ends. The knots ride over the reproducing heads with no perceptible interference during modulated passages.

If mistakes are made in the recording of either music or dialogue it is not necessary to discard the entire take. The recording may be reproduced to the performer, and, at the appropriate time, the recording button may be pushed, whereupon the performer repeats that passage which was previously in error. The recorder performs the operations both of erasing the previously recorded incorrect signal and dubbing in the correct program in its proper sequence. This has been demonstrated many times in both dialogue and music.

The recording of incidental sounds and sound effects may be made advantageously on wire. Here the fact that the wire does not deteriorate with repeated playings is a valuable feature. Recordings have been reproduced for several thousands of times with no appreciable impairment of the signal.

With suitable mechanical means it would be possible for the amateur to make his own sound recordings and reproduce them in synchronism with the picture. This system might also be utilized for providing sound with rushes which are normally silent. This recording system is ideally suited to dialogue rehearsals. In these applications the immediate playback feature of the wire and its low cost are obvious advantages.

Industrial films, where the cost must be kept as low as possible, can use wire recorders to great advantage in view of the small cost as compared with film recording methods.

Location recording is more enjoyable with less bulky equipment.

In conclusion, the authors do not mean to suggest that magnetic recording offers the industry a cure-all for recorded sound. There remain problems to be worked out in its specific application to the motion picture art. However, it does offer certain advantages not found in other systems of recording.

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MAGNETIC SOUND RECORDING ON COATED PAPER TAPE*

H. A. HOWELL**

Summary.—The object of this paper is to discuss the application of coated paper tape as a magnetic sound recording medium. The special features of this interesting new development which may render it desirable for many commercial uses are pointed out. Current trends in recorder design are discussed. A brief summary of tape recorder performance is given, including dynamic range, frequency response, and distortion characteristics. Some special features of the new recording medium relative to its possible use in the motion picture industry are pointed out.

In order to portray the present status of magnetic recording on coated media, it is necessary to mention briefly its history. The art is not new, but the techniques and equipment have progressed far beyond those of Poulsen, who devised the first magnetic sound recorder 50 years ago. Through the intervening years, many investigators have tried to achieve acceptable fidelity and length of recording time, but it was not until the advent of the Camras¹ wire recorder that this goal was reached. During World War II, the wire recorder served well in our armed forces and was used extensively throughout the world.

It was recognized many years ago that certain fundamental advantages could be gained by the use of a flat ribbon or tape for the recording medium, but these were overbalanced by the high speed at which it was necessary to operate the tape and the cumbersome reels which were required to maintain a satisfactory playing time. Some of the first powder tapes were coated with finely ground iron powders having relatively poor permanent magnet properties.

For several years before the war, and until it ended, the Germans² had achieved a large measure of perfection in equipment using magnetic powder coated media instead of wire. This was accomplished in spite of the relatively poor permanent magnetic properties of the iron oxide powders (gamma phase Fe_2O_3) employed as a coating material for these tapes.

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** Indiana Steel Products Company, Chicago, Ill.

Magnetics of Magnetic Sound Recording Media.—The performance of any magnetic sound recording medium depends greatly upon its magnetic properties. Since reference must frequently be made to the properties of permanent magnet materials in order to deal properly with the present subject, a brief review of these properties is in order for the benefit of those who may not be familiar with the terminology. The two most important properties of a permanent magnet as applied to magnetic sound recording are remanent magnetism and coercive force. Simply stated, remanence is the magnetic induction remaining in a magnet after an applied magnetizing force is removed. The applied magnetizing force may be produced either by a coil of wire carrying an electric current or by another permanent magnet held in close proximity. Coercive force can be broadly defined as its resistance to demagnetization. More spe-

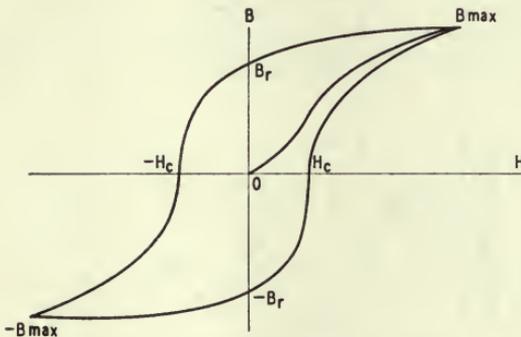


FIG. 1. Normal magnetization curve and hysteresis loop.

cifically, the coercive force in oersteds is the value of the applied demagnetizing field in a closed magnetic circuit required to reduce the magnetic induction to zero.

Fig. 1 is a hysteresis loop typical of a material having permanent magnet properties. Holmes and Clark,³ and more recently Camras,⁴ have discussed the relationship of the sound recording performance of wire and its magnetic properties. A magnetic record of sound along a wire or tape may be described simply as a variation in the intensity of magnetization produced by the magnetism from the recording head. Therefore, it can be seen by inspection of Fig. 2 that the external magnetic field extending from the surface of the tape coating will determine the energy that is usable in reproducing a sound record. In any case this external magnetic field is dependent upon the mag-

nitude of the internal magnetic induction in the tape and the magnetizing force. Special techniques in the use of supersonic magnetizing fields in connection with the audio frequency magnetizing field assures a linear and distortion-free magnetic sound record.

The density of the usable external field in a magnetic record of sound over a wide range of frequencies is rather complex in that, at the lower audio frequencies, it is most influenced by the magnetic remanence of the magnetic material and at the higher audio frequencies it is most influenced by its resistance to demagnetization. The large self-demagnetization factor of short magnets is very important since it influences the required inherent coercive force of the

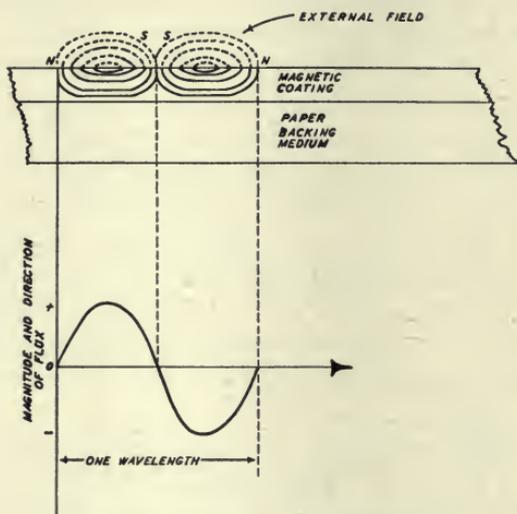


FIG. 2. Sinusoidal flux configuration on a magnetic sound record.

magnetic material. For this reason, the physical dimensions of the recording medium, whether it be a wire, or a thin coating of magnetic powders, must be taken into consideration in any appraisal of performance at the higher audio frequencies.

Magnetic Materials for Powder Coatings.—Progress in the development of coated magnetic tapes in this country during and since the war has resulted from several independently conducted research programs and has been responsible for the development of both metallic and oxide powders having permanent magnet properties superior to the German product. One such program initiated by the author has resulted in the development of a metallic coating

having permanent magnet properties approaching those of some of the well-known Alnico alloys, yet bearing no metallurgical resemblance to them. This material produced in the finely divided state has been applied to paper tape and is known as Hyflux.

The oxide materials which have been and are still being investigated fall into two general composition types. The magnetic ferric oxide (gamma phase Fe_2O_3) seems to have been used exclusively by the Germans. Investigators in this country, so far, seem to prefer magnetite and special variations of ferrous and ferroso-ferric oxides of the type (Fe_3O_4) produced by special methods and thermal treatment. While coercive forces of as high as 350 oersteds have been reported for specially processed ferrous oxide, most of the available experimental oxide tapes have coercive forces of less than 200 oersteds.

The recently announced metallic coated tape, Hyflux, has been produced with a coercive force of from 350 to 550. Hyflux powder, when compacted to form solid bar magnets, compares in general magnetic properties with other solid permanent magnet materials as follows:

	Density Grams per cc	Residual Induction B_r Gauss	Coercive Force H_c Oersteds	Max. Energy Product $B_d H_d$ max $\times 10^6$
Hyflux	2.81	2255	550	0.35
Hyflux	4.9	6610	390	0.97
Hyflux	4.96	7460	395	1.14
Magnetite	2.62	1600	190	0.09
Alnico III	6.9	6900	475	1.35

Any of the above materials, when finely ground to have particle sizes of one micron or less, would exhibit values of residual induction much lower than indicated for the solid state. The values for coercive force usually increase with decrease in density. This is particularly noticeable in the case of Hyflux.

Hyflux is produced by a unique process resulting in a very unusual physical structure, which may be a fundamental factor in the attainment of its surprising permanent magnet properties. An extensive investigation is being continued to establish a more complete understanding of this condition.

Sound Recorder Performance.—It should be understood that any presentation of data on the performance of magnetic sound recording media is limited by the conditions under which testing procedures have been conducted. Much of the performance data presented in

current literature is subject to various interpretations, depending on the equipment and the components used and the choice of parameters. Until such time as standardization factors can be established, it will be necessary to accept the data presented here as comparative values obtained under certain specific conditions.

Constant current response curves have been found to be greatly dependent on recording head design and materials. Theoretical response based on tape speed, gap length, *etc.*, is often masked by the more practical factors of core loss, permeability, and saturation characteristics of the head. A head with a low copper-to-iron ratio will

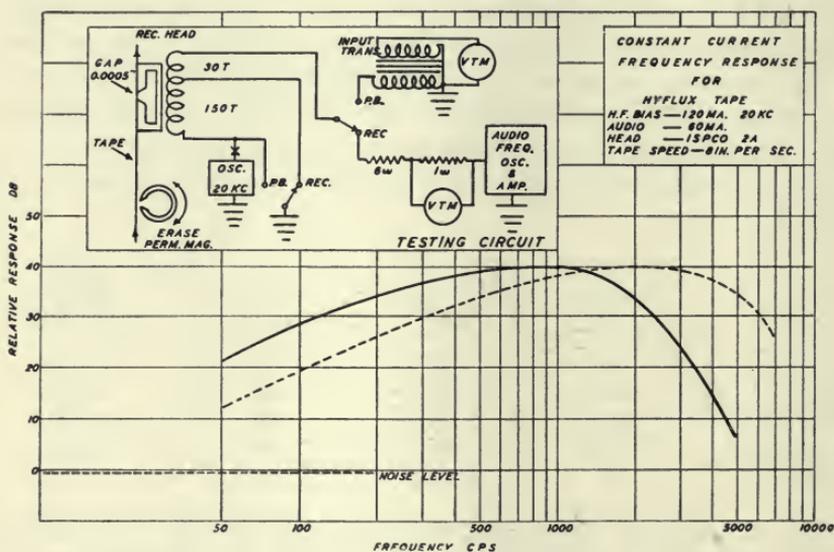


FIG. 3.

be more efficient at the lower frequencies than at the upper end of the audio range at low tape speeds. This may be more desirable than high-frequency efficiency at the expense of the low, because most of the background noise has been found to be in the lower frequency range.

The constant current response curve in Fig. 3 was made with a laminated head of low copper-to-iron ratio under the conditions indicated. Under the same conditions of tape speed, gap length, *etc.*, but with a different head, the peak may be moved forward by more than a thousand cycles at the expense of the lower frequency output as shown in the dotted line curve. The response of the head used in

making the second curve was substantially flat from 50 to 10,000 cps.

During the past two years, several sound recorders have been built to use Hyflux tape. Fig. 4 shows the over-all response of one of these machines. While the useful response is limited to within a 6000 cycle range because of the slow tape speed (8 in. per sec) recent research indicates that even at this slow speed the useful range might be increased to above 7000 cps through improved head design. The dynamic range is in the neighborhood of 40 db with less than 5 per cent distortion.

Fig. 5 shows input-output curves on Hyflux tape at three frequencies: 100, 1000, and 3000 cps. The point at which the curves begin

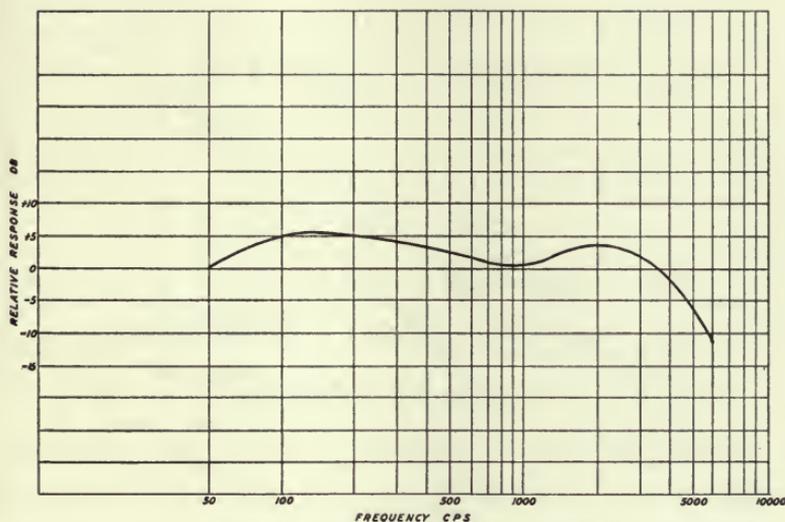


FIG. 4. Over-all recorder response Hyflux tape at 8 in. per sec.

to deviate from a 45-deg line by one decibel was taken as the point at which maximum undistorted output occurred. Since these points do not occur at the same input levels at the three different frequencies, it is evident that a rising characteristic is necessary for recording in order to prevent distortion at the lower frequencies. For example, a characteristic rising 3 db per octave from 100 to 1000 cps and 6 db per octave from 1000 to 3000 cps would be very nearly ideal for this system.

Hyflux tape requires a much higher supersonic biasing field than any of the oxide tapes. The required bias current under a given set of test conditions appears to be a function of the coercive force of the

recording medium. Fig. 6 shows noise and output versus bias characteristics of Hyflux tape. After roughly determining the proper audio input levels for each frequency, the three curves shown for 1000, 3000, and 4000 cps were run. Then with no audio input, the noise level was checked as a function of bias current. The optimum bias current was then selected by noting the point at which the maximum signal-to-noise ratio occurred.

It is significant that in all of the foregoing results constant field saturation was employed in erasing. This was accomplished by means of a small permanent magnet which subjected the tape to a longitudinal field of about 2000 oersteds. There is evidence indicating that

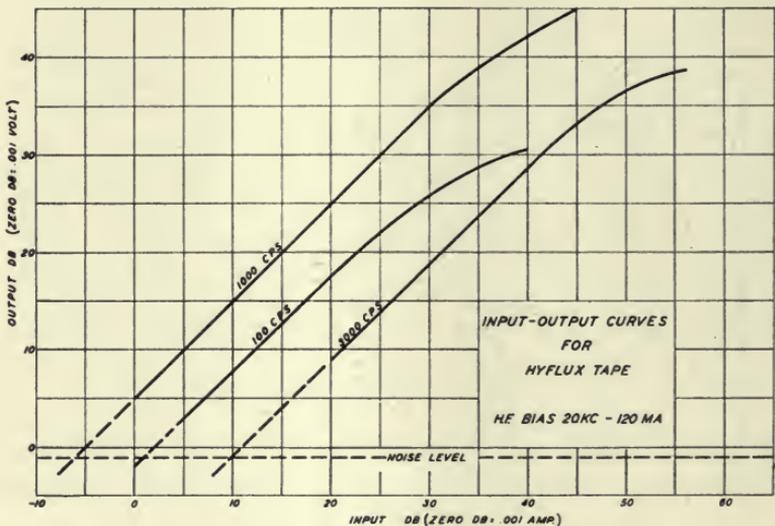


FIG. 5.

a significant improvement in signal-to-noise ratio might result if high-frequency erasing were used. The high coercive force of Hyflux introduces some difficulty in high-frequency erase head design, although it has been reported that such heads have been made to function satisfactorily.

Choice of Paper As a Backing Material.—The question may arise as to why paper was chosen as a base for Hyflux magnetic coating. During the early stages of the development it was necessary to devote considerable time on experimental tape pulling mechanisms. It soon became apparent that, in order to eliminate wow and flutter, a very rugged, positive grip, driving capstan was necessary. Such a

mechanism, if effective, is not inherently gentle on such fragile materials as plastic ribbons and the weaker grades of paper. Therefore, a special paper was chosen because of its superior dimensional stability and physical strength. Experience has shown that any material that stretches, tears easily, or becomes distorted under stress will be seriously impaired in its performance or fail completely. This is particularly important when the backing medium is 0.002 in. or less in thickness. On the other hand, coated cellulose acetate or other plastic backing results in somewhat less surface noise by virtue of its smoother finish. The use of a composite paper-plastic ribbon

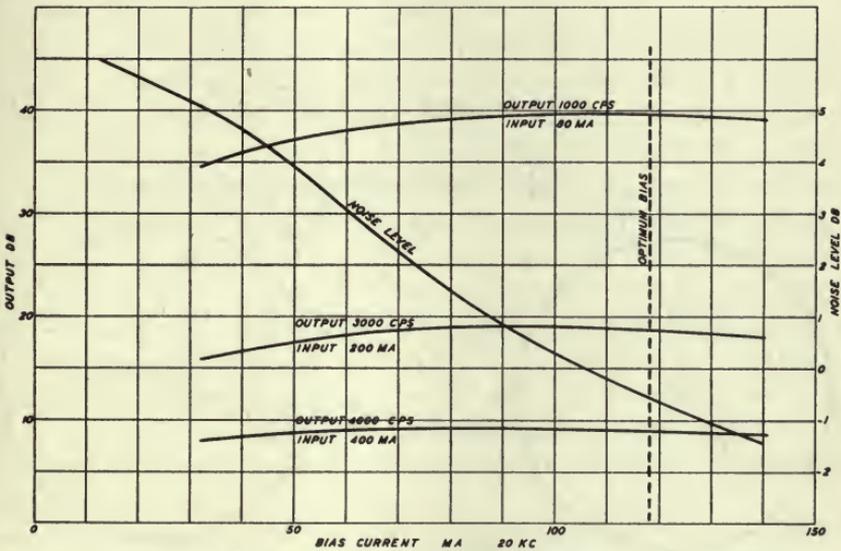


FIG. 6. Noise level and output versus bias current for Hyflux tape.

has been suggested in order to take advantage of both the excellent dimensional stability of paper and the more uniform surface finish of plastic ribbons.

In addition to its superior dimensional stability, paper has the advantage of being easier to handle, edit, and repair. The uncoated side can be utilized for markings, such as time, footage, synchronization, indexing, etc. From the manufacturing standpoint, its good handling properties and cheapness are important factors.

At the present time, most coated magnetic tapes have been produced in 1/4-in. widths, although there has been no move to standardize this dimension. As a matter of fact, coated magnetic recording

media can be produced to meet almost any specification in sheets, disks, ribbons, or bands. Techniques for production are being established and uniformity of output will be assured through the thousands of feet being produced for developmental purposes.

Trends in Recorder Design.—Few recorders designed to use coated tapes have been built in this country. Most of these have been engineered to meet the requirements of the home recording enthusiast, and none, so far as the writer knows, has reached the market.

One model now being planned will have a frequency range of from 50 to 9000 cps, and will be suitable for commercial recording. During

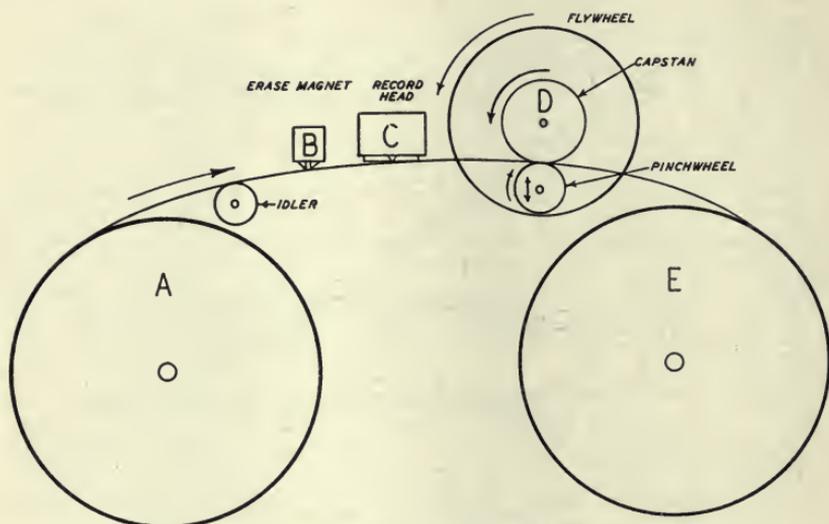


FIG. 7. Simplified magnetic tape recorder mechanism.

the coming year, there will no doubt be a number of commercial high-fidelity tape recorders produced. Most of present day experimental tape recorders use 8-mm film reels with the $\frac{1}{4}$ -in. coated ribbon.

Fig. 7 is a simplified version of a mechanism suitable for use in coated tape sound recorders. The tape runs from supply reel A over the erase head B which is energized only when recording; then over the combination recording and reproducing head C to the driving capstan D and to the take-up reel E which is driven by a suitable take-up mechanism. Most of the present experimental recorders have been constructed with a fast rewind feature. The relatively

slow speed required for any frequency response requirement, coupled with the absence of the troublesome level wind mechanism necessary on wire recorders, greatly simplifies the mechanical design of coated tape sound recorders. The greater sound energy level on the tape itself so simplifies the electronic design that a high gain amplifier is unnecessary. For example, one model designed for use with Hyflux tape utilizes an amplifier having an over-all gain of only 30 db and delivers 10 w.

Application in the Motion Picture Industry.—The author does not feel qualified to specify where coated tape magnetic recorders might fit in the motion picture field. However, some features which may be attractive will be pointed out.

Coated tape or ribbons of paper can be perforated the same as 35-mm film. The tough grades of paper now available should withstand sufficient use in sound track work. The recording can be monitored directly from the magnetic record while being made, so that the sound for retakes can be made immediately. Magnetic powder coatings can be applied directly to 16-mm film, thus making possible a ready-to-use sound track during exposure in the camera. Such coatings can be made to withstand any of the reversal and processing operations. Duplicates of a 35-mm master with magnetic sound might be produced in the usual manner with a photo sound track. Magnetic sound recorders are insensitive to the motion of vehicles or other similar conditions. Multitrack sound effect records could be arranged so that any one of several could be made available at the touch of a button.

Acknowledgments.—Grateful acknowledgement is made to Harold L. Stout, of Midwest Research Institute, Kansas City, Missouri, for part of the response data; Dr. Robert C. McMaster, Battelle Memorial Institute, Columbus, Ohio, for some of the magnetic test data; and to Marvin Camras, Armour Research Foundation, Chicago, Illinois, for help in establishing the testing methods.

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³ HOLMES, L. C., AND CLARK, D. L.: "Supersonic Bias for Magnetic Recording," *Electronics* (July 1945).

⁴ CAMRAS, MARVIN: "Theoretical Response from a Magnetic Wire Record," *Proc. I.R.E. and Waves and Electrons*, **34**, 8(Aug. 1946), p. 597.

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DISCUSSION

MR. GEORGE TALLIAN: I would like to know if this process is applied to an existing film—for instance, a 16-mm film which is already processed and already bears a picture—will it in any way detract from the picture? Do you have to put it through any kind of a chemical bath, or in any way spoil the quality of the image that is already on the film?

MR. HOWELL: No, I do not think so. This is a coating that can be placed in any convenient location on the film, on either 16- or 35-mm, as Mr. Camras has demonstrated.¹ Usually it is put on the outside in the very small area away from the sprocket holes, and there is no processing required. It can be monitored at the same time you are making the recording, for that matter, and has no effect whatsoever on the picture.

MR. TALLIAN: I noticed that the samples Mr. Camras¹ demonstrated were badly warped. Now, for instance, in a 16-mm film we will have trouble focusing it in a projector if we have a coating which makes the film warped.

MR. HOWELL: I agree there is somewhat of a problem, but we shall be able to overcome that. Naturally, if you get one side thicker than the other, it is going to cause trouble.

MR. J. I. CRABTREE: What is the resistivity of the coating on the paper to wear? What is its propensity to becoming scratched and therefore giving you ground noise?

MR. HOWELL: Scratches on a magnetic coating ordinarily do not affect its performance unless it is excessive. Ordinary scratches such as that experienced in film running through a machine, I doubt very much if it would ever cause any trouble. However, we do have the problem of adherence. Of course, that is purely a problem of organic chemistry and plastics, and we have seen some coatings that are very good.

MR. CRABTREE: I thought this was paper, not film.

MR. HOWELL: This machine uses paper 0.002 in. thick, including the coating, but the magnetic material itself can be put on any type of backing medium like film, thread, or paper ribbon.

¹ CAMRAS, M.: "Magnetic Sound for Motion Pictures," *J. Soc. Mot. Pict. Eng.*, **48**, 1 (Jan. 1947), p. 14.

MR. E. W. KELLOGG: How well does the surface stand repeated running? Does it tend to roughen, or does it polish down? You gave a figure for coercive force. Was that for the material as powder, or was that the powder applied in the form of tape coating?

MR. HOWELL: The material is produced in a finely divided form. The individual particles are in the range of two-tenths to one micron. This is the inherent physical properties owing to the process used in production. Its coercive force and other magnetic properties are there from the very beginning. The processing operation of dispersing it and producing it in paint form that can be applied to a paper or ribbon should not have any effect on its magnetic properties. The coercive force is just inherent with the material and the process used in producing it.

MR. SETHMIRE: Do you have any figures on the uniformity of the coating? That is to say, do you record a constant tone on it? How uniform does it play back?

MR. HOWELL: I have no scientific data on that. However, I have observed tones being played back to show a variation in some cases; but I attributed that more to poor resolution between the head and the tape. You see, paper is inherently a rough material. With a very smooth backing medium and using good techniques in coating, I should say that you should not have any appreciable variation in output.

MR. GEORGE LEWIN: Do you have any figures on how this material stands up over a long period of time under various atmospheric conditions? Does it oxidize?

MR. HOWELL: We have very little data outside of those which we have observed during the past three years, experimenting. We have tapes made three years ago on which there is no apparent decomposition. Hyflux is of such material that if it is subjected to long periods in moist salt air, it would no doubt suffer a certain amount of deterioration. However, the material, even though it does become completely oxidized, will still reproduce and can be used for recording. Under the very worst conditions, the drop should not exceed 6 db.

MR. LEWIN: You mean, all it does is give you a lower level?

MR. HOWELL: Exactly.

MR. J. F. CLARK: What data do you have on the signal-to-noise ratio over the entire frequency range under optimum bias conditions?

MR. HOWELL: It is a little hard to explain that because we have been using permanent magnet erasing for convenience, and because of laziness, we have not taken the time to design a high-frequency erase device. I would say that the signal-to-noise ratio at 1000 cycles is better than 40 db, and would probably improve if high-frequency erasing were used. There seems to be very little noise if the tape is properly erased. It is my guess that the slow tape speed contributes to freedom from noise.

DR. J. G. FRAYNE: In making any value for signal-to-noise, I think it would be of interest to know what the width of the sound track is.

MR. HOWELL: We have used sound tracks on the entire width of $\frac{1}{4}$ -in. ribbon. However, we have made experiments on sound tracks as small as $\frac{1}{32}$ in. It seems that the wider the track the less noise you will have. I do not feel qualified to

describe that relationship, but it is something like 3 db better if you have a track width doubled. Is that right?

DR. FRAYNE: That is right.

MR. HOWELL: But I have heard some pretty good recording on tracks of around $\frac{1}{16}$ in. wide.

MR. CLARK: Are there any low-frequency variations in the tape response such as occur on some of those slides?

MR. HOWELL: We did not use a French curve. We can plot the curve only a few cycles apart and find no bumps anywhere from 25 to 400 cycles.

MR. LEWIN: Do you have any data on splicing, and so forth, the ease or the difficulty with which you can make splices?

MR. HOWELL: With a little practice one can make a splice in about 5 or 10 sec that is impossible to notice in going over the recording head. Someone asked a while ago about the repeated use; what effect it had on the coating. So far, we have found that up to a certain extent repeated use improves the medium by smoothing off some of the irregularities that might exist there after processing the tape. As to the number of playbacks, I am not prepared to give you an idea, exactly; but I have run loops as much as 4000 or 5000 times with no appreciable drop in output. I have never measured the drop. It would stand to reason, with a coercive force of 500, that very little drop would occur owing to magnetic depreciation.

MR. R. C. HOLSLAG: What is the speed of the tape in this machine?

MR. HOWELL: The last time I clocked it, it was 8.4 in. per sec, in contrast to the $7\frac{1}{2}$ in. per sec used by Dr. Begun.²

DR. FRAYNE: As a metallurgist, can you advise us as to the relative merits from a performance standpoint of this magnetic coated tape and a solid metallic tape?

MR. HOWELL: I have never been connected with the manufacture of steel tape. I have never had any experience in processing it. But so far, we believe that this material can be processed in very large quantities from a large batch that has been homogenized, and that we can predict very uniform results with enlarged volume production.

MR. ALLEN JACOBS: If you doubled the speed of the tape, how good would it be?

MR. HOWELL: That is something I believe Mr. Camras or Mr. Holmes could answer better than I. Ordinarily, the faster you run the medium, the better your high-frequency response will be. I would say it almost doubles the range. Anyway, there is considerable increase in high-frequency response as you increase the speed of the recording medium.

MR. JACOBS: What is the fastest you have ever used it?

MR. HOWELL: I have never had any tests made in the laboratory over 18 in. per sec. However, we have constant current response data from people who have run it up to 4 ft. per sec.

MR. JACOBS: How good does it get at 18 in.?

MR. HOWELL: At 4 ft I believe it shows the peaks at around 6000 or 7000 cycles.

² BEGUN, S. J.: "Recent Developments in the Field of Magnetic Recording," *J. Soc. Mot. Pict.*, **48**, 1 (Jan. 1947), p. 1.

MR. KELLOGG: Can you give us an idea of what percentage, either by weight or as metal, and how much plastic it contains after it is dried out?

MR. HOWELL: The material is metallic in nature and naturally the magnetic density in the coating will depend on how much of the metal you use. You necessarily have to use a certain amount of bonding material to keep it together and make it adhere to the paper—not more than 10 per cent, ordinarily, if you use a properly chosen material.

MR. KELLOGG: Is that by volume or weight?

MR. HOWELL: By volume.

RESEARCH COUNCIL BASIC SOUND COMMITTEE: DISCUSSION OF MAGNETIC RECORDING*

Summary.—The following notes on discussions held at two meetings of the Research Council Basic Sound Committee concern the use of magnetic recording in motion picture studios. These meetings were held for a general discussion between the designers and manufacturers of magnetic recording and reproducing equipment and studio sound personnel for two reasons: (1) to allow the manufacturer to have an idea of the possible uses of their equipment and to obtain very general specifications on equipment to fulfill these uses, and (2) to allow studio personnel to obtain an idea of the present and possible future capabilities of magnetic systems.

It should be realized that definite conclusions have not yet been reached and the recommendations contained herein are very tentative.

The Research Council Basic Sound Committee has set up a Subcommittee on Magnetic Recording. This subcommittee is available to answer questions concerning studio practices and recording and reproducing equipment and will co-operate actively with those interested in the design, development, and manufacture of magnetic recording and reproducing equipment. Inquiries to this subcommittee may be addressed to the Research Council, 1217 Taft Building, Hollywood 28, Calif.

Meeting of Oct. 24, 1946.—A meeting of the Basic Sound Committee of the Research Council was held on Thursday, Oct. 24, 1946, at 4:30 P.M., in the Registration Room of the Hollywood Roosevelt Hotel. L. L. Ryder, Chairman, opened the meeting by explaining that the purpose was to have a general discussion between the designers and manufacturers of magnetic recorders and studio sound personnel interested in possible uses in recording studios. This procedure allows the manufacturer to have an idea of the possible uses of their equipment and to obtain very general specifications. Also, it allows the studio people to obtain an idea of the present and possible future capabilities of the magnetic recording systems.

The question was asked, "Are the manufacturers interested in developing a magnetic recorder for synchronized operation?" The resulting comments follow:

- (1) The Indiana Steel Company believes that some types of

* Research Council, Academy of Motion Picture Arts and Sciences, Hollywood, Calif.; dated Jan. 9, 1947.

paper or cellulose acetate could be adapted to a magnetic material coating. Either would make synchronized operation possible.

(2) The Magnecord Company now has magnetic wire which at present is "non-sync." However, the company is interested in "sync" operation and believes that it may be possible to sync wire recordings automatically.

(3) The Armour Research Foundation is not a manufacturing company, but concerns itself primarily with fundamental research and development. This company's representative offered to disseminate to Armour's licensees the information obtained at this meeting. If these licensees are interested, (and it is believed they are), the Foundation will investigate the problem.

(4) The Brush Development Company is interested in both phases; that is, sync and non-sync. The company is now using both the wire and the tape.

Suggestions on possible studio uses of magnetic recorders listed below were made, and incorporated into this material are the results of subsequent discussions on the quality necessary for each application. The quality requirements are broken down into three classifications:

Quality A.—Quality at least as good as present original motion picture recordings. This quality is necessary in any recording subsequently rerecorded and used as part of the release or any recording which is used as a playback check of original material.

Quality B.—Quality between *Quality A* and the commercial quality now available for amateur and home-type recorders. This type record is used as a guide or tool in the making of pictures but not in the release.

Quality C.—Quality *C* is the commercial quality now available for amateur and home use.

Items	Quality	Sync or Non-Sync
1. Original recordings, both dialogue and music	A	Sync
2. Playbacks		
(a) Check of original material	A	Sync
(b) For directorial purposes, such as rehearsals, etc.	B	Sync
3. Location sound effects	A	Non-sync
4. Talent tests	A	Sync
5. Prescoring		
(a) For release	A	Sync
(b) Temporary rerecordings	B	Sync

Items	Quality	Sync or Non-Sync
6. Creating reverberation	A	Sync
7. Signal delay mechanism for noise reduction	A	Non-sync
8. Cue tracks	B	Sync
9. Dialogue rehearsals such as dialect practice	B	Non-sync
10. Audience reaction	C	Sync
11. Presetting dials for rerecording	A, B, or C, depending on amount of control provided by the device	Sync
12. Timing of special effects		Sync

Dr. Begun stated that before the magnetic recorder manufacturers could proceed with the development of equipment suitable for studio use, it would first be necessary to know quality requirements of the studios. Do the studios want a recorder superior in quality to that of present film recorders, or one that is equivalent?

In reply to this question, the following studio requirements were given (in addition to those which have been incorporated into the list of suggested uses):

(1) *Release Sound Track.*—At the moment, at least, there has been no consideration given to the magnetic recording medium for release purposes.

(2) *Production Recording.*—For production recording of dialogue and music, a quality comparable to present film recording quality would be necessary.

(3) *Currently, the Following Frequency Ranges Are Used.*—For dialogue, from about 80 cycles to between 7000 and 8000 cycles; for music, from about 50 cycles to between 7000 and 8000 cycles. This means that the equipment must be of high quality from 50 to 10,000 cycles.

(4) *Volume Range.*—With film the range is about 48 db from maximum modulation to no signal with noise-reduction applied. Through the use of push-pull, reverse bias, pre- and post-equalization, etc., it is possible to get a volume range up to 55 db. Through overload, for instance, in sound effects passages, a range of 60 to 65 db may be obtained. It should be noted that even this type of overload must not destroy the character of the sound. While going into

overload is not desirable, it indicates a need for a greater volume range. Our present effective range in the theater may at times be as low as 40 db.

(5) *Speed*.—The speed should be 90 ft per min for the purposes of synchronizing and editing. Any other speed must have a very important advantage to be given consideration.

(6) *Distortion*.—Film distortions are in a range from one to two per cent total harmonic distortion between 400 and 1000 cycles. This distortion increases with frequency and is in the neighborhood of four per cent at 3000 cycles.

In transmission equipment, the total harmonic distortion is one per cent or less through the useful frequency and volume ranges; in theater equipment this total harmonic distortion is two per cent or less at full power output. These figures are quoted to show that distortions in film recording and film reproducing equipment are not in the order of five to eight per cent.

Although these figures are given in terms of total harmonic distortion, the industry uses intermodulation and cross-modulation tests for determining distortion. The Council's Basic Sound Committee is now correlating this information and expects to have available, in the near future, maximum allowable distortion in percentage intermodulation and cross-modulation.

Although distortion measurements are used to check and maintain equipment, listening tests are the final criterion in determining quality.

(7) *Flutter*.—A magnetic recorder should have a flutter content of not more than $\pm 1/10$ of one per cent, based on the operation of present film recording equipment.

(8) *Slating*.—The recording medium should be capable of accepting visual marks for identifying and synchronizing purposes.

(9) *Edge and Code Numbers*.—Edge numbers, placed on negative film by the manufacturer, are visible on raw stock and print through onto the print. These numbers are used for identification purposes on both picture and sound negative until the picture and sound release negatives have been finally assembled. It would be a great convenience if the recording medium were capable of accepting such numbers for purposes of identification.

Code numbers are numbers which are added to the separate picture and sound work prints for purposes of easy synchronizing and identification in the studio. These numbers are in addition

to negative edge numbers and run consecutively through each reel, identifying both the reel and the sequence in the print as assembled. Code numbers are used throughout the editorial procedure. Here again, it would be of great convenience to be able to code the recording medium. This could be accomplished if the recording medium were capable of taking ink.

(10) *Duplication*.—For protection, editorial, and other purposes, duplication (through rerecording) should be available with no greater loss from the original to the duplicate than now obtained in film from the negative to the print.

(11) *Durability*.—The recording medium must be as durable as film, from handling, projection, and storage standpoints. Prints are projected from 50 to 500 times.

(12) *Perforations*.—The ability to perforate the recording medium for editorial and synchronizing purposes would be advantageous. Thirty-five millimeter perforations on a single side of the recording medium would probably be satisfactory for studio use.*

(13) *Splicing and Blooming*.—Quick and accurate splicing would be an advantage for editorial purposes and it must be possible to “bloop” all splices.

(14) *Shock Resistance*.—The magnetic recorder must be capable of withstanding normal handling in all types of transportation. Ordinary shock and vibration during such transportation should not affect the operation of the modulator.

(15) *Safety Base*.—The base carrying the recording medium and the recording medium itself should burn at a rate comparable to acetate film and not nitrate film.

(16) *Volume Compression and Expansion*.—Volume compression and expansion might be given consideration for future use.

* Subsequent to the meeting, it was suggested that consideration be given to the width of the recording medium from the following three standpoints:

(1) What width should the recording medium have, considering the necessary equipment changeover? Should 35-mm width be given preferred consideration, as there would be no difference in the handling procedures?

(2) Should it be possible to make two magnetic recordings simultaneously on the same recorder; one to be used as a negative, the other to be used as a print?

(3) Would it be advantageous to be able to make a photographic image and a magnetic image simultaneously on a combination recorder?

(17) *Push-Pull Sound Tracks.*—Push-pull sound tracks are not necessary if satisfactory quality can be obtained without their use.

It was pointed out to the manufacturers present that it would be the responsibility of the manufacturer to indemnify, patentwise, the equipment for the studios.

It was pointed out that in giving consideration to the design of magnetic recorders for studio use, it should be realized that while important savings can be effected by a reduction in the cost of recording medium, more important savings can result from equipment which saves production time.

Mr. Ryder explained that the suggestions and statements made at the meeting were not intended to direct the manufacturers' efforts but rather to familiarize the manufacturers with studio problems.

Those attending the meeting were:

	L. L. RYDER, <i>Chairman</i>
	Paramount Studio
S. J. BEGUN	Brush Development Company
P. E. BRIGANDI	RKO-Radio Studio
MARVIN CAMRAS	Armour Research Foundation
J. P. CORCORAN	Twentieth Century-Fox Studio
CHARLES FELSTEAD	Universal-International Studio
BLAIR FOLDS	Brush Development Company
L. T. GOLDSMITH	Warner Bros. Studio
H. A. HOWELL	Indiana Steel Products Co.
W. F. KELLEY	Mgr., Research Council
H. A. LEEDY	Armour Research Foundation
W. E. MCKIBBON	Indiana Steel Products Co.
J. W. MCNAIR	American Standards Association
BOYCE NEMEC	Engr. Secy., Society of Motion Picture Engineers
W. V. STANCIL	Consulting Engineer
J. A. STRANSKY	Republic Studio
R. J. TINKHAM	Magnecord, Inc.

Meeting of Nov. 20, 1946.—The second meeting of the Research Council Basic Sound Committee to discuss magnetic recording was held on Wednesday, Nov. 20, 1946, at 12:30 P.M., in Hollywood, Calif. At this meeting the notes of the committee's meeting of October 24 were reviewed and again discussed. The committee was still in agreement with the comments and statements included in the information distributed on Oct. 24, 1946. It was decided:

(a) That the recording time should be at least 11 min of continuous recording,

(b) That the rewind time should be less than the recording time and it would be very desirable to have a rewind time of one minute,

(c) That it would be very desirable to have an operating time such that the recording medium has acquired constant speed ready for recording in three seconds from the time the recording motors are operated,

(d) That the width of the recording medium should be one of the following: 35-mm, 17¹/₂-mm, 16-mm, or 8-mm.

It was also decided that a subcommittee will be appointed by the Basic Sound Committee, which will closely follow the progress in the development of magnetic recording, will co-operate with those interested in the development and manufacture of magnetic recording and reproducing equipment, and will be available to answer questions concerning studio practices and studio recording equipment. Any inquiries to this committee should be addressed to the office of the Research Council to the attention of the Subcommittee on Magnetic Recording.

The meeting was attended by the following:

L. L. RYDER, *Chairman*
Paramount Studio

P. E. BRIGANDI	RKO-Radio Studio
G. A. BURNS	Metro-Goldwyn-Mayer Studio
L. I. CAREY	Universal-International Studio
W. F. KELLEY	Mgr., Research Council
J. P. LIVADARY	Columbia Studio
W. C. MILLER	Metro-Goldwyn-Mayer Studio
W. A. MUELLER	Warner Bros. Studio
ELMER RAGUSE	Hal Roach Studio
J. A. STRANSKY	Republic Studio
F. R. WILSON	Samuel Goldwyn Studio

MAGNETIC RECORDING FOR MOTION PICTURE STUDIOS*

WESLEY C. MILLER**

Summary.—Magnetic sound recording systems are being investigated for possible application by the motion picture industry. With limited current literature and the general nature of present industry discussions, certain peculiar requirements for studio use have not been taken into account, but are outlined here. The discussion represents the opinion of one studio's sound department based on the present state of developments and the information at hand, but is, of course, subject to modification as experience and additional information are acquired.

It seems almost certain that some form of the magnetic methods of recording and reproducing sound can have an important value in many phases of motion picture sound recording. That their value can extend to the theater reproduction field as well seems probable but for present purposes no attempt will be made here to evaluate the use in this part of the field.

Many groups are studying magnetic methods but the limited current literature and the discussions in general appear to be directed along lines which, while valuable in themselves, do not take into account certain peculiar requirements which are important to the studio use of recording media in picture production. While a new medium which may be a replacement for film may, because of its nature, require changes in existing technique, nevertheless these existing techniques should be studied to see how much could be salvaged by adapting the new processes to what we have rather than by taking the other point of view of trying to change everything to conform to present known forms of the magnetic medium.

As a starting point, let us make a few assumptions as follows and then see what could be done with the magnetic methods:

(1) Frequency response can be made at least equivalent to that of our present film. This must be qualified by the factors of signal-to-noise ratio and distortion, in other words, high-quality volume range.

* Submitted Jan. 11, 1947.

** Sound Department, Metro-Goldwyn-Mayer Studios, Culver City, Calif.

(2) The recording medium in the form of iron oxide or equivalent magnetic material can be used on a physical carrier having the same general characteristics as our present film base.

(3) The present film velocity of 90 ft per min, or $1\frac{1}{2}$ ft per sec, can be maintained.

(4) Recording and reproducing heads can be physically adapted to existing film running apparatus.

These assumptions will be discussed later and the probability of their being sound can be evaluated in terms of existing data and of design possibilities. However, if they are sound we can readily outline some of the immediate modifications which would seem desirable in the normal studio technical routine.

All original recordings could be made on magnetic film with all the advantages of immediate monitoring of the recorded signal, direct playback, reuse of film previously used on discarded takes. In this connection it should be emphasized that the use of the photographic printer and of the photographic developing processes are completely eliminated. While they have been brought to a good degree of control under optimum conditions, nevertheless they are constant contributory trouble factors in the complex chain of processes now necessary to produce a finished record.

The magnetic film original record would then correspond to our present original film negative and would be treated with the same care afforded to the latter. Daily prints, editorial and rerecording reprints would be magnetically recorded from this magnetic film original.

Using film as a carrier for the magnetic material would continue the use of key numbers, edge numbers, and sprocket holes for editorial identification, synchronization and measurement, using the identical equipment now in use and with which all studio personnel have become familiar.

It is conceivable that had the magnetic development taken place a few years ago the motion picture industry might even have recommended the elimination of sprocket holes for sound film if some other suitable length-metering device had been developed. Now, however, the sole purpose of the sprocket holes is for driving and for general synchronization purposes, as all modern film running equipment uses some form of a constant speed drum device and filter system to maintain constant film speed at the optical center. All of this equipment now exists or is in the process of manufacture for new

installations and it will put an insurmountable burden on any other form of physical carrier for the magnetic material to show why the present costly equipment should be discarded.

In this connection also, all of the magnetic heads of the type which has both poles on the same side of the recording medium have to date been of such size that they can be mounted with little difficulty at some suitable place in the film path of each type of existing equipment. Not only this, but they can usually be mounted in addition to the present optical systems so that during a long transition period from photographic to magnetic methods, the existing equipment can run either kind of record interchangeably.

Rerecording procedure would be much the same as at present, neglecting for the moment the plans already under way for automatic features in rerecording work. The many rerecording sound tracks would ultimately all be on the magnetic film but for a long time to come both photographic and magnetic records would be used interchangeably to make full use of the great amount of sound library material which has been accumulated. Until some further development is made to utilize magnetic methods for the theater, the release tracks would continue on the existing photographic media.

General editorial technique in the preparation of master and other rerecording sound tracks would remain virtually unchanged with one or two important exceptions.

In the first place, the editor can no longer read the striations on the magnetic tracks. There can be no doubt that this is a disadvantage. However, a modified type of Moviola device is already projected which will permit the editor to stop a track accurately at a precise point, and mark it for later splicing. Editorial personnel, given improved equipment of this kind, will undoubtedly develop cutting technique which will permit the full flexibility now enjoyed.

Perhaps offsetting this disadvantage is the fact that dirt and scratches, which are so much of a noise hazard at present, will virtually disappear as a problem. All of the time and care now required to condition properly tracks and splices should be greatly reduced.

In addition, methods will be developed to permit magnetic fading and elimination to supplant and replace the existing methods of painting or otherwise treating sections of track which require modification. Plans for one such type of apparatus include a potentiometer arrangement which permits making fades or eliminations by listening trial until the proper length and character of fade is deter-

mined. Then current corresponding to the potentiometer and footage settings is automatically applied to modify the magnetic record by the precise predetermined amount.

The choice of the film width to be used is a matter to be determined. At the MGM Studios the selection will undoubtedly be 17.5 mm. This has been of extraordinary value in the photographic form and there appears to be no good reason to change. The one change that may be recommended is to use 17.5 mm for negative instead of the two-edged use of 35 mm at present. The latter was adopted to make use of 35-mm developing equipment in the film laboratory, a requirement which no longer would have any bearing.

There may be some discussion of the use of 16-mm film but in the writer's opinion the 17.5-mm film having sprocket holes of the 35-mm type on one edge only has the advantage of using the larger and more frequent holes for which all equipment in the studio is already supplied.

Returning to the assumptions previously made, perhaps a brief analysis of the various quality considerations will still further indicate that full development should be made to try to adapt the magnetic methods to the film carrier medium. However, it should be clearly understood that this does not in any way imply that the various forms of wire and magnetic tape, not on film, are improper for other kinds of uses for the magnetic methods. For home recordings, stenographic purposes, high-quality time delay devices for broadcasting, *etc.*, the film medium is perhaps not the best. But for motion picture studio purposes it probably is.

Quality considerations in the magnetic medium, in particular the oxide or equivalent tape or film, are in many respects the same as they are in our present photographic recording media. Certainly the end point is the same. We are looking for proper frequency response, absence of spurious harmonics and secondary effects, a minimum of noise. Also, both methods have certain inherent similarities such as variable response at various parts of the frequency spectrum, overload limits, *etc.*

As an approach let us first consider that the so-called flat response is a kind of theoretical starting point from which we immediately have to deviate because of the characteristics of microphones and speaker systems and also because of the particular requirements which the final reproduction must meet. One very important aspect of such adjustments, and one which is much less commonly under-

stood and recognized than it should be, is that sound reproduction for motion pictures is and should be much different than for radio, phonographic, or public address work. Without going into a detailed discussion of this problem, it is the desire merely to point out the difference in reproduced volume level and the presence factor required for pictures which has no counterpart in radio or phonograph work.

In any case, this means adjustment of characteristics—equalization at one place or another in the over-all system. In film work it happens that much of this equalization amounts to a reduction of low frequencies and to a reasonable extent the augmentation of high frequencies. The reduction of lows does little to the noise content if it is done properly. Among other things we use a pre- and post-equalization technique in film work whereby the highs are increased in the recording in conformity with the statistical probability of relative occurrence in various parts of the spectrum, and are then correspondingly decreased in reproduction.

In magnetic work the pre- and post-equalization will apparently involve pre-equalization at low frequencies and the corresponding posting in reproduction. From the data available it would appear that it will be quite practicable to secure the proper over-all characteristic including microphone and speaker.

Frequency response in the magnetic method depends upon several factors, notably film speed, pole piece separation and of course constant and uniform contact between the pole piece and magnetic film.

It is certain that the contact problem is to be readily solved. A brief study of existing film paths will show this to be the case.

Pole piece separation is quite analogous to recording and reproducing slit widths. In fact in many respects the magnetic tape methods may be considered to some extent the counterpart of a variable-density film sound track produced by a variable intensity-constant slit width method, with variation in what might be loosely called the magnetic density instead of variation in the density or transmission of a photographically produced record.

With this comparison in mind, the problems of film velocity versus slit width should be susceptible to analysis on somewhat the same basis for the two methods. At a 90-ft per min ($1\frac{1}{2}$ ft per sec) velocity we have found by experience that a reproducing slit 0.001 to 0.0012 in. wide is satisfactory over the frequency range required. It would seem that the same reasoning can apply to the magnetic device.

Present magnetic air gaps have certain fringing effects which, of course, are increasingly important at the higher frequencies. These will be minimized by design developments. In any case, they ultimately may quite possibly be no more serious than the diffraction and reflection effects we now have resulting from our attempts to pour a large amount of light through a very small slit formed by mechanical devices which are quite large relative to the light wavelength going through them.

The extent of the frequency range required in motion picture work should be considered. It is very doubtful if frequencies above 7500-8000 cps will be required for a very long time to come, if ever. The industry is fully aware of the fact that this range is limited but practical considerations over a number of years have all combined to produce what might almost be termed a standardized limited range. We need and want the closest practicable approach to perfection within this range but we can very safely discard everything above it for commercial purposes. It seems extremely unlikely that public tastes will be so affected by any use of frequency modulation or stereophonic recording as to require much modification of this requirement.

ACHIEVEMENTS OF THE SMPE FOR 1946*

D. E. HYNDMAN**

This year of 1946, on July 24, marked 30 years of achievement in motion picture engineering for the Society of Motion Picture Engineers. The general growth, progress and achievement of our Society has been described in a previous article by Hyndman and Maurer.¹ I thought you might be interested in a brief review of the accomplishments of your Society this year.

Twenty-six new American Standards have been issued and five additional proposals have been submitted to Sectional Committee on Motion Pictures Z22 of the American Standards Association. The 26 American Standards have been referred by the ASA to the United Nations Standards Co-ordinating Committee [succeeded by International Organization for Standardization—*Ed.*], the new international standardizing body. The ASA has proposed to the UNSCC that the Secretariat for Motion Pictures on international standards be located in the United States. In addition to the standards and proposals mentioned, three more proposals for standardization are now out to letter ballot of the Committee on Standards of the SMPE. You are all familiar with the American Standards Binder or book which your Society issued. This binder has already received much commendation from engineers and has been widely circulated as an authoritative reference.

Revision of 35-Mm and 16-Mm Visual Test Films as recommended by the Joint SMPE-Research Council Committee has been completed by the Committee on Projection Practice of the SMPE. The initial or answer print of this new film will be previewed by the Joint Committee during this Convention. The Research Council of the academy of Motion Picture Arts and Sciences and the SMPE are now mutually co-operating on specifications for both sound and visual test films, in both 35-mm and 16-mm widths, to make unified recommendations and provide standard test films to industry.

* Presented Oct. 21, 1946, at the opening luncheon of the Sixtieth Semiannual Convention in Hollywood.

** President, Society of Motion Picture Engineers.

In the past nine months our membership has grown to 2400, an increase of 425 new members since January 1. Five hundred new subscriptions to the JOURNAL have been received from colleges, engineering schools, libraries, and foreign film interests. The Executive Office Staff has been increased by the addition of an Engineering Secretary and Technical Stenographer, who have materially accelerated the engineering and general service of the SMPE.

As the result of a survey by the Committee on Motion Picture Instruction, arrangements are now in progress to establish Student Chapters of the SMPE at colleges and universities. Your Society has also created a Committee on Citations to honor and recognize the engineering and technical progress of individuals and companies that have contributed to the success of the motion picture industry. At the Banquet during the Convention you will hear more about this Committee's efforts. In honor of the Twentieth Anniversary of Sound in Motion Pictures, Warner Brothers Pictures, Inc., has arranged with the Board of Governors of the Societies for an annual SMPE Samuel L. Warner Memorial Award to consist of a suitable Gold Medal and an appropriate certificate to be presented to any individual contributing an engineering or technical invention or improvement which, in the opinion of an appointed Committee of the SMPE, is considered to be a recent advance in the art and a worthy asset to the motion picture industry.

This year we have obtained an increase in Sustaining Memberships which to date amounts to approximately \$14,000. These additional funds have permitted increases in our service, particularly when it is realized that the average member-cost to the Society has been over \$14 per year for the past ten years.

I have given you just a few brief facts in this motorcycle trip through the SMPE—much more has been done. These accomplishments result from the splendid co-operative work of the Executive Office Staff, the Officers, Board of Governors, Committees, and Members. As your retiring President, I thank you, one and all; and as the engineer said to the fireman on the heavy freight, "Pour on the coal, boy, it's a long hard run ahead." Thanks a million.

REFERENCE

¹ HYNDMAN, D. E., AND MAURER, J. A.: "The Past and Future Activities of the Society of Motion Picture Engineers," *J. Soc. Mot. Pict. Eng.*, 47, 3 (Sept. 1946), p. 212.

CITATION ON THE WORK OF RALPH H. TALBOT*

E. K. CARVER**

The Journal Award for 1946 has been made to Ralph H. Talbot for his paper entitled "The Projection Life of Film," which was published in the August 1945 issue of the JOURNAL of the Society of Motion Picture Engineers. This paper described several types of film damage and means by which each of the types can be minimized, or in some cases almost eliminated. An illuminated certificate was presented to Mr. Talbot in Hollywood, California, at the banquet held at the Hollywood-Roosevelt Hotel on the evening of October 23, 1946, during the 60th Semiannual Convention of the Society. The Journal Award is presented each year to the author or authors of the most outstanding paper originally published in the JOURNAL during the preceding calendar year and treating some phase of motion picture engineering.

A native of Illinois, Mr. Talbot took his degree of Bachelor of Science in Chemical Engineering at the University of Illinois in 1925, following up with Master of Science degree in organic chemistry in 1926. While there he was elected a member of three honor societies—Sigma Xi, Phi Lambda Upsilon, and Phi Mu Alpha.

Mr. Talbot joined the Eastman Kodak Company in 1927 where he was a member of the Synthetic Organic Division for a short time before he left for the Tennessee Eastman Corporation, Kingsport, Tennessee, where he organized and equipped a control laboratory. He returned to Kodak Park in 1930 to join the Department of Manufacturing Experiments.

For some time Mr. Talbot's chief work was on nitration of cellulose and the development of special solvent formulas which gave an improved film support for motion picture film. Later, he turned his attention to various problems on the projection of film, including wear and tear on the film during projection, scratch protection, and projec-

* Recipient of 1946 Journal Award of the Society.

** Eastman Kodak Company, Rochester, New York.

tion quality in general. He has published several papers on these subjects.

Mr. Talbot is a musician of considerable ability. He has acted as conductor of an amateur concert orchestra for many years, in which



RALPH H. TALBOT

Recipient of the SMPE Journal Award for 1946.

he occasionally plays the trumpet. He is also a skillful fisherman, and trains and breeds setters for partridge hunting. He is an enthusiastic amateur photographer, a past President of the Kodak Camera Club, and a member of the American Chemical Society.

THE ASA SECTIONAL COMMITTEE ON MOTION PICTURES, Z22*

C. R. KEITH**

Summary.—The purpose, organization, and operation of the Committee on Motion Pictures are described, with particular reference to its relation to other standards groups such as the SMPE Standards Committee and the Standards Committee of the Research Council of the Academy of Motion Picture Arts and Sciences.

The formulation of standards for the motion picture industry has been recognized from the beginning as one of the most important functions of the Society of Motion Picture Engineers, and was one of the purposes for its organization. A large number of very valuable standards have been worked out by its Standards Committee during the 30 years since the founding of the Society, and more recently a number of important standards have been adopted by the Standards Committee of the Research Council of the Academy of Motion Picture Arts and Sciences. With these two groups functioning in the motion picture field, it may well be asked why a third organization, the American Standards Association, is also needed.

One of the important reasons for the existence of the ASA Committee on Motion Pictures, Z22, is to provide the widest possible representation for approval of proposed standards. In addition to a wide representation from the motion picture industry, the Z22 Committee includes representatives of numerous organizations not specifically represented on the two other standardizing bodies. Among these organizations represented on the Z22 Committee are:

Acoustical Society of America
ASA Committee on Still Photography, Z38
Bureau of Standards.
Illuminating Engineering Society
National Electrical Manufacturing Association
Optical Society of America

* Presented Oct. 23, 1946, at the SMPE Convention in Hollywood.

** Chairman, Sectional Committee on Motion Pictures, Z22, American Standards Association, New York.

Photographic Society of America
Motion Picture Association of America
U. S. Navy Department
U. S. War Department

Although motion pictures are a secondary interest to most of these organizations, they may in some cases have important interests which should be taken into account before a nationwide standard is adopted.

Another purpose of the Z22 Committee is to co-ordinate motion picture standards with other American Standards. This avoids duplication or overlap between committees working in different fields. For example, the Z38 Committee on Still Photography has specified the same dimensions and perforations for 35-mm slide and microphones as have been established by the Z22 Committee for 35-mm motion picture film. Also the Z22 Committee has recently adopted for the motion picture field a definition of safety film prepared by the Committee on Still Photography, Z38.

However, one of the most important reasons for the existence of the Z22 Committee is to co-ordinate American standards with foreign standards. The world-wide distribution of American films and motion picture apparatus is, to a large extent, dependent upon the existence of the same basic dimensional standards in all countries.

A good example of what happens when foreign standards are different from American standards was the situation created a number of years ago when Germany adopted a standard for 16-mm sound films which would not permit interchange of American and German films or equipment. Although this difference in standards was unintentional, it nevertheless caused a considerable amount of confusion and loss in the industry. Direct negotiations between the American Standards Association and foreign standardizing bodies should prevent such occurrences in the future.

The choice of organizations to be represented on Z22 is made jointly by the sponsor (the Society of Motion Picture Engineers) and the American Standards Association. Every effort is made to have broad representation without giving too much weight to any one group. Organizations represented are classified as producer, consumer, or general interest, and an approximately equal division is maintained among the three types. The choice of the individual who is to represent an organization is left to that organization. The chairman is elected by the committee.

An important point in the committee procedure is that any member or group may propose a new standard or revision to an existing standard. Although most of the present standards were originally proposed and formulated by the SMPE, a number were originated by the Academy Research Council and some were taken from the work of the War Committee on Photography and Cinematography Z52.

At least once every three years each standard is reconsidered and if any dissatisfaction is shown, it is investigated by a subcommittee of Z22 or referred to the SMPE or to the Academy as may be most appropriate for a particular case. When practical the report of the subcommittee, SMPE, or Academy is discussed at a meeting of the Z22 Committee, although because of the wide separation of members it is usually not feasible to hold a meeting more than once a year.

All proposals are submitted for approval by letter ballot and considered as approved only when receiving the affirmative vote of practically all members. All persons sending in negative votes are asked to give their reasons for disapproval. If in the opinion of the chairman the negative votes are justified, the proposal may be submitted for a second vote with a transcript of the dissenting opinions.

When approved by the Z22 Committee, the proposal goes to the SMPE Board of Governors for final approval from the sponsor, and from there to the ASA Standards Council. Having passed all of these hurdles, the proposal becomes an American Standard and after printing is available to any interested party in any part of the world.

THE DETERMINING ROLE OF RESEARCH IN THE FUTURE OF THE MOTION PICTURE*

BYRON PRICE**

Years ago, when I was at college, I had to listen to many lectures I did not think I wanted to hear. Most of them turned out to be valuable lectures; some were interesting; a few were even entertaining. I cannot forget, however, my profound distaste for the speaker who began with a recitation of historical data, hastily collected from the opening pages of the college catalogue, which his listeners had read, studied, and lived with for months. Such a recitation usually gave notice of a talk which spanned more time than its subject matter deserved.

When Mr. Hyndman invited me to be here today, I gave some thought to what I might say about technical advances, standardization, and simplification in motion pictures. But those subjects are in the opening pages of your catalogue. Your technical deliberations will take you to heights which no layman could scale, and my chances of bringing you anything new in your own field are at absolute zero.

I can stand off a bit, however, and speak in a general way of the importance of the work you are doing.

The problems which face your members in these discussions, and in their daily search for technical betterment in the laboratory, are serious and challenging problems. They are of a character far removed from the ordinary conception of gay and light-hearted existence in this much publicized community. Your meetings will constitute an example (and not an isolated example, either) of the serious, weary striving toward perfection which is the central inspiration of this great industry. In you, the outside world may see Hollywood at its best.

You have assembled here at a time of great trouble in the affairs

* Presented Oct. 21, 1946, at the opening luncheon of the Sixtieth Semi-annual Convention in Hollywood.

** Chairman of Board, Association of Motion Picture Producers, Inc., Hollywood.

of humanity, and your meeting is by no means separate from the strivings of thoughtful men everywhere to bring a wool-gathering world back to mental stability. In the year that has passed since the glorious day of victory for united democratic peoples, a strange epidemic has swept the globe. Our own country has not escaped. At the moment of its greatest strength, it has been stricken with a creeping paralysis of frustration and indolence.

The optimists may undertake to excuse this condition as a reflex of natural weariness after the supreme effort of the war. But surely after a year of floundering and failure, it is time to wonder whether the malady may not be more deep seated than that, and more dangerous to our very existence. It is encouraging beyond words, therefore, to see that our technical men, including yourselves, are not only dissatisfied with things as they are, but are undertaking to open new avenues of recovery and progress.

The challenge to research is a continuing challenge of the ages. If in our present dilemma our public men are unable to find a cure, perhaps the men of science can save us. Whether that be true or not, at least the scientific world must have the will to try. It is clearly an obligation of science that the momentum of the war years, which carried us so far on the road of destruction, shall not be lost as we turn to the building of a new world.

In spite of all past progress, the making and exhibition of motion pictures still presents an important and fertile field for scientific research. I might dwell at length upon the contributions already made by your fine association, by the Research Council of the Academy, and others. But this is hardly a time to point with pride. The important consideration is what we shall do with the future.

It has become trite to say that the motion picture is the most potent human instrument of national and world understanding. But we must not forget that the screen will fulfill its destiny and reach its greatest power only in proportion to the fidelity of its portrayal of human life. The mirror it holds up to nature must be alive and untarnished, purged of corrosion and refined to a degree perhaps not yet dreamed of.

For it is an axiom of the art of public entertainment that the public taste is fickle. Always the demand—not merely the desire, but the demand—is for something different and better. Today's audience would never be even moderately pleased with the crude mechanics of the Elizabethan theater.

Unlike most of you, I am old enough to remember the earliest motion pictures. The patron paid a nickel for the privilege of sitting for a while in a highly uncomfortable chair, in a stuffy room, to see a flickering reproduction of the antics of amateurs, without spoken words and with no obligatto except the unceasing hammering of a piano badly out of tune, and the sputtering of a reel which broke or jumped the track with invariable regularity. We liked it, not so much because we experienced any sensation of beauty or inspiration, or even of entertainment, but because it was a novelty. I am very sure we would have tired of it soon enough, had not improvement held our interest. I even venture to say that if sound and color and other mechanical accomplishments had never been attained, the motion picture never would have survived except as a small side show of American life.

Nor could the motion picture of the present day, with all of its miraculous qualities, expect to survive if research simply sat on its hands, surrendering to smugness and dreaming that perfection had been attained. The effective capture of the third dimension alone provides a goal worthy of the endeavor of the best minds among you. Instead of musing on the attainments of the past and present, we must have another kind of daydreaming. We must dream as Edison did, as Galileo did, as da Vinci did, and many others before and since.

Much has been accomplished, but the plain truth is that the sum total is far too meager. In no way does it square with the opportunity. We must have in the industry a vastly more comprehensive research program, and I am happy to say that under the leadership of Eric Johnston preparations for such a program are in the making. What form it will take eventually cannot now be foreseen, since plans are far from complete; but I feel justified in saying that already important and universal support for the project has become apparent throughout the industry.

In this endeavor the industry greatly needs your continuing help, and that is why I am doubly happy to welcome you to this convention. We greet you, not only merely as friends, but as friends in need, and sincerely wish you all success in the serious and significant work of your convention.

SCREEN ILLUMINATION WITH CARBON ARC MOTION PICTURE PROJECTION SYSTEMS*

R. J. ZAVESKY, C. J. GERTISER, AND W. W. LOZIER**

Summary.—Data are reported on the amount of light that can be projected to the screen with typical present-day carbon arc projection systems. Curves are presented which enable ready determination of illumination intensities on screens of various widths. Correlation is also made between the various systems and size of screen that can be illuminated to the brightness specified by the applicable ASA Standard.

The history of the motion picture industry is documented with many new developments in the light sources used for projection. The individual developments in the carbon arc systems used for theater projection have been described in many papers published in previous issues of this JOURNAL. In addition, a paper¹ was presented in 1940 which summarized the progress in the application of carbon arcs to motion picture projection from the beginnings of the industry up to that time. In the years subsequent to 1940, new developments in carbons, lamps, and optical systems have offered further substantial advances.

In view of these improvements it is the purpose of this paper to present data on screen light obtained from measurements on typical present-day carbon arcs with various optical systems. Such a set of data is necessary for the determination of the projection system required to illuminate adequately a motion picture screen of a given size. It is also of benefit in planning for new fields of projection.

Projection Systems.—The various units chosen as typical of present motion picture theater practice include low-intensity carbon arc combinations with reflector optical system, high-intensity arcs with nonrotating carbons and reflector systems, and high-intensity arcs with rotating carbons and condenser optical system.

Mirrors 10 in. in diameter with a speed of $f/2.3$ and approximately 4- and 24-in. working distances were utilized to obtain representative

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

** National Carbon Company, Inc., Fostoria, Ohio.

information for low-intensity trim operation with 12-mm \times 8-in. low-intensity positives and 8-mm \times 8-in. low-intensity negative carbons.

"One Kilowatt" direct-current arcs with 7-mm "Suprex" positive carbons and 6-mm "Orotip" *C* negatives and with $f/2.5$ mirrors having working distances of about 4-in. crater to mirror and 30-in. mirror to aperture were used as typical in this field.

Mirrors 14 in. in diameter with a speed of $f/2.3$ and with working distances of approximately 5 in. from the carbon crater to the mirror, and 34 in. from the mirror to the aperture were chosen as typical for simplified high-intensity lamps. The 8-mm \times 12- or 14-in. "Suprex" positive and 7-mm \times 9-in. "Orotip" *C* negative carbon trim, and the 7-mm \times 12- or 14-in. "Suprex" positive and 6-mm \times 9-in. "Orotip" *C* negative carbons were considered in combination with such lamps.

The rotating high-intensity carbon trims chosen were the 13.6-mm \times 22-in. regular high-intensity and super-high-intensity positives with $7/16$ -in. or $1/2 \times 9$ -in. "Orotip" negative carbons. Condenser lenses adjusted to give an $f/2.0$ beam were employed as typical of good practice in this type of operation. The $6\frac{1}{4}$ -in. diameter rear element was placed approximately 3 in. from the carbon crater and the $7\frac{1}{2}$ -in. diameter front condenser was about $12\frac{13}{16}$ in. from the film aperture.

The film aperture considered was the standard 0.600×0.825 in. for 35-mm film. Representative projection lenses designed for 35-mm film projection were utilized.

Light Measurements.—The measurements of screen illumination were based on the following general procedure. First of all, the arc lamp, film aperture, and projection lens were positioned as specified by the equipment manufacturers' instructions. By this means, the mirror-to-aperture (or condenser-to-aperture) distance was adjusted and the carbon crater-to-mirror (or crater-to-condenser) distance was set approximately. Optical alignment was achieved by placing a straight rod on the optical axis of the lamp, and by moving the aperture and projection lens so that the optical axes of the lamp, aperture, and lens all coincided.

For convenience, most measurements were obtained using a short projection throw of about 12 ft and an illuminated screen area 2 to 3 ft in width. However, a number of confirming tests were made with projection throws as long as 65 ft and screen sizes as wide as 12 ft.

Light intensities on the screen were obtained using accurately calibrated Weston Photronic cells equipped with Viscor filters. The cells were placed at five locations on the screen: one at the center, two

on a horizontal line through the center and near the sides, and the other two near diagonally opposite corners of the illuminated screen area. The side and corner cells were spaced in from the boundaries of the lighted screen area by distances equal to five per cent of the horizontal and vertical dimensions of the lighted area.

In order to obtain total lumens falling on the screen, it is necessary to have some method of averaging and weighting the values of intensity obtained at the five selected points. A satisfactorily close approximation to the average intensity has been found to be given by giving the center intensity a weight of two, the average of the sides a weight of two, and the average of the corners a weight of one. The average intensity so obtained is multiplied by the illuminated screen area to give total lumens.

Wire screens of calibrated transmission placed over the front of the lamp, were found convenient to reduce the amount of light passing through the projection lens and to the screen. Some tests were carried out with no absorbing screens in order to check further on the accuracy of the transmission factors of the wire screens employed.

Before any light measurements were made, the intensities at the sides and corners of the screen were balanced by tilting the mirror or by moving the condenser lenses vertically or horizontally. The distribution of light on the screen, *i. e.*, the ratio of intensity, sides-to-center, was adjusted by axial movement of the carbons in the mirror lamps, or by axial adjustment of the condenser lenses in the condenser lamps. In all cases, the positive carbon crater position, and the arc current and arc gap for the carbon trim were accurately maintained. The importance of close control of crater position and arc current to provide constant light on the screen has been described in a previous paper.²

Discussion of Data.—Results of measurements of screen light are shown in Table 1. The description of the carbon trim used, its operating conditions and the lamp optics are specified in the first five columns of Table 1.

Screen lumen values are next listed, both for a screen light distribution ratio of 80 per cent side-to-center, and for the ratio resulting when the system is adjusted to give maximum intensity at the center of the screen. With each such adjustment, an $f/2.5$ and an $f/2.0$ projection lens was employed. The $f/2.5$ lens is untreated, and of 5.5 in. focal length, while the $f/2.0$ lens, an example of a high-quality modern lens, is surface-treated and of 5.0 in. focal length. Similar measure-

TABLE 1
 Screen Illumination with Carbon Arc Motion Picture Projection Systems
 35-mm Film Projection Systems—0.600-in. \times 0.825-in. Aperture

Item	Carbon		Arc Amp	Volts	Lamp Optical System	Untreated Lens			5-in. E.F. $f/2.5$ Treated Lens				
	Positive	Negative				80 Per Cent Dist.	Max. Light ³ Screen Lumens	Per Cent Dist.	80 Per Cent Dist.	Max. Light ³ Screen Lumens	Per Cent Dist.		
<i>Low Intensity</i>													
1	12 mm \times 8 in. Low Int.	8 mm \times 8 in. Low Int.	32	55	10 in. Dia. $f/2.3$ Mirror	2,500	70	3,400	70	
<i>"One Kilowatt," D-C</i>													
2	7 mm \times 12 or 14 in. "Suprex"	6 mm \times 9 in. "Orotip," C	40	27.5	11 $\frac{1}{2}$ in. Dia. $f/2.5$ Mirror	4,600	80	5,000	65	5,900	80	6,500	65
<i>Nonrotating High Intensity</i>													
3	7 mm \times 12 or 14 in. "Suprex"	6 mm \times 9 in. "Orotip," C	42	33	14 in. Dia. $f/2.3$ Mirror	4,900	80	5,500	60	6,600	80	7,500	60
4	7 mm \times 12 or 14 in. "Suprex"	6 mm \times 9 in. "Orotip," C	50	37	14 in. Dia. $f/2.3$ Mirror	6,400	80	7,200	60	8,600	80	10,000	60
5	8 mm \times 12 or 14 in. "Suprex"	7 mm \times 9 in. "Orotip," C	60	36	14 in. Dia. $f/2.3$ Mirror	7,600	80	8,200	65	10,300	80	11,000	65
6	8 mm \times 12 or 14 in. "Suprex"	7 mm \times 9 in. "Orotip," C	70	40	14 in. Dia. $f/2.3$ Mirror	9,600	80	10,600	65	13,000	80	14,000	65
<i>Rotating High Intensity</i>													
7	13.6 mm \times 22 in. High Int.	$\frac{7}{16}$ \times 9 in. "Orotip"	125	68	Condenser Lenses at $f/2.0$	7,500	80	9,200	65	11,500	80	14,500	60
8	13.6 mm \times 22 in. High Int. ⁴	$\frac{1}{2}$ \times 9 in. "Orotip"	150	78	Condenser Lenses at $f/2.0$	11,000	80	13,000	60	16,000	80	19,500	60
9	13.6 mm \times 22 in. Super-High Int. ⁴	$\frac{1}{4}$ \times 9 in. Heavy Duty "Orotip"	170	75	Condenser Lenses at $f/2.0$	11,000	80	13,000	65	18,500	80	21,500	60

NOTES: 1. Screen lumen figure is for systems with no shutter, film, or filters of any kind.

2. Per cent distribution refers to ratio of light intensity at side of screen to that at the center.

3. Maximum light is value with system adjusted to produce maximum light intensity at the center of the screen.

4. Heat filter may be necessary; reduce light approximately 20 per cent if Akio or Phosphate glass is used.

ments with other 4.5 and 5 in. *E.F. f/2.0* lenses of various make were also made, but gave no significant difference in amount of screen light.

The screen lumen values quoted are without allowance for shutters, filters, *etc.*, since these more general light values can readily be corrected for the transmission of the particular accessories incorporated in a specific assembly of interest. The data in Table 1 show screen lumen values at maximum light ranging from 2500 to 21,500 and illustrate the wide range of possibilities offered by the various combinations of lamps, carbons, and optical systems. It will be noted that the side-to-center screen distribution at maximum light is generally 60 or 65 per cent. If a more uniform distribution of light is desired, this can be obtained at a sacrifice in intensity. Values of screen lumens are quoted at 80 per cent distribution as an example of a more uniform distribution and are approximately 10 to 15 per cent lower than maximum values.

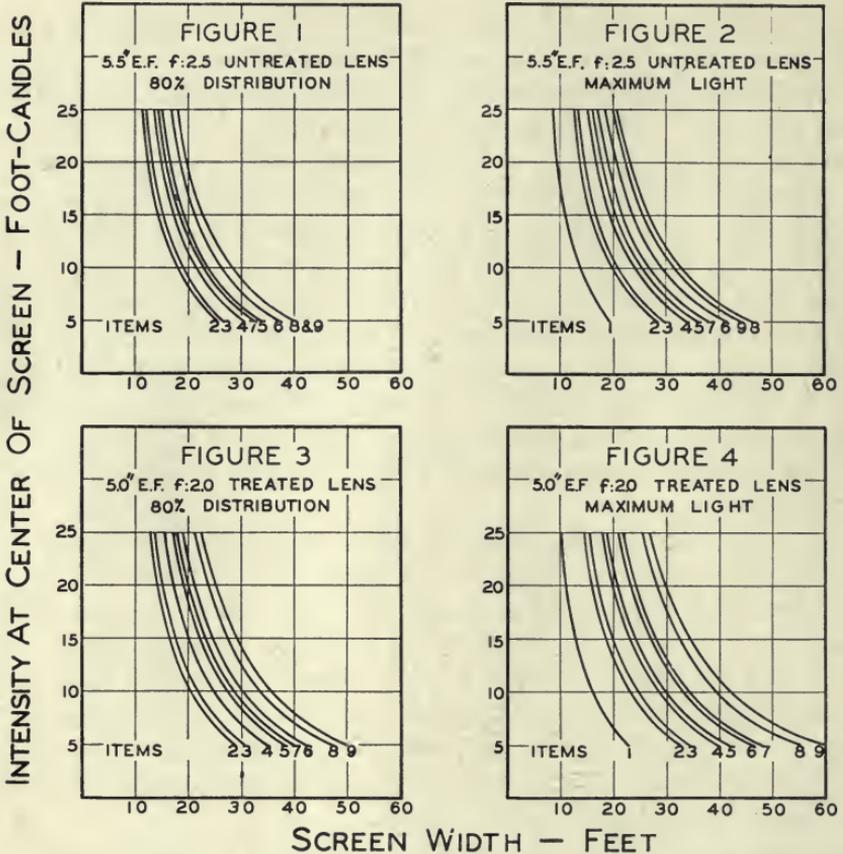
The importance of adequate lens speed in utilizing the light provided by the projection lamp is also illustrated by the data. The *f/2.0* treated lens gives approximately 50 to 60 per cent more light than the *f/2.5* untreated lens with the condenser lamp and 30 to 35 per cent more with the mirror lamps. Much of the gain with the mirror systems results from the greater transmission of the treated lens. There is an additional gain with the condenser system because the *f/2.0* lens transmits light from the *f/2.0* condenser system which is not passed by the slower speed *f/2.5* lens.

In order to compare the screen light intensity in motion picture theaters it is necessary to take into account such other factors as projector shutter, heat filters, port glasses, draft glasses and screen size. Values of light intensity in foot-candles at the center of the screen are plotted for a range of screen widths in Figs. 1-4. These are based on the various projection systems and conditions of Table 1, and allowance has been made for:

- (1) A projector shutter of 50 per cent transmission,
- (2) A projection room port glass of 90 per cent transmission.

The values obtained in a particular theater installation may differ from those reported here for numerous reasons, among which are the following:

- (1) Departure from the optical characteristics specified in Table 1. For example, many of the older lenses are of slower speed than *f/2.5*.
- (2) The possible presence of absorptive factors in the optical train other than the ones assumed here. For instance, shutter transmission may be other than



Figs. 1, 2, 3, and 4. Light intensity³ at center of various sized screens with typical carbon arc projection systems.

Items¹

- 1 12-8-mm Low Intensity, 32 amp., 55 volts.
- 2 7-6-mm "Suprex", 40 amp., 27.5 volts.
- 3 7-6-mm "Suprex", 42 amp., 33 volts.
- 4 7-6-mm "Suprex", 50 amp., 37 volts.
- 5 8-7-mm "Suprex", 60 amp., 36 volts.
- 6 8-7-mm "Suprex", 70 amp., 40 volts.
- 7 13.6-mm- $1/16$ " High Intensity, 125 amp., 68 volts.
- 8 13.6-mm- $1/2$ " High Intensity, 150 amp., 78 volts.²
- 9 13.6-mm- $1/2$ " Super-High Intensity, 170 amp., 75 volts.²

Notes

- (1) Refer to Table 1 for details on items.
- (2) May require heat filter and result in 10 per cent decrease in width at given intensity.
- (3) Foot-candle values assume—
 - (a) 50 per cent shutter transmission,
 - (b) 90 per cent projection port glass transmission,
 - (c) No film or filters other than port glass.

50 per cent, a heat filter is sometimes employed, a draft glass is often used, and the present assumption with respect to the port glass may not apply.

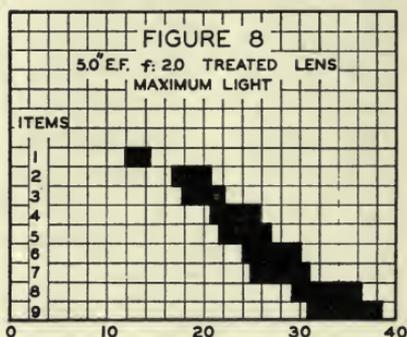
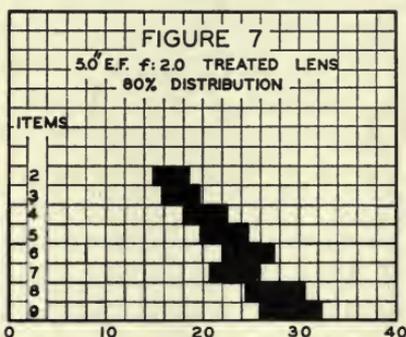
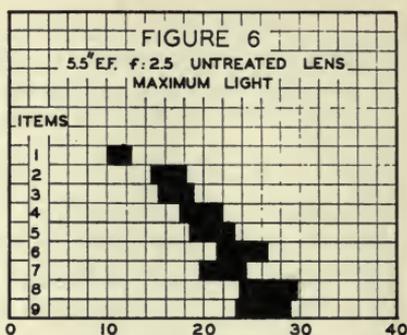
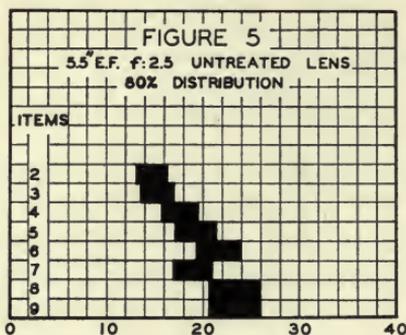
- (3) Degree of cleanliness or misalignment of the optical system.
- (4) Departure from the specified operating conditions for the arc.

Figs. 1 and 2 show the foot-candle intensities at the center of the screen under the above conditions for 80 per cent distribution and maximum light with the $f/2.5$ untreated lens. Figs. 3 and 4 show similar data with the $f/2.0$ treated lens. These curves show the screen widths that can be illuminated to intensities of 5 to 25 ft-c. The screen widths involved range from about 10 to 60 ft. It is perhaps worthy of note that in Fig. 2 with the $f/2.5$ lens Item 8, the 150-amp arc, gives higher screen intensity than Item 9, the 170-amp arc, whereas this is not the case in the other three illustrations. The explanation for this anomaly rests on the relatively greater radiation of the 170-amp carbon at wide angles. It is necessary to use the higher speed of the $f/2.0$ lens in order to obtain the higher light from the 170-amp arc.

In order to ensure a sufficient screen brightness for proper viewing conditions, the American Standards Association Standard Z22.39-1944 has specified that "The brightness in the center of a screen for viewing 35-mm motion pictures shall be 10_{-1}^{+4} foot-Lamberts when the projector is running with no film in the gate."

The screen light intensities in Figs. 1 to 4 can be converted to screen brightness in foot-Lamberts by multiplication by the screen reflectivity. This has been done using a screen reflectivity of 75 per cent and the resultant data have been used to plot Figs. 5-8. These block diagrams define the widths of screen which can be illuminated within the brightness limits of the ASA Standard just quoted by each of the nine projection systems with the screen distribution and projection lens specified. It should be noted again that this is a general guide and variations from these data will occur under the conditions previously described.

As an example of the use of the illustrations, Item 2, the "One Kilo-watt" direct-current system, is shown in Fig. 5 as being capable of illuminating screens 13 to 16.5 ft wide at 14 to 9 ft-L, respectively, with an $f/2.5$ untreated lens and with an 80 per cent screen distribution. If an $f/2.0$ treated lens is substituted, larger screens of 15 to 18½ ft can be illuminated as shown in Fig. 7. If now this same system is adjusted for maximum intensity at the center of the screen then the widths become 14½ to 18 ft with an $f/2.5$ untreated (Fig. 6) and 16½ to 21 ft with an $f/2.0$ treated lens (Fig. 8).



SCREEN WIDTH - FEET

FIGS. 5, 6, 7, and 8. Size of screens capable of illumination to 9 to 14 ft-L³ at center with various projection systems.

Items¹

- 1 12-8-mm Low Intensity, 32 amp., 55 volts.
- 2 7-6-mm "Suprex", 40 amp., 27.5 volts.
- 3 7-6-mm "Suprex", 42 amp., 33 volts.
- 4 7-6-mm "Suprex", 50 amp., 37 volts.
- 5 8-7-mm "Suprex", 60 amp., 36 volts.
- 6 8-7-mm "Suprex", 70 amp., 40 volts.
- 7 13.6-mm-⁷/₁₆" High Intensity, 125 amp., 68 volts.
- 8 13.6-mm-¹/₂" High Intensity, 150 amp., 78 volts²
- 9 13.6-mm-¹/₂" Super-High Intensity, 170 amp., 75 volts²

Notes

- (1) Refer to Table 1 for details on items.
- (2) May require heat filter and result in 10 per cent decrease in width at given brightness.
- (3) Foot-Lambert values assume—
 - (a) 50 per cent shutter transmission,
 - (b) 90 per cent projection port glass transmission,
 - (c) No film or filters other than port glass,
 - (d) Diffusing screen with 75 per cent reflectivity.

It is worthy of note that the nine typical systems described are capable of covering a screen width range of 10 to 39 ft to recommended brightness levels.

Projection systems employing $f/2.0$ condenser lenses (Items 8 and 9, Table 1) sometimes produce an "in and out of focus" flutter of the film in the aperture,³ so that heat filters or other means may be necessary to prevent such action. If filters of Aklo or Phosphate glass⁴ are so used, the light values quoted in Table 1 will be reduced by approximately 20 per cent and the screen widths in Fig. 1 to 8, inclusive, will be reduced by about 10 per cent, because of the light absorption by the heat filter.

Although the discussion of screen illumination in this paper has been confined to systems commercially available at present, it should be kept in mind that experimental systems⁵ are capable of delivering considerably more light than any of those described, and it is to be expected that the continued developments of higher brightness carbons and improvements in optics will enable the achievement of still greater screen lumen values.

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CURRENT LITERATURE OF INTEREST TO THE MOTION PICTURE ENGINEER

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

American Cinematographer

27, 11 (Nov. 1946)

Mitchell Camera Company Opens New Plant for Expanded Production (p. 399)

Maurer Introduces New Professional 16-Mm Camera, (p. 402)

Filmo "Electro" Camera for Time and Motion Study (p. 414)

Kodachrome Introduced Commercial-Type 16-Mm (p. 421)

British Kinematograph Society, Proceedings of the Theater Division (Session 1945-46)

Electronics and the Kinema:

- | | |
|---|-------------------------|
| 1. Electricity and the Atom (p. 1) | G. PARR |
| 2. The Photoelectric Cell and the Thermionic Valve (p. 6) | G. PARR |
| 3. Electronic Aspects of Sound Reproduction (p. 10) | H. W. HASTINGS-HODGKINS |
| 4. The Cathode-Ray Tube (p. 17) | G. PARR |
| 5. Television (p. 22) | T. M. C. LANCE |
| The Thermionic Valve (p. 31) | R. E. GREENE |

International Photographer

18, 10 (Nov. 1946)

Orthicon Television Camera Technical Data (p. 18)

New 16-Mm Lab Opens in Hollywood (Acme Film Laboratories, Inc.), (p. 22)

International Projectionist

21, 11 (Nov. 1946)

Electronic Aspects of Sound Systems (p. 5) H. W. HASTINGS-HODGKINS

Incandescent Lamps for Film Projection (p. 12) J. J. A. MANDERS

Basic Radio and Television Course, Pt. 27—
Superheterodyne Trouble-Shooting Procedures
(p. 20)

M. BERINSKY

Projection Rectifier Tube Data (p. 24)

J. K. ELDERKIN

Physical Society, Proceedings

58, (Sept. 1946)

The Performance of Aircraft Camera Lenses (p. 493) E. W. H. SELWYN AND
J. L. TEARLE

Optical Problems of the Rotating Prism Cinematograph Projector (p. 598) J. KUDAR

Radio News

36, 6 (Dec. 1946)

Sound Amplification by Air-Stream Modulation (p. 39) J. McQUAY

SOCIETY ANNOUNCEMENTS**MIDWEST SECTION MEETING**

Lloyd Thompson, of the Calvin Company, Kansas City, Mo., and E. J. Weinke, of Motiograph, Chicago, were guest speakers at the meeting of the Midwest Section of the Society in Chicago on Dec. 12, 1946. Speaking on "Quantity Production of Kodachrome Prints," Mr. Thompson described a projection mat contact step printer for making a limited number of prints, and a continuous "Multimatic" printer for obtaining effects by use of a mat.

Mr. Thompson also discussed the drum printer used for color control and check of prints, and the edge-numbering machine developed by the Calvin Company.

Mr. Weinke spoke briefly of the 50th anniversary of Motiograph and described their new projector. Of particular interest to the members and guests present were the double concentric barrel shutter, grease-sealed bearings, gun-latch gate opening, and measured adjustable shoe pressure.

The meeting concluded with a showing of a motion picture supplied by the Calvin Company, and examination of the projector head.

INTER-SOCIETY COLOR COUNCIL

The sixteenth annual meeting of the Inter-Society Color Council will be held on Feb. 24-25, 1947, at the Hotel Pennsylvania and Hotel Commodore, New York, and members of the SMPE are cordially invited to attend any session of interest. The Secretary of the Council advises that the meeting is planned to follow that of the Optical Society and to coincide with that of the Technical Association of the Pulp and Paper Industry. Complete and final programs are available from Dorothy Nickerson, Secretary, P. O. Box 155, Benjamin Franklin Station, Washington 4, D. C. In brief, the program on February 24, at the Pennsylvania Hotel, beginning 9:30 A.M., will consider color terms, color aptitude test, color blindness test, illuminating and viewing conditions for colorimetry, and the illuminant in textile color matching.

On February 25, at the Commodore Hotel, starting at 9:30 A.M., papers will be presented on "The Paper Man's Interest in Color," colorimetric standardization in industry, and color-order systems. At 2:00 P.M., topics on spectrophotometry

ICI standard observer and co-ordinate system, inter-relation of color specifications, and color engineering will be discussed.

We are grieved to announce the deaths of Hastings W. Baker, Associate member of the Society, on October 25, 1946, in New York, N. Y., and Harry L. Denton, Associate member of the Society, on December 14, 1946, in Chicago.

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HOTEL RESERVATIONS AND RATES

The management of The Drake, located at Lake Shore Drive and Upper Michigan Ave., Chicago 11, Illinois, Convention Headquarters, extends SMPE members and guests the following per diem room rates, European plan:

Room with bath, one person.....	\$4.55-5.50
Room with bath, two persons, twin beds.....	\$7.50-8.50-9.00-10.00-12.00
Parlor suites with connecting bedrooms, two persons.....	\$18.00-20.00-22.00-25.00

Note.—Room accommodations must be booked early and direct with W. N. Cowan, Front Office Manager, The Drake, prior to April 15. When making reservations be sure to advise Mr. Cowan that you are attending the SMPE 61st Semiannual Convention. No rooms will be assured or guaranteed at The Drake unless confirmed.

TRANSPORTATION

With travel conditions still not normal, the Eastern and West Coast members who are contemplating attending the 61st Semiannual Convention should consult their local railroad, Pullman and plane agents regarding effective schedules and rates at least 30 days prior to your departure.

REGISTRATION

The Convention Registration Headquarters will be located in the French Room Foyer of The Drake. Members and guests are expected to register. The fee is used to help defray the Convention expenses.

TECHNICAL PAPERS AND SYMPOSIUMS

Members and others who are contemplating the presentation of papers at the Chicago Convention can greatly assist the Papers Committee in the early scheduling and assembly of the program by mailing in the title of paper, name of the author, and an abstract to the Papers Committee Chairman, or to the Society's offices in the Hotel Pennsylvania, New York, *not later than March 15*. Complete manuscripts must be received by *April 7* to be included in the final program. Your co-operation in this regard is solicited.

The Convention business and technical sessions will be held in the Grand Ballroom located on the lobby floor of the hotel.

SMPE GET-TOGETHER LUNCHEON

The usual Get-Together Luncheon will be held in Gold Coast Room on Monday, April 21, at 12:30 P.M.

The luncheon program and eminent guest speakers will be announced in later bulletins. Guaranteed seating at the luncheon will be assured only if tickets are procured *prior to 11:00 a.m.* on April 21. Assist the Committee and hotel in providing accommodations by complying with this request.

INFORMAL BANQUET AND DANCE

The SMPE 61st Semiannual Banquet and social get-together will be held in the palatial Gold Coast Room of The Drake on Wednesday evening, April 23, at 8:00 P.M. (Dress optional.)

Banquet tickets should be procured and tables reserved at the Registration Headquarters prior to *noon on April 23*. The Banquet program will be announced in later bulletins.

Luncheon and Banquet tickets may be procured in advance of the dates of these functions through W. C. DeVry, Chairman of the Luncheon and Banquet Committee, located in Chicago, or through W. C. Kunzmann, Convention Vice-President, who will be at The Drake several days prior to the opening date.

Note.—All checks or money orders issued for registration fee and luncheon or banquet tickets should be made payable to W. C. Kunzmann, Convention Vice-President, and *not to the Society*.

LADIES REGISTRATION AND RECEPTION HEADQUARTERS

Ladies attending the Convention should register with Mrs. A. Shapiro, the hostess, and members of her Committee in their headquarters, Parlor *H*, which is adjacent to the Grand Ballroom where the Convention sessions will be held.

Ladies' entertainment program will be announced later by the Ladies Committee.

RECREATION

Convention recreational program will be announced later by the Local Arrangements Committee. Consult the hotel bulletin board or Registration Headquarters for other local amusements available in Chicago during the Convention dates.

MOTION PICTURES

Convention identification cards will be honored through the courtesy of the Balaban and Katz Corporation at the following *deluxe* theaters located in the Loop, namely: Chicago, State Lake, and United Artists Theaters.

The H. and E. Balaban Corporation extends their courtesy and will honor these cards at their Esquire Theater located in the immediate vicinity of The Drake Hotel.

RKO Theaters (Chicago Division) extends their courtesy of honoring the Convention identification cards at their *deluxe* RKO Palace and Grand Theaters, located in the Loop.

TECHNICAL SESSIONS SCHEDULED

Monday, April 21, 1947

Open Morning.

- 9:30 a.m. *French Room Foyer:* Registration. Advance sale of Luncheon and Banquet tickets.
- 12:30 p.m. *Gold Coast Room:* Get-Together Luncheon (Speakers).
- 2:00 p.m. *Grand Ballroom:* Business and Technical Session.
- 8:00 p.m. *Grand Ballroom:* Evening Session.

Tuesday, April 22, 1947

- 9:30 a.m. *French Room Foyer:* Registration. Advance sale of Banquet tickets.
- 10:00 a.m. **Morning Session:** Location to be announced later.
- 2:00 p.m. *Grand Ballroom.* Afternoon Session.
- Open Evening.

Wednesday, April 23, 1947

- 9:30 a.m. *French Room Foyer:* Registration. Advance sale of Banquet tickets.
- 10:00 a.m. **Morning Session:** Location to be announced later.
- Open Afternoon.
- 8:00 p.m. *Gold Coast Room:* SMPE 61st Semiannual Banquet and evening for social get-together will be held in the palatial Gold Coast Room (dancing and entertainment). The program for this evening will be announced later by the Banquet Committee. Tables may be reserved at the Registration Headquarters prior to noon on April 23.

Note: The Registration Headquarters will be open on this afternoon for those desiring to make final arrangements for the Banquet.

Thursday, April 24, 1947

Open Morning.

- 2:00 p.m. *Grand Ballroom:* Afternoon Session.
- 8:00 p.m. *Grand Ballroom:* Evening Session.

Friday, April 25, 1947

- 10:00 a.m. *Grand Ballroom:* Morning Session.
- 2:00 p.m. *Grand Ballroom:* Afternoon Session. Adjournment of the 61st Semiannual Convention.

Note.—All sessions during the five-day Convention will open with an interesting motion picture short.

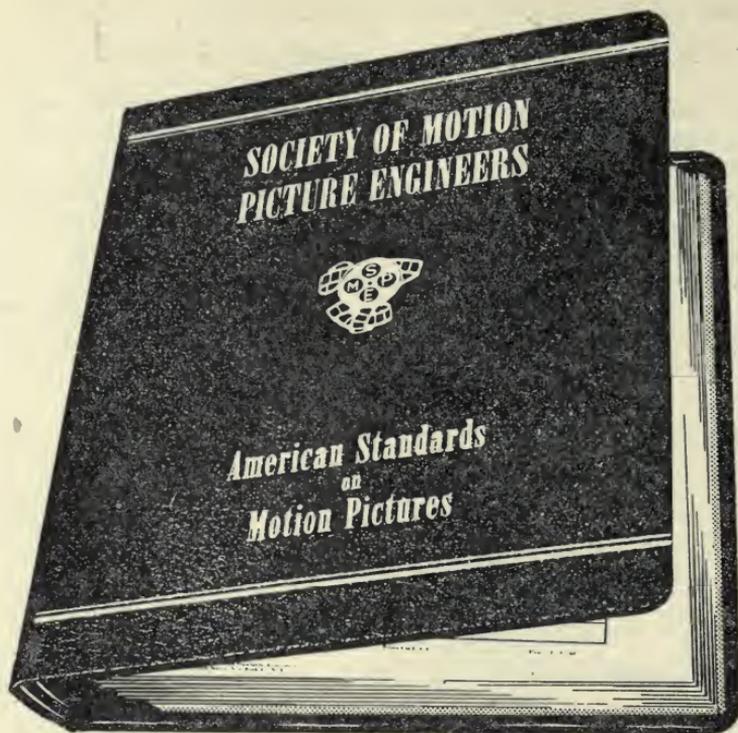
Important

Book your room accommodations early and direct with W. N. Cowan, Front Office Manager, The Drake, Chicago, Illinois. All reservations are subject to cancellation prior to April 10.

Co-operate with the Luncheon and Banquet Committee by procuring tickets well in advance of the dates for these functions, so that hotel arrangements can be made accordingly.

This is a tentative schedule and is subject to change.

W. C. KUNZMANN
Convention Vice-President



✓ **The second group of American Standards on Motion Pictures**—printed in the new distinctive $8\frac{1}{2} \times 11$ -in. format is now available for inclusion in the SMPE Standards Binder shown above. These six additional Standards, published in the September 1946 JOURNAL, are supplied as a service to motion picture engineers and industrial librarians who must maintain files of American Motion Picture Standards for easy and ready reference.

✓ **As a further service**, purchasers of this Binder are notified by the Society when new Standards or revisions thereof are published. All American Motion Picture Standards published in the future will be punched to fit this Binder.

✓ **The price** of the SMPE Standards Binder with a complete set of all 26 current American Motion Picture Standards is only \$5.10.* Send check, money order, or company purchase order now to the Society of Motion Picture Engineers, Hotel Pennsylvania, New York 1, N. Y.

* Add 50 cents for postage and special packing if mailed outside the United States. If mailed to New York City address, add 2 per cent Sales Tax.

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FILM PROJECTORS FOR TELEVISION*

RALPH V. LITTLE, JR.**

Summary.—*Television will make wide use of 35-mm and 16-mm motion picture film. The method of televising motion pictures using the storage-type pickup device is described. Theater and television projection practice are compared and methods of meeting proposed RMA Television Standards are discussed. Recently designed 16-mm and 35-mm RCA television projectors are described in detail.*

Television, the new vehicle for providing entertainment in the home, relies on three main sources of program material. These are: studio productions of plays, interviews, and related material; field pickups of such events as boxing, tennis, baseball, and other on-the-spot items of general interest; and motion picture film subjects. A well-planned program will endeavor to use all of these means, possibly in the same broadcast period, to achieve the smoothest and most pleasing continuity obtainable for the entertainment of the home audience. It is also quite evident that for economic reasons the smaller station may, initially at least, lean more heavily on motion picture film, either of the standard variety or in the form of syndicated films of television studio productions as a source of program.

For such reasons it may be of interest to outline the developments and general problems peculiar to television motion picture projector systems. Motion picture films are reproduced in a television system by projecting the motion picture image upon the photosensitive surface of a pickup tube in the television camera. The video signal is generated at this point by a process of scanning the motion picture image electrically to produce an electrical or television signal.

There are several possible projector systems for carrying out this transfer of optical information into a video or picture signal. They can be divided into two main classifications, using either continuous

* Presented Oct. 24, 1946, at the SMPE Convention in Hollywood.

** RCA Victor Division, Radio Corporation of America, Camden, N. J.

or intermittent film motion in the projector. At RCA we have concentrated our efforts on the "intermittent" type of film projector. In this system it is essential that the television pickup tube have "storage" or the ability to retain a photoelectric charge image corresponding to the illuminated picture pattern projected on its light-sensitivity surface by the action of a light-pulse applied during those intervals when the film is stationary in the film-gate. The "Iconoscope,"¹ a tube used for this purpose, has this property of storage, which allows the picture information to be projected, stored, and then utilized to form an electrical picture signal by television scanning during the time intervals when the tube is in complete darkness.

The scanning process consists of a systematic sweep from left to right and from top to bottom of the photosensitive area by an electron beam followed by the return of the beam to the starting position. The time required for the beam to return to the top of the raster after completing a vertical scan is called the *retrace time*; during this interval the beam and the system are cut off by the use of a vertical blanking pulse. It is during this blanking time that the film is at rest in the projector and the picture is flashed on the mosaic by a high-intensity light pulse. The stored picture is then scanned in complete darkness by the electron beam during the succeeding vertical scanning interval.

With this over-all preview of the fundamentals of operation we can now examine in more detail the various points involved in intermittent-type motion picture television projectors.

Theater Projectors.—Motion picture practice has standardized on a projection rate of 24 frames per sec for both 16-mm and 35-mm sound films. The method of projection is such that the projected light is interrupted twice per frame; once to permit pull-down to the successive frame and once during frame time to give an additional interruption to the picture image. This double showing of each frame reduces the sensation of flicker to the eye by doubling the repetition rate of the flicker.² Since each picture is actually seen twice, the flicker or field frequency is 48 times per sec, high enough to give the illusion of no flicker at all at the picture brightness normally employed in theaters.

Television.—Television operating standards have been proposed by the Radio Manufacturers Association for adoption by the industry and by the Federal Communications Commission.

One of the recommendations of the RMA is that of operating a

television system so that it can be tied in with the 60-cycle power lines which are widely used in America. Such television operation minimizes the effects of hum-pickup and makes electrical filtering at both the transmitter and the receivers considerably easier and more economical. The repetition frequency of television pictures is therefore 60 fields per sec, well above the perceptible flicker rate.

The use of interlacing,³ which is a system of transmitting all the odd-numbered scanning line detail in one field followed by all the even-numbered scanning line detail in the next field, produces one completely scanned picture in one frame or $1/30$ sec. This gives an effect which is quite analogous to the action of the shutter in standard theater projectors. Scanning begins in the upper left-hand corner and proceeds in parallel lines until the scanning beam reaches the bottom of the raster. The even lines have now been scanned and the beam returns to scan the odd lines. The present system scans $262\frac{1}{2}$ parallel lines during one field and $262\frac{1}{2}$ alternate lines during the successive field, to form a 525-line raster at the rate of 30 frames per sec. This gives a repetition rate of 60 fields per sec, which is high enough to eliminate flicker without requiring the prohibitively wide frequency channel necessary for other methods of arriving at the same result.

However, the adoption of standards giving a scanning of 60 fields or 30 complete frames per sec, using standard 24 frame-per-sec moving picture has required the development of special television-type motion picture projectors.

Picture Fields and Frames.—Certain fundamental definitions can be introduced in order to develop a useful approach to an understanding of the television processes which are taking place when film transmissions are being made. Terms which are closely analogous in motion pictures and in television can be used to advantage. By using the term "field" to designate each interval in which motion picture or television information is projected, we can say that theater motion picture projections are at a rate of 48 fields from 24 frames per sec, and television images are made up of 60 fields interlaced to become 30 frames per sec.

Considerable time is required between frames to move the film past the aperture from one frame to the next; during this interval the light is cut off by the shutter whose additional function is to interrupt the light once during the frame time. We show this diagrammatically.

Picture Sequence.—In the sequence diagram of Fig. 1, the first block indicates showing time; the next shaded portion indicates shutter time; the third shows time; and the fourth, shutter time to

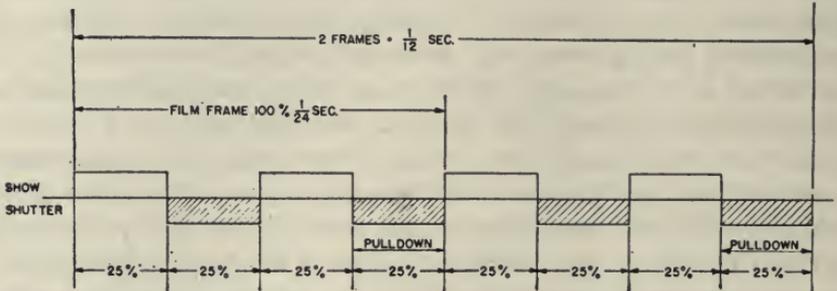


FIG. 1. Thirty-five millimeter theater projector time cycle.

complete one frame. The second shutter time covers the film pull-down interval. Fields and frames are designated and the relative intervals for 35-mm practice are shown. In television there is also a function comparable to pull-down which must be completed between fields; this is the return of the scanning beam from the bottom of one

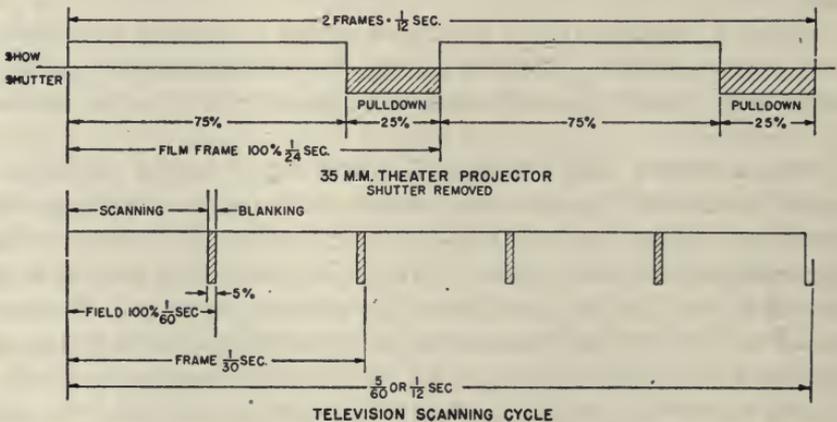


FIG. 2. Time-cycle comparison.

scanning raster to the top of the next scanning raster. An electrical blanking signal is used during this interval to make the picture beam blank or cut off so as to allow for an invisible retrace of the scanning beam. The signal used is called *vertical blanking* and occurs at the end of each vertical scanning field.

Time-Cycle Comparison.—The terminology in Fig. 2 is similar to that used in Fig. 1; the difference in the proportion of showing to blanking is noticed at once. A change has been made in the representation of the theater projector cycle, removing the shutter in order to permit maximum showing time. Television scanning is characterized by using a nominal five per cent of the total available time for blanking between fields. The remainder of the time is used for scanning or showing.

The problem is to obtain picture information for the television system at a repetition rate of 60 times per sec in order to have information for each television field, and still run the film at 24 frames a sec.

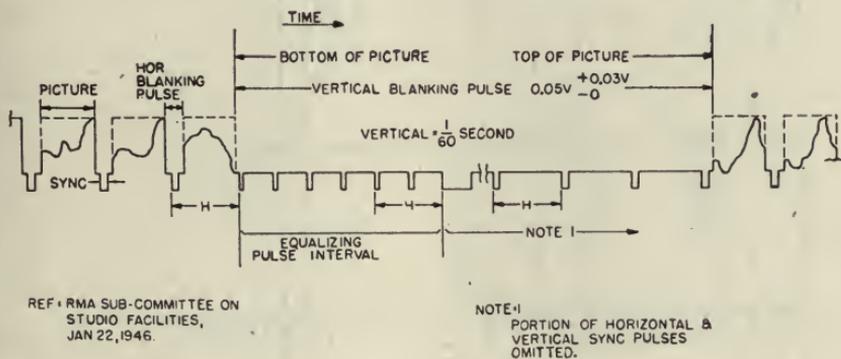


FIG. 3. Detail of proposed RMA television signal.

We can see that the scanning intervals of the television system do not occur in such a manner as to give uniform picture information from the film to the television system. Scanning times occur in some cases during pull-down so that the picture information would change during a scanning and hence give the equivalent of travel ghosts. Pull-down requires such a long interval that it is impossible to use a conventional projector and have the required information available for each scanning.

This alternative suggests itself: the television system can obtain video information during blanking by the storage principle. The Iconoscope allows the picture information to be supplied during the interval of blanking, stored as an electronic image, and scanned during periods of darkness. Therefore, methods must be devised to have a stationary picture available for every television field.

Proposed RMA Signal.—A single television field is shown in Fig. 3 as taken from the proposed RMA standard signal recommendations. It illustrates the design requirements on television showing time.

The interval designated between *bottom* and *top* of picture is the vertical blanking time and is the time between scanning fields in which we must expose the television camera. The duration is shown as five per cent with a plus tolerance of three.

Television Projector Time Cycle.—Examination of this chart, line (A), shows two standard 35-mm picture frames each of $\frac{1}{24}$ sec duration, with each frame represented as a 360-deg cycle;

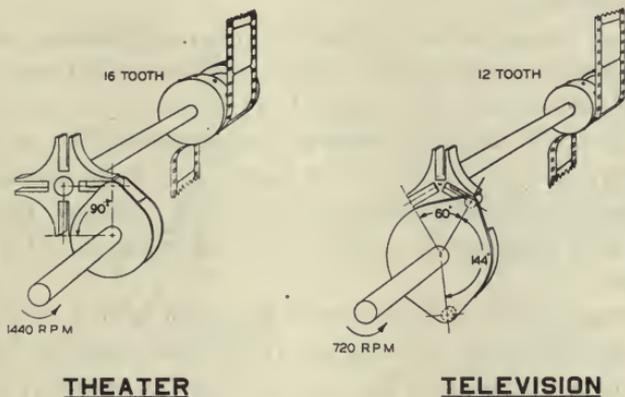


FIG. 5. Thirty-five millimeter film projector intermittent mechanism.

from this we see a pull-down time indicated as 90 deg, leaving the balance as showing time, if we ignore standard shutters in this discussion.

In this chart, television fields with five per cent blanking have been added to scale. These blanking intervals must occur during projector showing time intervals. The most important thing to point out here is the extremely short time interval between television fields, and the impossibility of a fast enough pull-down to accommodate the television system. Let us see how we can circumvent these practical mechanical limitations. If we use the Iconoscope we can store a picture during the intervals of vertical blanking and scan the picture in complete darkness.

Two possible methods of obtaining the proper showing time are charted. In line (B) the first showing interval can be shortened to

accommodate two blanking intervals for the projection of the first frame, and the second frame can be held for a longer time to accommodate three blankings as indicated. In such a manner two exposures are made of one frame and three of the successive frame. Thereby we have made five television fields out of two frames of $\frac{1}{24}$ sec each. This gives us 60 television fields or 30 television frames per sec from film running at 24 frames per sec. This 2:3 ratio of picture projection, a very clever piece of trickery, is described in U. S. Patent 2,082,093, A. V. Bedford of RCA Laboratories, Princeton, N. J. Light pulses for the Iconoscope are produced by a rotating shutter properly phased, with the television system using a high-intensity light source.

The other method shown in line (C) charts conditions with a very short pull-down time interval. If this is made approximately 50 deg as indicated, it allows two showings to be centered in one frame and three showings in the successive frame without resorting to any change in the time ratio of the intermittent mechanism from frame to frame. U. S. Patent 2,303,960, Stuart Seeley, RCA Licensee Laboratories, describes this alternative method for television of film projector mechanisms.

The design of a 35-mm television projector with a fast pull-down (such as 50 deg) does not appear practicable because cutting the allowable time in half increases the acceleration forces by four times. These forces would exceed the elastic limit of the film; the mass of the film in this case represents the major part of the load. Therefore, the 2:3 ratio intermittent represents a good solution to the problem.

35-Mm Intermittent Mechanism.—This type of intermittent mechanism is used in the Brenkert *BX80* theater projector which is being built by the Brenkert Light Projection Company for the RCA Victor Division. The standard theater Geneva movement is shown functionally in Fig. 5. A driveshaft turns the cam, with its single drivepin, at 24 rps; each revolution of the cam turns the four-point star wheel 90 deg and the picture moves one frame. The television intermittent designed for the *BT90* projector is shown with a special cam divided in the ratio of 2:3 and driven at a reduced speed of 12 rps to maintain 24 rps at the sprocket shaft. The star now has three points to give the faster pull-down necessary because the cam pin speed has been halved. The sprocket has also been modified to have 12 teeth instead of 16. Since the angular rotation has increased to 120 deg, the film travel is maintained at the same rate as

previously used; i.e., four sprocket holes to advance the picture one frame.

16-Mm Intermittent Mechanism.—Our 16-mm projector intermittent problem (Fig. 6) has been solved by increasing the nominal 65-deg pull-down, of the RCA *PG201* Projector, to approximately 45 deg to accommodate the necessary picture exposures in the manner shown in line (C) of the time-cycle chart of Fig. 4. The designer, in an ingenious solution, has applied elliptical gears which are interchangeable with the existing spur gears. In effect the gear ratio is variable

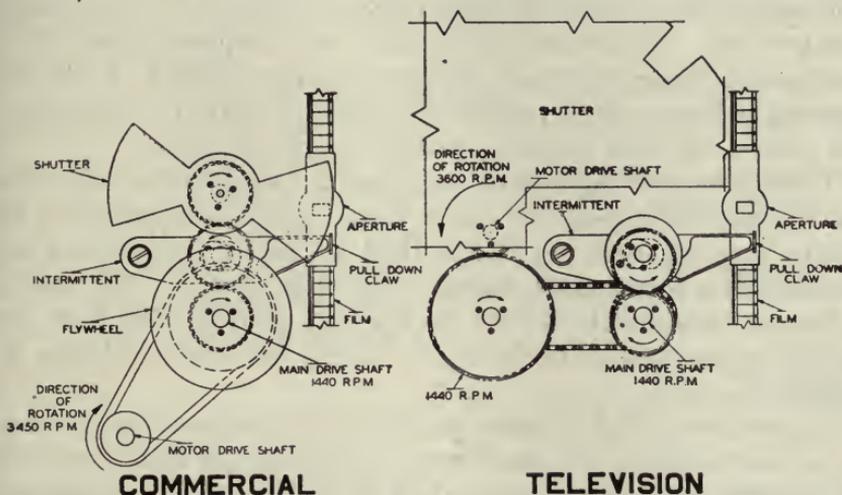


FIG. 6. Sixteen-millimeter film projector intermittent mechanism.

so as to give an almost two-to-one speed change which is sufficient to make the pull-down 45 deg. The pull-down action is phased with the fast half-cycle of the elliptical gears so that the propelling motion is then the product of the normal cam action and the elliptical gear action. The result is a portion of a sine squared motion and very well suited for film advancing mechanisms.⁴ The time gained on the pull-down stroke results in a retarded return stroke which reduces the strain and vibration in the mechanism.

Light Source.—Design of the intermittent mechanism represents the solution to the first of three projector functions peculiar to television. The second problem is the light source and the method of accurately timing the duration and repetition of projected light.

An adequate light source for the Iconoscope must be capable of producing approximately 40 ft-c average illumination on the mosaic with no film in the machine. The duration of projection time must be five per cent or less with a repetition rate of 60 times per sec.

There are two methods of meeting the light requirements: first, an adequate light source with a shutter can be made to give accurate timing of the projection interval; second, a type of light source which can provide the correct illumination by switching this source on at the proper instant and for the correct exposure duration. The first method has been used in previous television projectors and is the one used in our 16-mm television projector because of its simplicity and low cost. The second type of light source requires a lamp which can have its illumination cycle instantaneously controlled. Until very recently it has not been possible to obtain a practical source having the control, the light intensity, and life for this purpose.

The shutter for the 16-mm projector is located where the cross section of the light beam to be interrupted is small compared with the shutter opening used; by this method we have a fast opening and closing and a considerable region of full opening time. The shutter is located immediately behind the aperture plate so that light and associated heat are on the gate only during the actual exposure interval.

Nevertheless, a light source operated by an electronic switch would be an ideal solution; the short duty cycle of five per cent would conserve power, and greatly reduce the heat in the projector mechanism and film. It is certainly logical to turn the light on when it is needed rather than to keep it on continuously and waste 95 per cent to obtain the five per cent pulse by a mechanical shutter.

Early experimenters attempted to modulate a carbon-arc source with little success because of the glow retained in the incandescence of the arc crater. RCA has been experimenting in collaboration with Edgerton, using gaseous discharge lamps for this purpose for the past several years. Some degree of success has been obtained. A recent General Electric announcement has made public a successful system of pulsing a low-pressure xenon lamp using radar keying technique.

RCA is planning to adopt this pulsed-light source for the 35-mm television projector. This will make possible many projector simplifications. The problem of designing and driving a 3600-rpm shutter has always been a difficult mechanical one. Without this shutter load the projector can be driven by means of sound head; the

conventional arrangement for standard theater projectors, using a $\frac{1}{4}$ horsepower 1800-rpm synchronous motor.

Design of shutters and light sources requires an accurate method of analyzing the projector light-output pulse. A phototube light-pulse checker was devised for this purpose. Some actual results are shown in Fig. 7. "A" represents the sharp opening and closing edges with long-duration flat top, indicating a long period of constant-intensity illumination. "B" shows a light pulse from a prewar television projector using a front shutter with an opening equal to the diameter of the light beam leaving the lens. The opening and closing require a relatively long time, while the maximum illumination persists for only a small time interval.

Trace "C" shows the light pulse which is expected when the new pulsed-light mercury lamp is used. The opening and closing edges are almost infinitely steep and the top is flat, which gives an ideal system of operation. The sharp rise-and-fall edges provide an additional margin of safety within the television blanking interval.

By using a two-trace oscilloscope it is possible to observe simultaneously the light pulse and the kinescope blanking pulse. With this technique the pulse phasing, overlap, and the lock-in characteristic between the television synchronizing generator and projector synchronizing generator and projector synchronous motor can be studied in complete detail.

The electrical details of the light-pulse checker are shown on the drawing of Fig. 8. The first tube is a 927 photocell, the second, a 6J5 amplifier. A 6X5-GT rectifier tube furnishes a convenient d-c supply voltage. The light-pulse checker is placed at the focal plane of the Iconoscope camera tube and the amplifier output is connected to the vertical amplifier input circuit of a cathode-ray oscilloscope. The pulse duration can then be measured by using a synchronous 60-cycle sine-wave sweep for horizontal oscilloscope deflection. With the pulse phased to be in the middle of the sweep, the width of the pulse, divided by π times the horizontal sweep amplitude and

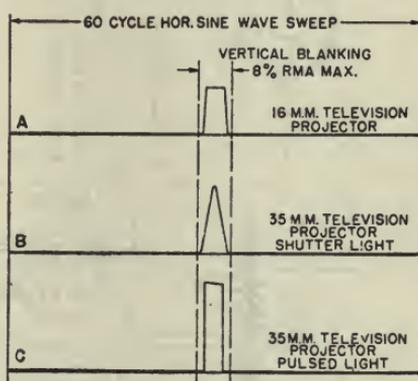


FIG. 7. Light-pulse comparison.

multiplied by 100, will give the percentage time duration. The pulse checker can also be used to study any recurrent light pulse cut-off characteristics of standard theater projector shutters.

A fundamental requirement of a projector is its ability to synchronize accurately with the television system. Synchronization is accomplished by virtue of the fact that both the television synchronizing generator and the special synchronous motor on the projector have a common source of power supply. The special motor has several requirements; first, of course, it must lock in with the power line, and second, since a standard synchronous motor has two

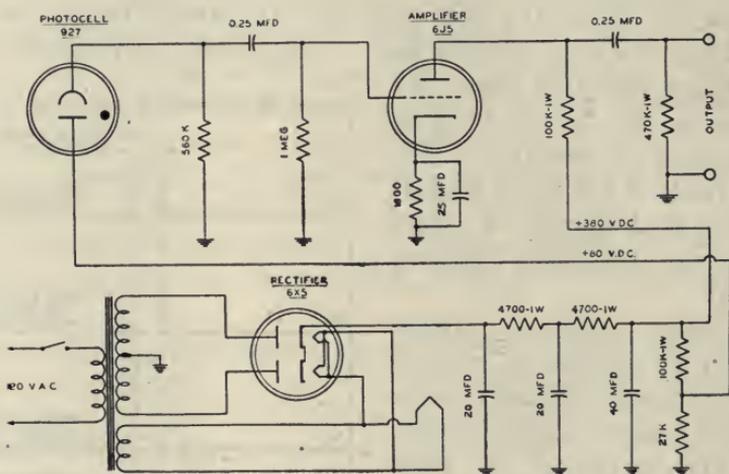


FIG. 8. Schematic light-pulse checker.

lock-in positions, we must select the proper one. The projector can be incorrectly phased in such a manner as to be projecting a picture on the Iconoscope during scanning time; that is a lock-in 180 deg out of correct phase. To eliminate this possibility of error, the motor is built with a wound rotor having polarized field-coils so that it will automatically lock in with only one phase relationship. The motor used must be designed for small torque angle change with changes in load so as to avoid any tendency to hunt, and to maintain accuracy of lock-in for any changes in load due to film loading, or changes in adjustment of the projector during operation.

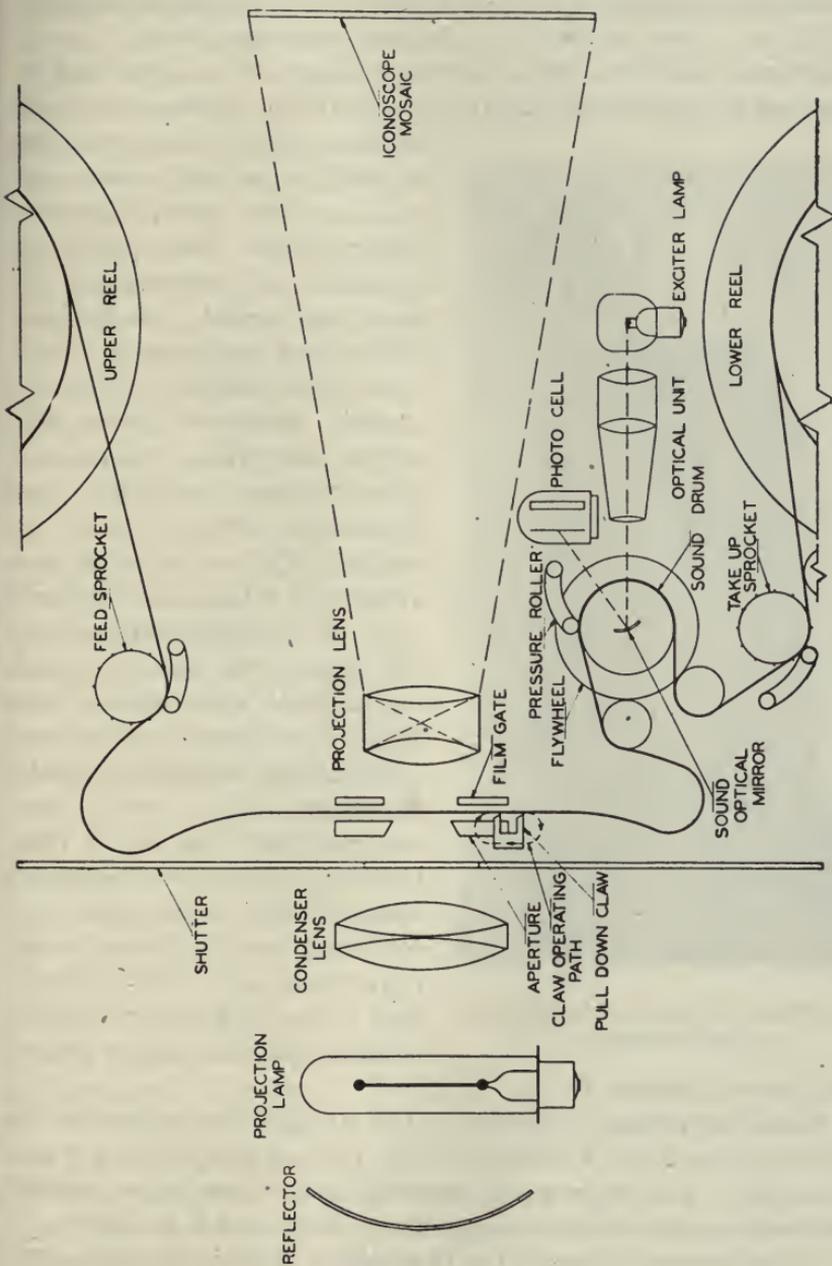


FIG. 9. Sixteen-millimeter television film projector.

Television Sound.—Film-sound for a television system will place a challenge on the moving picture industry to maintain standards of excellence, since television uses frequency-modulation sound transmission and the public is being educated to appreciate increasingly improved standards.

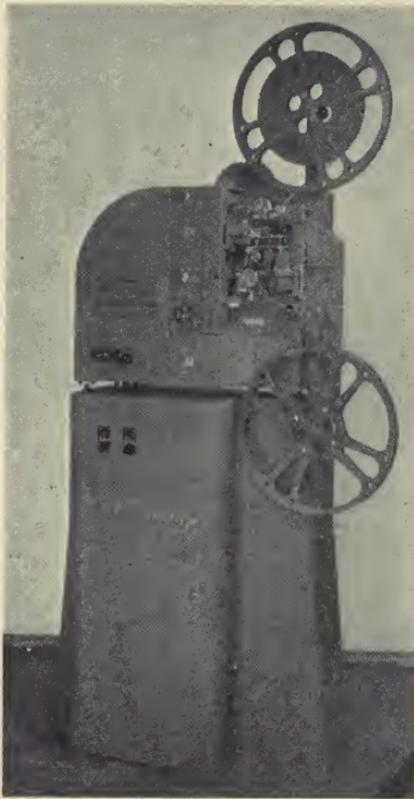


FIG. 10. RCA 16-mm television film projector.

Sound-track reproduction from 35-mm motion picture film has a fidelity comparable with that of the best vinyl recording transcriptions. Such quality approaches the requirements for television sound broadcasting. The 16-mm film projector equipment can produce good sound quality, useful to about 6000 cycles, but wide variations in 16-mm sound recording and processing technique make desirable a 4500-cycle cut-off characteristic. Film-sound standards must be set high enough so that the listener will make favorable comparisons with existing radio standards of sound performance.

Functional Diagram—16-Mm Projector.—The 16-mm projector is shown in Fig. 9 functionally indicating the film path through the mechanism and over the sound drum to the lower take-up. The intermittent is the claw type previously shown, with the shutter located

immediately behind it.

Television Projector—16-Mm.—The RCA 16-mm television film projector, type *TP16A*, shown in Fig. 10, is a completely self-contained unit. The projector is mounted on a cabinet-type pedestal which contains the control equipment and the motor-field supply.

The mechanism is that of the basic RCA *PG201* projector, modified for television systems using a storage-type pickup tube. A $3\frac{1}{2}$ -inch $f/2$ lens is used for projection of the image. The illumination is

furnished by a 1000-watt air-blast-cooled incandescent lamp. A special synchronous motor drives the timing shutter at 3600 rpm to give a pulse of six per cent duration.

Fig. 11 shows the film side of the projector with covers removed from the machine and the pedestal. For normal operation the two circuitbreakers are closed, which completes the circuit to the motor-field supply, the audio amplifier, and the control circuits. The stand-by switch is then closed, placing the projection lamp on warm-up voltage, supplied through dropping resistors. The projector can now be placed in operation by closing the *run* switch, energizing the motor, and placing the lamp on full brilliance. An elapsed-time indicator is provided to record projection lamp hours.

For installation it is necessary only to connect the equipment to a source of 220 v, 60-cycle, three-phase power for the motor, and 115 v, 60-cycle single phase for the projection lamp and auxiliaries. Control circuits with provision for remote operation are connected to the usual 12-v, d-c supply voltage common to most installations.

Fig. 12 shows details of the shutter and drive gear. The small motor beneath the main drive shutter operates a blower which ventilates the lamp house. The RCA rotary stabilizer used for the sound take-off drum is shown in the foreground. A ladder chain-drive powers the lower reel take-up. The amplifier assembly is a completely self-contained unit shock-mounted in the base casting. It consists of a three-stage audio amplifier, designed to feed sound at a 4-db level to a 250-ohm line, an oscillator-type exciter-lamp supply, and the power-supply rectifier.

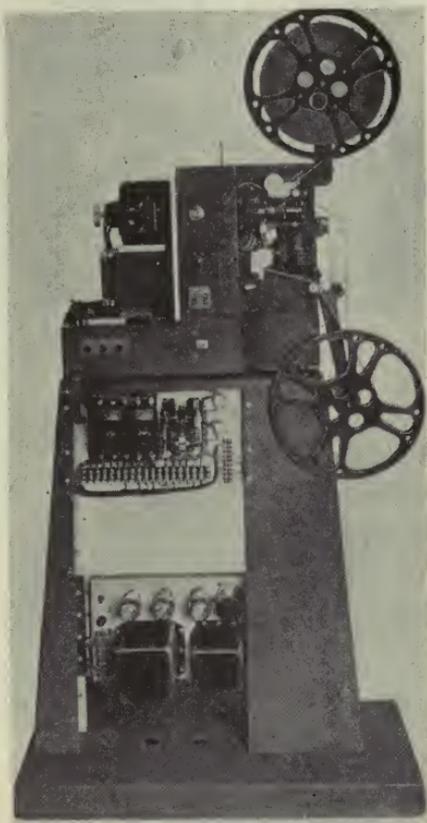


FIG. 11. Covers removed from RCA television projector.

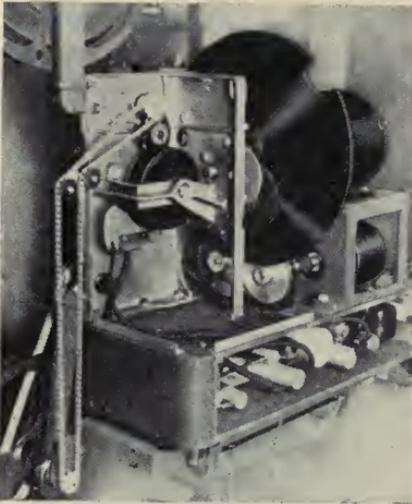


FIG. 12. View of television projector mechanism.

jector, type *TP35A* (Fig. 13). This projector represents the latest advance in the art of motion picture projection for television. The basic machine is

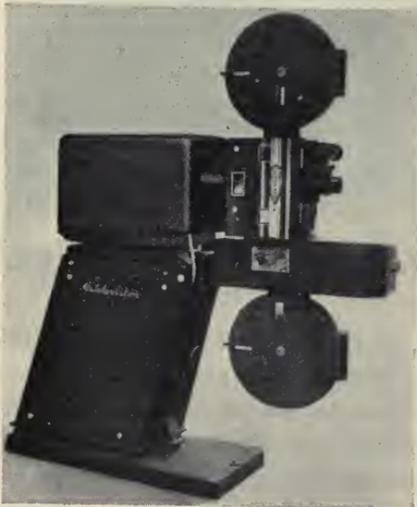


FIG. 13. RCA 35-mm television film projector with Brenkert picture-head with GE Syncrolite.

The base casting rests on leveling screws to provide proper projector alignment.

Composite photographs have been prepared to show the new RCA 35-mm television film pro-



FIG. 14. Film path of 35-mm television projector.

the well-known Brenkert *BX 80*, noted for its rugged design, automatic lubrication, and outstanding performance. The latest RCA high-fidelity soundhead

powered with a special synchronous motor is used as a companion unit. This combination is mounted on a deluxe Brenkert pedestal for rock-steady projection. The lamp house contains the pulse-light⁵ unit, complete, with all power supplies and auxiliaries.

The operating side of the projector is shown in Fig. 14 to illustrate the clean and rugged design of the equipment. All bearings are automatically lubricated on the gear side of the Brenkert projector, thus keeping oil away from the film side.

Wide-mesh helical gears (Fig. 15) running in a continuous flow of oil provide a long-life, trouble-free mechanism. Oil is pumped from the reservoir in the base of the main frame to the rotary lubricator which throws the oil to all bearings and gears. The shutter governor is shown at the top, the framing adjustment through the link appears at the left, and the intermittent mechanism with its cam flywheel is shown at the lower right. A gear-case cover completes the assembly of the Brenkert picture-head and provides an oil-tight gear case for the mechanism.

The design efforts of many people are gratefully acknowledged. W. R. Isom of Advance Development devised the elliptical gearing and built the first 16-mm projector model. The RCA 16-mm group under Sidney Read, Jr., engineered the 16-mm projector, and Karl Brenkert, of Brenkert Light Projection Company, designed the 35-mm picture-head. The entire project was co-ordinated by M. A. Trainer, of the Television Terminal Equipment Group, RCA Victor Division, at Camden, New Jersey.

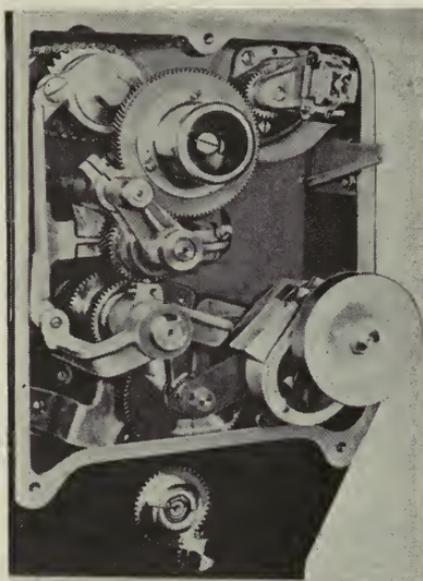


FIG. 15. View of 35-mm television projector mechanism.

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STUDIO PRODUCTION WITH TWO-COLOR BIPACK MOTION PICTURE FILM*

JOHN W. BOYLE, ASC, AND BENJAMIN BERG**

Summary.—The increased use of color in motion pictures has brought about a revival of interest in two-color bipack processes. With proper handling, allowing sufficient production time, and good co-ordination between camera, make-up, art, and wardrobe departments, the results with a two-color process are very adequate.

The entire production program of the Hal Roach Studios is in a two-color process. The technical departments have had the advantage of planning for the limitations of a two-color process. This has enabled the studio to obtain the ultimate possible from such a process. This paper describes briefly some of the problems overcome and techniques developed.

The increased use of color in motion picture production and the inability of the producers to secure sufficient three-color footage for release prints has brought a revival of interest in two-color bipack processes. With proper handling, allowing sufficient production time and good co-ordination among all departments, such as camera, make-up, art, wardrobe, property, *etc.*, the results with a two-color process are very satisfactory.

Since a two-color process can only record a limited range of colors successfully, this co-ordination between the various departments is absolutely essential.

The Hal Roach Studio, upon reopening after the war, is producing all of its pictures in color. With the entire product of the studio in color, the technical departments have had the advantage of planning for the limitations of a two-color process. This has enabled the studio to obtain the ultimate possible from such a process.

While a good deal of the following is common knowledge, we believe no literature is available which has attempted to give practical assistance to the worker attempting two-color photography for the first time.

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

** Hal Roach Studios, Culver City, Calif.

With a few changes, any standard 35-mm cine camera can be utilized to photograph bipack film. These are the changes we have found necessary to convert the *NC* Type Mitchell for bipack: (1) Move lenses toward film (emulsion) plane a distance of 0.0045 in., then use normal calibrations for focus. Cameras with standard instead of "slip-ring" lens mounts would have to be either eye focused or recalibrated; (2) Adjusting lenses will necessitate "shimming" the ground glass back 0.0045 in.; (3) Remove "stripper" shoe at back of main sprocket and replace with "cutaway" shoe; (4) Lock off clutch; (5) Substitute either a four-roller pressure plate, or a solid pressure plate, for the usual two-roller pressure plate. In the four-roller plate the top roller is straight while the other three rollers are crowned 0.003 in. The four-roller pressure plate is patented by the Cinecolor Corporation and license for use must be obtained from them. The solid-type plate is crowned 0.003 in. and is of polished chrome. Pressure can be obtained with a solid screw or by the use of a spring twice the tension of the normal spring. In practice we have used the solid screw for the four-roller plate, being careful to avoid "run-outs."

The proper adjustment of the pressure plate is very important; insufficient clearance with consequent "punching" will cause perforation damage and out-of-register images, while too much clearance will destroy contact of the rear negative resulting in "breathing" and out-of-focus pictures.

Too much stress cannot be placed upon adequate camera maintenance. One of the most common faults in the use of bipack has been out-of-register prints owing to faulty camera operation. Nothing is more destructive of quality than an image that is degraded in sharpness and color because of lack of register.

In the event the print is out of register and the negative shows no perforation damage, it would be wise to have the laboratory check the printing machine before assuming that the camera is at fault. Besides being mechanically perfect the printer, to obtain good register, should use the same perforation for registering the two negatives to the Duplitized positive as is used by the camera for register. Otherwise perforation idiosyncrasies may cause out-of-register prints despite good camera operation.

As an aid in properly maintaining the cameras we photograph a test chart at the end of each day's work. The chart used at Hal Roach Studio is modified from one originally designed by the camera

department of Republic Studios. An examination of the two negatives obtained is an excellent check on the camera's performance. Any lack of sharpness in the back negative, above that normally caused by the diffusion of the light passing through the front film, is easily noted. Another camera may be substituted and the camera sent to the shop for checking. Before the camera is used again another photographic check is made and the negative examined.

We have obtained our best results with coated lenses. It is recommended that the wide-angle lenses should be carefully tested for covering power before being used. We have had satisfactory results with 24-, 28-, 30-, 35- and 40-mm lenses, but such wide-angle lenses should be used with discretion. The present 400-ft capacity magazines used for two-color bipack are wasteful of film and the constant re-loading necessitated by the short lengths uses up valuable production time. The Roach Studios are engaged in the design and construction of a 1000-ft magazine.

The orthochromatic film in the bipack combination comes in two types: an exterior for daylight illumination, and an interior for tungsten lighting. Because of the difficulties of obtaining a sufficiently high level of illumination with tungsten lights and variations in color temperature owing to aging of incandescent lamps, only the exterior type of bipack is used at the Roach Studios. This necessitates the use of high-intensity carbon arc lights and Macbeth filtered incandescent units.

Lighting practice for bipack is similar to that for any color process and will only be summarized briefly. Backlight is kept to a minimum; only the necessary amount used to give detail in hair and separate the planes of color. An undue amount gives an unpleasant bluish tinge. In exteriors, backlight makes grass and foliage appear brown and should always be avoided except when special effects are desired. For street scenes and exteriors where there are no deep shadows, overcast days have given us our best results (since we always use high-intensity arcs, and booster lights) for foregrounds and faces. The use of an Aesculin-type filter to cut the ultraviolet helps in rendition of face values, skin textures, and colors. In general the set should be fully lighted, avoiding deep shadows. With coated lenses at $f/2.8$, a keylight of 500 ft-c is used, filled to an over-all of 650 ft-c.

For night effects, and somewhat deeper shadows, less fill and more crosslight is used. The negative should be fully exposed, the proper

effect being obtained by printing down. Night effects are accentuated by the use of "practicals" and brightly lit windows. In practice about 20 per cent of the lights used are incandescent lamps with Macbeth whitelite filters. Occasionally ordinary incandescent spots are used without Macbeth filters to bring out or emphasize reds and orange, or in the photographing of colored characters. Because of the volume of light necessary, large units are used as far away from subjects as set construction will permit. A *Y-1* filter is used on all high-intensity spots, to cut the excess of blue, while the Mole-Richardson broadsides are used without filters. The side arcs are 5500 K. The high-intensity arcs with *170-Y-1* Brigham filters are 5900 K.

No specific rules can be given for make-up since the problem changes with the actors and actresses. In general, in a two-color process the make-up should be on the light side to avoid a red-orange or sallow appearance. Lip rouge should be an orange-red, blue-reds photographing much too dark. We have found grease to be more satisfactory than "pancake" and no make-up is used above No. 25.

Because of the light make-ups, blended modeling is used to prevent masking appearance and to break color up into planes. For men, a beard cover must be used; otherwise the beard comes through as a blue shadow. No make-up is used on children. The make-up must be carefully balanced between characters to avoid extremes. Flesh tones are best rendered when the print is on the light side. Dark prints cause tones to take on an orange cast rather than the more desirable pink appearance. Make-ups made for existing three-color processes have not been found satisfactory. Standard black-and-white technique in lighter shades has been found more suitable.

The successful use of two-color bipack requires the most careful selection of colors in both sets and wardrobe. Certain difficult colors should be avoided and the most painstaking attention paid to the relationships of colors used. The use of pastel tones of colors produce the best results. Excessive use of brilliant colors is to be avoided except in small areas for emphasis only. Colors darker than the middle range of the scale should not be used except where special effects are desired. This is because all dark colors tend to reproduce with a certain sameness, giving a monotone effect. The use of black and white is good in this regard, to give added range. Contrasting colors used together are excellent for heightening color effectiveness. Blue appears bluer by virtue of being adjacent to a yellow. In men's wardrobes too many grays should be avoided since they tend to

reproduce alike, leaning to the blue-green. For white shirts, towels, bedding, *etc.*, we use a buff color, rather than the usual gray, since the buff reproduces a better white. Browns reproduce fairly accurately, therefore graduations can be better judged. In the selection of wardrobes it is better to make actual photographic tests.

It should be remembered that only the faces are the really fully lighted areas so that clothes are somewhat underexposed. This tends further to degrade dark colors. In general, grays reproduce with a greenish cast, yellow goes orange-brown, reds on the magenta side, tend towards brown, orange-reds reproduce the brightest. Fluorescent cloth used for stage productions reproduces with unusual brightness and can be used effectively where a very brilliant color is desired.

In all instances it is best to make photographic tests of both sets and wardrobes prior to actual production. It is essential that the art director, the wardrobe designer and the cinematographer work closely together to achieve a harmonious result.

Adequate liaison between the color laboratory and the studio is most important, both in keeping the cinematographer informed about his negative and in assisting the laboratory in achieving the effect the cameraman is striving for.

Process shots, matte shots, wipes, dissolves, speed work, *etc.*, can all be done in two-color bipack; in fact, anything which is possible in regular black-and-white photography is feasible in two-color bipack.

THE PRACTICAL PROBLEMS OF 16-MM SOUND*

ALLEN JACOBS**

Summary.—As a service organization for a large number of 16-mm producers in this country, we are constantly impressed with the obvious lack of adequate equipment for making good 16-mm sound. This paper is, in fact, a plea for general improvement in the engineering management and design of sound channels for 16-mm recording. This paper, recognizing the lack of availability of specialized 16-mm equipment, describes the practicability of adapting standard broadcast and disk recording equipment to 16-mm work. This may at first seem obvious, but many 16-mm producers still think that a 16-mm recorder requires a "16-mm amplifier." An attempt is made to convey to the producer the fact that while we cannot buy new 16-mm recorders and film phonographs, we can surround our present recording units with finely engineered sound channels for recording and reproducing that will represent fine quality for years to come.

During the past two years there has been a definite increase in the number of industrial motion pictures made in this country. Some were made by new producers, some by old established firms. The Calvin Company, as a service organization, has had the opportunity to hear and appraise much of this work.

Many sound tracks go through our plant every month. Some are processed, some are printed. Quite often the job is an old 35-mm track for rerecording to make it usable, or an improperly recorded 16-mm track, or a disk recording to be transferred to film. Levels must be smoothed out, volume raised to commercial standards, and tracks re-equalized to make them intelligible. Excellent tracks are the exception. We do hear them, they *are* being made, but not too often do we hear a sound track that could not be improved by the use of better sound channels.

An engineer, walking into this business for the first time, notices the equipment first, or rather the lack of it. This is the only branch of the electronic industry I know of that does not have competitive equipment and lots of it. It would have a wholesome effect on the 16-mm industry if several manufacturers were to enter the electronic

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** The Calvin Company, Kansas City, Mo.

side of it and make new recorders and film-phonographs available—but that is for the future.

Your present problems are not theoretical, they are practical. We want to make better sound quality today. I cannot tell you how to get a new recorder or a new film phonograph, but I can make suggestions that might make it possible for you to make better quality with your present recorders. While I, personally, believe that many of the 16-mm and 35-mm light modulators used in this country are considerably less than perfect, it is still true that the average producer is not turning out sound tracks as good as his recorder is capable of making.

So let us design sound channels around our recorders that will represent fine quality for years to come, and will feed into the recorder quality at least its equal, and generally better. We can *do* something about the quality we deliver to our recorders, and we can *do* something about the quality after it leaves our reproducers. It is the purpose of this paper to discuss these problems, and to describe a typical sound recording channel suitable for a permanent film and a disk installation, and the choice and use of the components that make it up.

Whether you record on paper tape, magnetic wire, 16- or 35-mm film, or rotating disks, your basic problem is the same. It is adequate power with good wave form. You will never make better quality than the weakest point in your sound system. So I think a wise thing to do is to let the weakest point be the recorder or the film itself. I think that is a practical answer to a present problem. Also, a good sound channel today will be a good sound channel five years from today.

Now, how would you build a sound channel for a 16-mm recorder? What are the basic requirements for 16-mm sound? Many producers still think that a 16-mm recorder has to be fed with a 16-mm amplifier. That is not true. The signal fed into a 16-mm recorder is fundamentally no different than the signal fed into a radio transmitter, or into a public address system, or into a disk recording head. The only difference lies in the shape of the curve, which is an equalizer problem, and the amount of power required. Basic quality is quality, regardless of what you are going to do with it.

Now where do we get good quality? It comes from good equipment properly used. Fortunately there is excellent sound equipment available today. The one fundamental and essential of all quality

is good wave form. Maintaining good wave form throughout a recording channel is an engineering problem of high order. You will do it only with finely engineered equipment. You will not get good wave form in cheap equipment, and you will not get it in equipment improperly used.

Now, for our typical sound channel. Basically, most recording sound circuits are the same. For convenience we shall divide them into five parts.

(1) The sound source may be one or more microphones—previously recorded film, reproduced by film phonographs or previously recorded disks, reproduced by disk reproducers. All of these sound sources require immediate amplification. This is called preamplification.

(2) After preamplification a common practice is to equalize. Possibly the most complex problem in all 16-mm work is equalization because it is by equalization that we are able to utilize the limited frequency response of 16 mm film so as to make it practical.

(3) After equalization comes mixing. Mixing permits the artful blending of our various sources of sound, so as to produce in one track the composite whole which is our objective.

(4) Following mixing is a logical point in our circuit arrangement to use compressors or limiters. They are practically indispensable in achieving high volume levels. This is specifically true in voice recording.

(5) After compressors or limiters comes power amplification. The power amplifier, in turn, drives the light modulator or any other recording device that may be used.

Thus we have sound source, preamplification, equalization, mixing—limiting or compression and, finally, power amplifiers.

Now, let us discuss these five parts of our sound circuit separately. First, sound source: The first thought of sound source is a microphone. Of the large number and variety of microphones made in America, only a few are really suitable for film work. Since the possible frequency response on 16-mm film is restricted, and many 16-mm modulators possess poor dynamic stability, the shape of the curve fed the modulator becomes very significant. It is important, therefore, that we use a microphone with a smooth frequency response permitting us to shape these curves later with our equalizer networks.

While it is true that, many times, a diaphragm-type microphone with a definite resonant characteristic makes what seems to be a better track, generally it is more desirable to use a microphone with an essentially smooth response, and shape the curve later with our equalizers to suit the characteristics of the modulator and the film. This is particularly true inasmuch as the dynamic instability of the

modulator is often aggravated by the resonant frequency of many microphones. This means one should not buy cheap microphones. It does not mean, however, that all expensive microphones have smooth response characteristics.

Another sound source is a disk recording. We do considerable rerecording from disk to film for clients, who for various reasons do not wish to record directly onto film. Disk recording is a flexible, practical way to record *if you make good records*. What is true regarding sound channels for film recording will also be true for disk recording. A smooth frequency response, carefully equalized to suit the reproducer characteristic to be used, can result in a disk recording very practical for rerecording to film. The days of poor disk reproducer and the wobbly turntable of erratic speed are over. There is no necessity for using inferior disk recording or reproducing equipment.

Our last sound source to be mentioned is the film phonograph. You cannot run down to the corner and buy a new film phonograph. All you can do is pick the signal up where it leaves the photocell and feed it into the best preamplifiers you can buy.

Now, all these sound sources mentioned above require amplification by preamplifier before the signals we get from them can conveniently be handled. Preamplifiers are very important. They establish our original signal-to-noise ratio which we cannot alter after the signal leaves the preamplifiers. A preamplifier should bring the level of our sound source up to where it can be handled conveniently. Generally a gain of about 40 db is satisfactory. The noise level should be about minus 90 under one milliwatt, weighted. Synchronization work, where long pickup distances are often necessary, requires considerable amplification, making it very necessary that our preamplifier be very quiet. It should have a flat frequency response from 20 or 30 cycles to 15,000. Its input and output impedances should be standard. Regardless of any inherent superiority of one impedance over another, impedances have become fairly standardized the last five years, and it is very annoying to have equipment that requires external matching transformers. There is no reason to buy preamplifiers that will not approximate these specifications. Distortion characteristics will be mentioned when we discuss power amplifiers.

After we have amplified our weak signals from our sound sources they are ready for equalization. As previously stated, possibly the most complex single problem in producing 16-mm quality, assuming we have good audio channels, is equalization. A narrator's voice

seldom requires the same kind of equalization as an orchestral background or an organ background, so it is very desirable to have separate equalization for every sound source. This means equalization has to be done before we mix these signals. The level coming out of a two-stage preamplifier is generally around minus 30. This is a convenient equalization level. Levels up to around zero may be used, but some equalizers lose some of their equalizing ability if too high levels are fed into them.

The demand by the broadcasting and disk recording industry a few years ago was responsible for the evolution of our Standard Broadcast Equalizer. They are suitable for much of our film work. Most commercially available equalizers have four selector points for the high-frequency end, and three points for the low-frequency end. The high end is generally topped at 4000, 6000, 8000, and 10,000 cycles, and the low end at 100, 50, and 25 cycles. In any ordinary 16-mm work the 4000 cycle point is generally used. The 8- and 10-kc positions are superfluous. However, if other than 16-mm recording is to be done they are essential. Probably 85 per cent of the recording on 16-mm film should be equalized to around 4000 cycles.

The low end is relatively unimportant as very little equalization is ever needed. If needed, some point around 100 or 150 cycles is suitable. A 50-cycle tap and a 25-cycle tap are practically useless. That is also true for disk recording. We do need low-frequency attenuators, however, and their use is essential for the shaping of our curve that is to be fed into the modulator. So, for the average equalizer requirements for 16-mm, the ordinary commercial equalizers will be adequate. The low-frequency attenuators available are also adequate for most work. These units, like the low-frequency equalizers, are generally tapped at around 150, 100, and 50 cycles.

The units just described are very suitable for much 16-mm work and for many producers would be entirely satisfactory. However, at our plant the requirements are a little more severe. Many re-recording jobs are sent into our plant that require radical equalization to make the sound tracks usable. Sometimes the intelligibility is so poor that we have to equalize at a point as low as 1500 cycles to make the track understandable. The demand for this type of work made it necessary to build suitable equalizers that were flexible enough to meet any of these extreme conditions, and at the same time satisfy the need for our ordinary requirements. Our latest equalizers have taps every 500 cycles from 1000 cycles to 7000 cycles. On the

low end they are tapped at 500, 300, 200, and 100 cycles. The shape of the curve, on the low end especially, differs somewhat from that generally used in commercial equalizers. It cuts off more sharply; that is, after the curve breaks, it falls faster. We find this more practical in creating the desired balance between low- and high-frequency energy that is so necessary in work where the frequency range is restricted.

The use of equalization, like mixing, is almost an art. The recognized fact of the frequency response limitations of 16-mm work makes it absolutely necessary that we utilize the frequency width available in the most advantageous way. Most engineers know that the shape of the curve is, in many instances, more important than the width of the frequency response. Quality on 16-mm film demonstrates this very clearly. It requires the highest skill and the finest equipment to put a signal from 80 cycles to 4000 cycles on a finished print of a 16-mm sound track and on color film it is even more difficult. These limitations are primarily dimensional. When it is realized that at 36 ft per min, which is 7.2 in. per sec, the image size of a 2-kc tone is approximately the same as a 5-kc tone on 35 mm. In other words, it is harder to record 4 kc at 7.2 in. per sec than 10,000 cycles at 18 in. per sec. This creates an acute problem, not only of the frequency response attainable, but also of wave form, thus justifying our previous care as to the wave form characteristic of our sound channels.

We utilize the restricted frequency response of 16-mm film by shaping the curves so as to overcome or partially neutralize the inherent limitations of the film and the reproducing equipment. Many studies in recent years show clearly that there is a necessary balance between high-frequency cutoff and low-frequency cutoff to produce pleasing quality. This is very significant in 16-mm work because we are actually obliged to create what quality we can within a frequency range of between about 80 cycles and 4500. If there is any secret to equalization, it is to have equipment flexible enough to create curves to suit any requirement of our sound source, however severe.

After we have equalized our various sound sources, they are ready to be mixed into a single composite signal. A mixing panel is a relatively simple affair, but much thought should be given to its flexibility and convenience of operation. A good mixer should be designed by an engineer and most manufacturers of mixing equipment will help you with mixer design.

After our signals are equalized and mixed, it is practical to feed them into a limiter or compressor amplifier. High average volume levels are hard to maintain without some method of controlling sudden peaks of energy, and sudden peaks of energy are very common in 16-mm when, by equalization, you emphasize the energy in the sibilants of a narrator's voice. From these limiting or compression-type amplifiers, we can drive our power amplifiers.

Power amplifiers are just what their name implies. They take the mixed and equalized signal and increase its power until it is sufficient for the work to be done. The requirements of a good power amplifier are as severe as for any of our equipment. The frequency response should be as wide as our preamplifiers; the noise level should be very low. It should not be possible to hear a good power amplifier when it is coupled directly to a good speaker and is running wide open. That means a noise level at least 50 db below 6 milliwatts. In a sound channel, such as I am describing, a gain of from 60 to 75 db should be available in the power amplifier.

In the light of our new knowledge gained during the past five or six years, new standards of excellence have been set up for amplifiers. This means preamplifiers, line amplifiers, compressors, and power amplifiers. Many engineers remember when we could do a frequency run on an amplifier at some indifferent volume level, and if it was reasonably flat it was considered a good unit. Then we began to appraise wave form—that is, steady-state wave form, such as a constant tone from an oscillator. Everybody was happy when, in conjunction with our reasonably flat frequency run, we also took a reading on our harmonic distortion and found it was only a few per cent. But many engineers remember that even when our frequency response looked good, and our steady-state wave form distortion crept down to around 2 or 3 per cent, quite often our quality seemed to be imperfect.

Gradually it came to be recognized that other characteristics of our amplifiers and speakers and microphones were involved—that measuring these components with steady-state signals was not enough. Finally it has become recognized that wave form is an extremely complex thing and is the basis of most of our quality.

We are just entering an era in amplifier design where the design engineer is obliged to recognize there is something more than just a good frequency response necessary—something more than steady-state distortion of one or two per cent. This "something more" is the

ability of the amplifier to take a complex wave form and amplify it without adding to or subtracting from its complexity. The inability of an amplifier to amplify several frequencies at the same time produces a form of distortion called "intermodulation."

Intermodulation distortion appears to be one clue to that intangible something that sound engineers have heard for years, but were never quite able to identify. Equipment is appearing on the market now that permits us to begin measuring this sickness in our sound channels. Amplifiers are not the only offenders in possessing intermodulation distortion. Cutting heads for disk recording are a common example. Record reproducers may have it, light modulators have it, and, of course, loudspeakers are very much subject to it. So we have added another specification to our amplifiers throughout our whole recording channel.

Last, but not least, I want to emphasize the power handling capacity of your amplifiers and the power necessary to drive various pieces of equipment. When you have a light modulator that requires, say, +20 db to drive it—that is, the manufacturer says it takes only +20 to drive it—how much power do you think an amplifier should be able to deliver? Plus 20 above a 6-milliwatt reference level is 0.6 of a watt. It is impossible to drive it with 0.6 of a watt, or twice 0.6 of a watt, or even 3 times 0.6 of a watt, and do a good job. The instantaneous values of power involved in following a complex wave form may swing many times above the basic power rating of the modulator.

This is also true of disk recording head ratings. It does not hurt to have too much power if it is good and clean. So, be sure the amplifiers have a large excess of power above what the work requires. Good clean power available in 12 or 15 w is not too much to ask for in most recording work. A sound channel that will deliver this much power makes it convenient to switch to disk recorders, also.

Now, the typical recording channel I have just outlined can deliver an excellent signal to any recorder. It can shape this signal so as to take full advantage of the recording medium to be used. It will represent good quality for years to come. As film recorders are made available or new ones developed it will still be suitable. The use of standard components makes replacement easy, although it will be many years before a 30- to 15,000-cycle signal of adequate power with excellent wave form characteristics will not be considered fine quality.

So, we have available excellent sound channels, we have recorders,

and I am sure better ones are on the way. All we lack now is a very important factor, and that is personnel. The 16-mm sound business needs operating engineers. We can get them from two fields. One is the 35-mm business and the other is the broadcast business.

The broadcast field offers the greatest possibilities. This country is full of good broadcast engineers, many with disk recording experience, who need only a short breaking-in period to become good 16-mm men. For example, any good broadcast engineer would consider the typical sound channel I have described as an ordinary straight-forward channel with the exception, perhaps, of the extra attention we pay to the equalizers. Quality is an old subject to him. The use of microphones and amplifiers and mixers is his every-day problem. However, a word of warning: Know what you are looking for in an engineer before you choose one.

This paper is really nothing more than a plea to the manufacturers to deliver us better film phonographs and recorders, and a plea to the producers to take advantage of the fact that they can have excellent sound channels immediately and can find personnel to operate them.

DISCUSSION

MR. H. C. MOORE: How much improvement can be expected by equalization before mixing as compared to equalization after mixing?

MR. JACOBS: Suppose a narrator is talking and you wish to put music and sound effects behind his voice. The same equalization used on his voice is generally unsuitable for music, quite often ruins music. The best equalization for music is generally bad for voice. Obviously, it is better to equalize these signals separately and then blend them in the mixer.

MR. C. R. SKINNER: Could you give us an idea of any definite standard curve that you would have, for instance, for a voice recording, and a standard curve for a music recording which would be used in 16-mm work? For recording, it is necessary to have some sort of a curve to begin with. Have you set up a standard?

MR. JACOBS: I do not have any proposal. I do not think 16-mm could bear such a standardization yet. The sound sources are too varied. Several pictures could be shown here and no two will sound alike. I am not particularly sold on standardizing 16-mm in that respect. However, it might be a good idea if there were.

MR. SKINNER: That is the problem: It is a question of whether you are going to do it on the projector or recorders. In the old days in 35-mm they went around that same vicious circle until a standard was established.

MR. JACOBS: I grew up in the disk recording business; and disk reproducers are not standardized yet, after 20 years. The new Western Electric has seven equalizer positions on the playback circuit, two on the vertical, and five on the lateral. Standardization is not possible until the manufacturers standardize the

reproducer characteristics. How are you going to know when you make good quality? All you can do is choose a projector that is considered fairly standard and make pictures which sound good on it. Even then, some will sound bad on another make of projector. One has to try for a happy average.

MR. C. R. KEITH: When you are playing a record that you have made on your equipment, on one of these projectors which you consider average in the area you are operating in, do you play that record on the medium position of the tone control, or elsewhere?

MR. JACOBS: We arbitrarily have chosen the position on our volume control of about "11:30," and "12:00 o'clock" on our tone control for black-and-white, and "1:00 o'clock" for color track. We realize if it has plenty of volume at "11:30" it is a satisfactory track. If it sounds good, regarding balance at "12:00" or "12:30" on the tone control, it is satisfactory.

MR. GEORGE TALLIAN: I am very much surprised you did not mention anything about flutter in 16-mm sound. It seems to me that flutter is the biggest offender.

MR. JACOBS: I was speaking only of the sound channels. Flutter is a mechanical problem, and I could not cover that. Of course, I agree with you, there is a problem there. However, the new recorders probably will not have any appreciable amount of flutter.

INTERNATIONAL MOTION PICTURE STANDARDS*

D. E. HYNDMAN**

The year 1946, on July 24, marked 30 years of achievement in motion picture engineering and standardization for the Society of Motion Picture Engineers. From its first organization meeting the Society has had as its fundamental aim the standardization of motion picture film, equipment, and accessories from the standpoint of dimensional tolerances, data, processes, nomenclature, and the like which either directly or indirectly might be applicable to the production, distribution, and exhibition phases of the motion picture industry. The early organizers, many of whom are now well-known engineers and scientists in this industry, did at their first meetings 30 years ago originate proposals to become standards of the SMPE, as the American Standards Association did not exist. These proposals and SMPE Standards were reviewed and redrafted many times before eventually becoming American Standards in the early 30's.

These early organizers of the SMPE were fully cognizant of the importance and value of international standards in any industry. They appreciated that the universal acceptance of standards internationally brought about understanding and friendship, encouraged freedom of design and application, expanded world markets for trade, and permitted interchange of products from one nation to another. The first decade of output was not great in quantity, but quality was being generated to produce well-planned proposals for standardization.

In the second decade, the late 20's and early 30's, numerous proposals and SMPE Standards became American Standards of the American Motion Picture Industry. In the early 30's and from then on, the Society entered into and, in so far as possible until the beginning of World War II, continued co-operation with the British and Germans on internationalizing Motion Picture Standards.

* Presented Nov. 21, 1946, before the Conference of Staff Executives of the Member-Bodies of the American Standards Association, New York.

** President, Society of Motion Picture Engineers.

The SMPE proposed in 1932 that 16-mm motion picture film be projected with the emulsion facing the lens, just the opposite of what was and is the standard practice with 35-mm motion picture film. In April 1933 the Germans copied the SMPE proposal and circulated their draft, but it was not until November 1933 that discovery was made that the German Proposal was the exact opposite of the SMPE or American Proposal. This discrepancy arose from a lack of familiarity with each others' languages. The SMPE, on invitation from the Germans and British, appointed a representative to attend conferences at which the differences were to be adjusted. These were held in June 1934 through April 1935 in Rome, Baden Baden, Stress, and Berlin. Then, in July 1935, George Freidl of the SMPE and J. W. McNair of the ASA left the United States for a final session on the subject at the International Congress of Scientific and Applied Photography in Paris, France.

After much discussion, the SMPE Proposal was accepted. Not all proposals or American Standards have such misfortune in becoming internationalized. This case is sighted merely to show that the SMPE has followed its original aims and purposes. It should be mentioned that this one problem of settling an international standard did bring about better understanding and greater appreciation of the other fellow's problems.

In the past decade an even more active program has arisen. Within the past few months the SMPE has forwarded 26 new and revised American Standards on Motion Pictures to the American Standards Association, requesting that they be submitted to the United Nations Standards Co-ordinating Committee for consideration as proposals for International Standards. The SMPE recommended also that the ASA propose to the UNSCC that the Secretariat for Motion Pictures on International Standards be located in the United States, as this country has been the leader in production and standardization of motion pictures. This has now been done with the formation of the International Organization for Standardization.

An additional ten proposals for American Standards are now, in various stages, drawing rapidly toward completion, and it is our intent to recommend to the ASA that these also be submitted to the new international organization. The Research Council of the Academy of Motion Picture Arts and Sciences and the SMPE are preparing mutually 35-mm and 16-mm picture and sound test reels, both for practical use by the projectionist in the theater and for scientific

measurement purposes by the equipment design engineer, which will be submitted as proposals for American Standards and recommended to the ISO. Numerous other projects for standardization are being considered by the Research Council and the SMPE.

If we are to enjoy international harmony there must be unity of effort by all peoples of all nations toward appreciation of the ideas and ideals of each. No better road can be taken than the one down through science, engineering, research, producer, distributor, and consumer to reach International Standards.

LIGHT CONTROL BY POLARIZATION AND THE APPLICATION OF POLARIZERS TO THE STEREOSCOPIC PROCESS*

J. A. NORLING**

Summary.—Among the devices for light control are color filters for separation selection, neutral filters for supplementary control of exposures, and polarizing filters. Polarizers may be used in photography for the control of reflections and for exposure and contrast control of certain surfaces. Among the many uses of polarizers which are of interest in photography is their application to photoelastic analysis. Another application is in the production of special effects in color and black-and-white photography. Of particular interest is the application of polarizers and polarizing photo-materials to three-dimensional photography.

The paper discusses briefly the fundamental mathematics involved in the polarizing effect with particular reference to crossed polarizers.

This paper is confined to photographic uses of polarizers. It does not attempt to explore their many nonphotographic uses.

An Analysis of Light Polarization.—Let us imagine we are looking head on at a beam of light and that we can conceive it in the form shown in the diagram (Fig. 1). This represents a complicated cluster of directions of vibrations such as we assume exists in ordinary unpolarized light. This diagram attempts to illustrate that light vibrations are in infinite directions at right angles to the path of the light. If by some means all the waves in a beam of light are made to vibrate in planes parallel to each other the light is said to be plane polarized.

For simplicity in illustrating the effect of plane polarization we may use the kind of representations shown in Fig. 2. In *A*, the unpolarized light is shown entering polarizer 1 and emerging as horizontally polarized light, the polarizing axis of the polarizer being horizontal, and entering another polarizer 2, whose axis also is horizontal. With the polarizing axes of both parallel, the polarized light passes through the second polarizer without loss, except for absorption in its passage

* Presented May 8, 1946, at the Technical Conference in New York.

** Loucks and Norling Studios, New York.

through the second polarizer. In *B*, the polarization axis of the second is crossed at 90 deg with that of the first polarizer, and the light is extinguished. In *C*, the second polarizer is turned at a smaller angle than in *B* and the light is diminished in passing through.

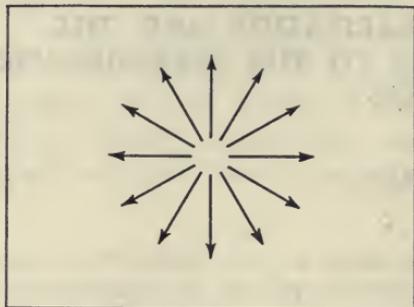


FIG. 1. Representation of a cluster of light vibrations.

Now, let us investigate more fully what happens when a polarizing filter is placed in the beam of light. The diagram of Fig. 3 shows a broken horizontal line *A*, which represents the axis of polarization of the polarizer. The polarizing filter transmits not only the vibrations which are originally parallel to the polarizing axis, but also the horizontal components of all the infinite number of other directions of vibrations. Consider the vibration identified by the symbol A_1 lying at angle α to the axis of the

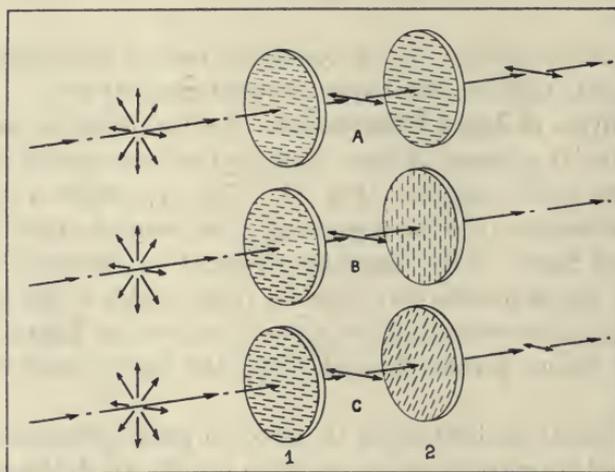


FIG. 2. Illustrating the effect of plane polarization.

polarizer. A_1 will have a horizontal component A_x . And so with all the other inclined vibrations in accordance with their inclinations.

Vibrations may be represented by triangle-of-forces diagrams. In the vector diagram shown in Fig. 4, line A_1 represents the amplitude of a vibration and its direction. Its length is a measure of the

magnitude of the vibration. Let us suppose that the line A_1 stands for the amplitude of the light vibrations coming from the first light polarizer (in C , Fig. 2). Let the line A_x represent the polarizing axis

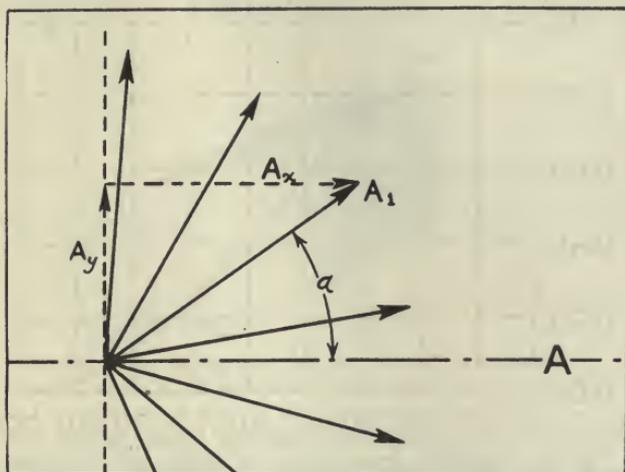


FIG. 3. Analysis of a single direction of vibration.

of the second polarizer. The amplitude A_1 gives a component along the direction A_x equal to

$$A_1 \cos \alpha$$

where α is the angle between A_1 and A_x .

The energy of a vibration is proportional to the square of its amplitude. Thus

$$I_u = I_o \cos^2 \alpha$$

where I_u is the relative intensity of light transmitted by two polarizers when the angle between their polarizing axes is α ; and I_o is the relative intensity of the transmitted light when the angle α is zero.

The curve shown in Fig. 5 is a graphical representation of the above formula, with I_o arbitrarily equal to unity. The curve and the formula are strictly true only for perfect polarizers.

An ideal polarizer should have a transmission coefficient of 0.50 but this is not attainable because of light losses at the front and back

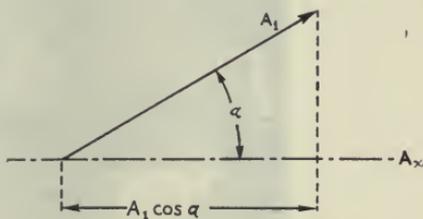


FIG. 4. Vector diagram of a vibration.

surfaces of the polarizer resulting in a reduction to a transmission coefficient of about 0.46. In addition, all polarizers absorb a certain amount. In the case of the best polarizers available for photography,

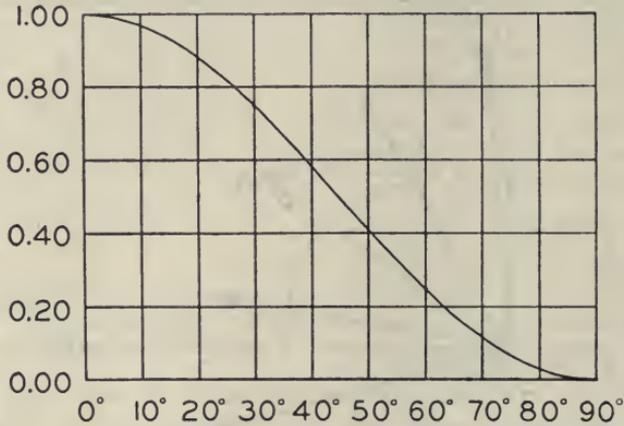


FIG. 5. Relative transmission of light through superposed polarizers.



FIG. 6. Showing double refraction in calcite.

the transmission coefficient is between 0.40 and 0.42. Polarizers for photography must be substantially neutral in color, have even absorption, be free of flare and fluorescence.

Natural Polarizers.—Some natural crystals are polarizers. Among these is calcite, which has the peculiar property of splitting

the light so that two separated images are seen through the crystal. Fig. 6 shows the effect.

In calcite the incident light ray is divided into two rays which are bent differently (Fig. 7). Thus calcite differs from glass in that it has

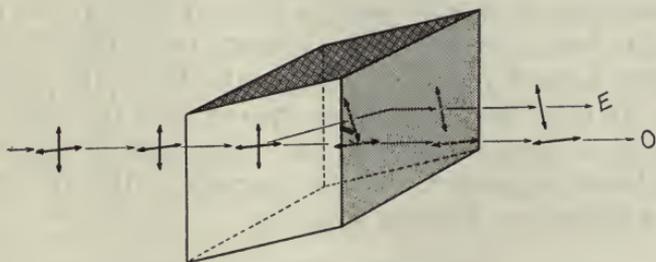


FIG. 7. Illustrating the double refraction in calcite.

two indices of refraction. In passing through the calcite the two parts of the ray are perfectly polarized, and when they emerge they are polarized exactly at right angles to each other. In other words, the calcite resolves all vibrations of the incident light into two components at right angles to each other, and it then transmits them with different speeds.

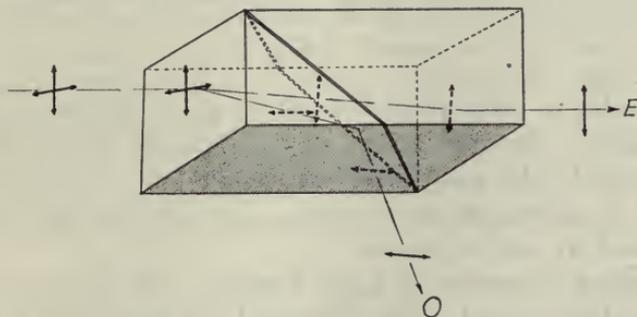


FIG. 8. Diagram of a Nicol prism.

The double refraction of light by calcite was first observed by the Swedish physician Erasmus Bartholinus, in 1669. Huygens and Newton later studied the phenomenon in detail.

Nearly all crystalline substances exhibit double refraction. To mention but a few, we find that quartz, sugar, mica, and ice show the effect.

The two opposite faces of a calcite crystal are parallel to each other, and the two refracted rays emerge parallel to each other but displaced, as shown in Fig. 7. When the incident light enters, one ray, called the ordinary ray O , passes through without bending and is polarized in one plane, while the other ray, called the extraordinary ray E , is polarized in a plane at right angles from the other and is bent away from the ordinary ray. The O ray obeys the ordinary laws of refraction and for the O ray the crystal acts like glass. In other words, the O ray travels with the same velocity regardless of its direction through the crystal and its axis of polarization is always perpendicular to the optic axis. But the velocity of the E ray is different in different directions.

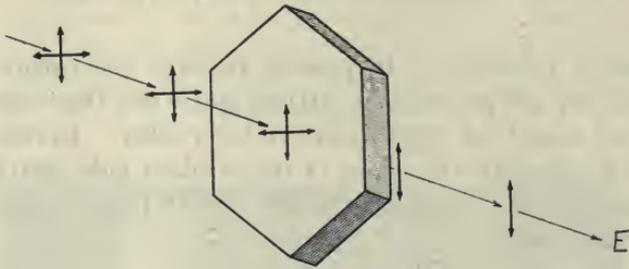


FIG. 9. Illustrating a tourmaline crystal and the absorption of the O ray.

It is possible to make prisms of calcite which eliminate one of the polarized rays. They are known as Nicol prisms, from the Scottish physicist Nicol, who made the first one in 1828. They have long been used in polarizing microscopes. Nicol prisms are limited to small size and are quite expensive.

Fig. 8 shows a diagram of a Nicol prism. The prism is made by cutting a calcite crystal along a diagonal and cementing it back together again with Canada balsam, which is used because it has a refractive index midway between that for the O and E rays. Consequently, there is a critical angle of refraction for the O ray but not for the E ray. The O ray is totally reflected by the Canada balsam surface, while the E ray passes through and emerges parallel to the incident light. If two Nicols are lined up they form an optical system frequently used in microscopes for studying the optical properties of other crystals. The first Nicol produces plane-polarized light as do

the polarizers 1 in Fig. 2. It is called the polarizer. The second Nicol, corresponding to polarizers 2 in Fig. 2, is used to test the light and is called the *analyzer*.

Some crystals, such as *tourmaline* (Fig. 9), exhibit double refraction in much the same way as in calcite but with the difference that the *O* vibrations are entirely absorbed by the crystal while the *E* vibrations pass through. Thus, tourmaline has selective absorption and, in this respect, is like the Nicol prism, for it takes in ordinary light, disposes of the *O* vibrations, and transmits plane-polarized light.

The behavior of this crystal, and many other substances, is caused by the molecular structure. To draw an analogy, regularly spaced molecules are like the pickets in a fence. A stick thrown would pass through when parallel to the pickets, but would be stopped if it landed against the fence at right angles to the pickets.

The reason tourmaline is not commonly used for polarizers is that the crystals are yellow in color. Many other crystals which polarize light have this drawback or are unsatisfactory in other respects.

Synthetic Polarizers.—All but a few light polarizers in present use are made with polarizing sheeting, which is a thin film of plastic containing innumerable polarizing elements (either crystals or molecular chains). These are entirely invisible and the film appears to be clear and homogeneous. The elements are aligned parallel to one another so that they reinforce one another's polarizing effect.

In 1852, the English physician, W. B. Herapath, discovered a synthetic crystalline material which transmits polarized light of all colors with high relative intensity. Chemically, this material is known as sulphate of iodo-quinine.

These crystals were so unstable mechanically as to shatter into a useless powder at the slightest impact, and those who tried to master the technique of handling them reluctantly gave up the research.

Approximately seventy-five years later, Edwin H. Land solved the problem of producing a stable synthetic polarizer. Instead of attempting to cover the whole area of a polarizer with one large crystal, he conceived of using innumerable little ones packed together and imbedding them in a transparent covering material which would prevent them from breaking up into a useless powder.

The search for other polarizing materials is going on continually and one of the later developments contains no preformed crystals at all. Its polarizing action is based on a linear control of the

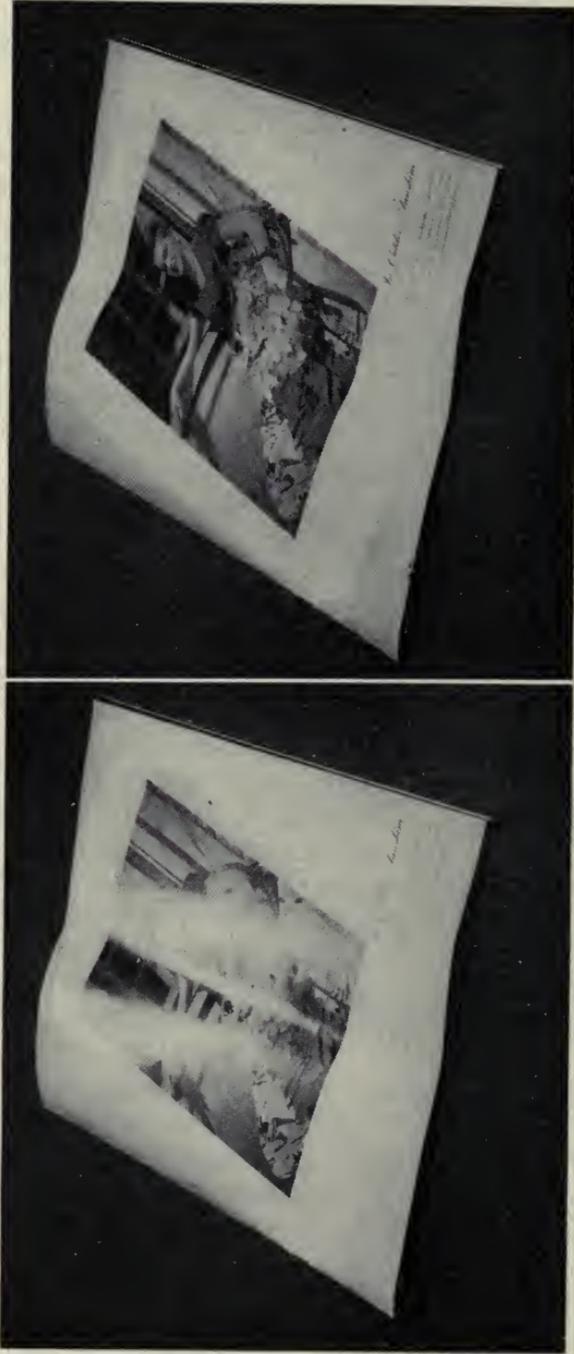


FIG. 10. Illustrating glare and its elimination by using a polarizer.

molecular structure of the material, forming a homogeneous and haze-free sheet.

Land has described its manufacture as follows: "In making actual polarizing sheets, we create a brush-like structure inside of a plastic sheet—a clear, tough plastic called polyvinyl alcohol. First, it is stretched in one direction so that the long, tangled molecules straighten out, all parallel to the direction of stretch. The sheet is then dipped into a solution like the ordinary tincture of iodine in your medicine chest. The rusty brown iodine is instantly and rather miraculously transformed. It now has two different colors. To polarized light vibrating in one direction, it is perfectly white and clear; to polarized light vibrating in the other direction, it is black. The sheet has become a light polarizer."

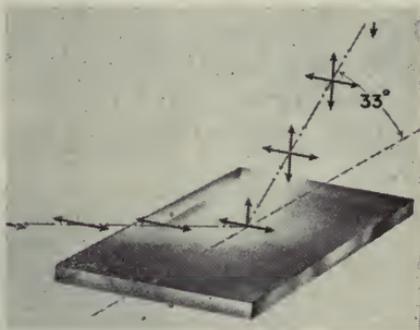


FIG. 11. Diagram of maximum polarization from a reflecting surface.

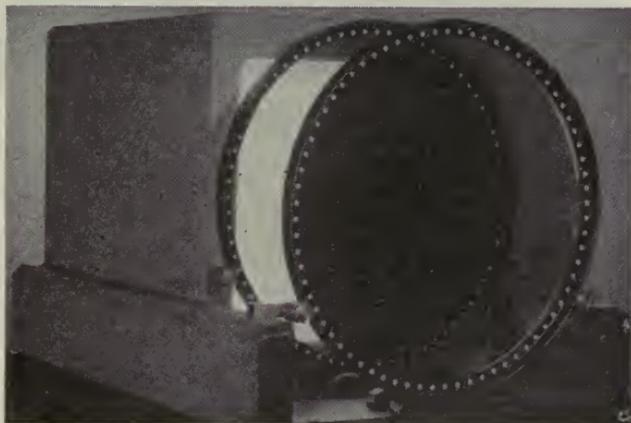


FIG. 12. A simple polariscope.

Photographic Applications.—Polarized light is found in Nature on every hand. The sheen on water, pavement reflections, window reflections, some of the light from the sky—these all have polarized light in some degree, and the widest present-day application of

polarizers in photography is in the control of light reflected from various surfaces.

Fig. 10 illustrates the effect of reflection of ordinary light from a paper surface and printing having a high reflectivity, and the effect of using a polarizer to eliminate, or cut down, the polarized glare light. This can be done by using a polarizer either over the light source or in front of the camera lens when taking a picture.

The diagram, Fig. 11, shows that glare light has large components of light polarized along an axis parallel to the surface, and small

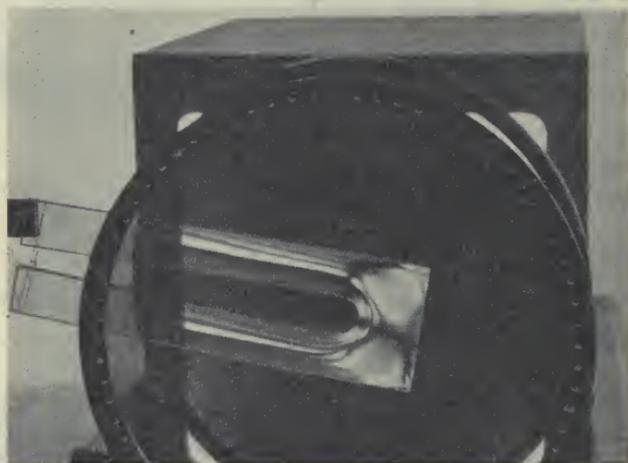


FIG. 13. Illustrating strain patterns in a photoelastic model.

components at right angles to this. To cut out the glare-light components all that is required is a polarizer whose polarizing axis is turned at right angles to the axis of the glare-light components.

In some cases polarizers can be used to great advantage over the photolamps, as well as in front of the camera lens, particularly in the photography of such things as silverware, glassware and shiny fabrics. One advantageous use of polarizers is in the photography of colored objects to eliminate parasite reflections that may come from surrounding objects or surfaces. Objects photographed this way usually have richer, truer colors because color-saturated reflections are reduced to a minimum.

One interesting application of dual polarizers is in their use as "faders." These can be placed to control the light from photospots

so as to increase or reduce a modeling light or for special lighting effects in wide variety.

Research and plant control laboratories find many uses for polarizers. Among these are the polarizing microscope, and the polariscope for stress analysis using photoelastic models.

The simplest type of polariscope has two polarizers with a space between. Behind them is a light source which can be diffused as in the apparatus shown in Fig. 12.

The polarizing axes of the polarizers are usually crossed at 90 deg. The photoelastic model is inserted between the polarizers and strain patterns are revealed if any stresses exist in the material. When a



FIG. 14. An airfoil section in a streaming birefringent liquid, showing eddy currents made visible by polarized light.

load is applied the strain patterns reveal information that could be obtained in no other way. These can be photographed quite easily (Fig. 13).

The reason for these patterns is that the photoelastic material is birefringent, or doubly refracting, in the areas under stress.

Among the plastics suitable for photoelastic models are specially aged Bakelite and cast Marbleite.

Birefringent liquid solutions can be prepared and used in the study of fluid flow around models of ship hulls, airfoil sections, and many other shapes. E. A. Hauser and Davis Dewey, of Massachusetts Institute of Technology, have made some very interesting and valuable contributions to the analysis of streaming and formation of eddy currents by using a polariscope tank setup. Liquid is pumped

through a tank placed between two polarizers and photographic records are obtained on color film. High-speed stills are also made for purposes of detailed study (Fig. 14). The solution used by Hauser and Dewey consists of suspended particles of Bentonite clay in water. To prepare the Bentonite it is first crushed; then finely powdered, the fine powder settled in water to remove gross particles; the remaining water, holding the finer particles in suspension, is run through a centrifuge where the submicroscopic platelets of Bentonite are separated for use in the solution. As the fluid is made to stream, the platelets align and this causes the solution to become birefringent.

A piece of quartz may be used to demonstrate the result of birefringence. The quartz is placed between polarizers. Immediately

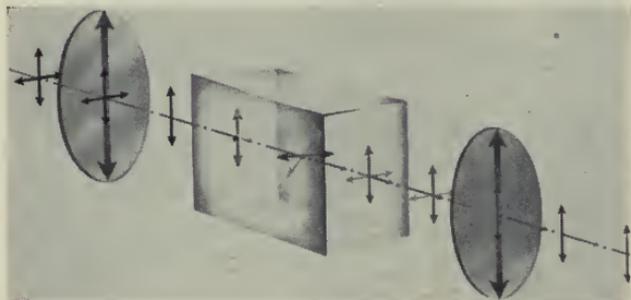


FIG. 15. Illustrating selective birefringence of polarized light in quartz.

the whole quartz glows with a pure solid color. A change in color takes place as the angle of the polarizing axis of the front polarizer is changed in relation to that of the rear polarizer.

The quartz does not produce any image doubling, but it does change the direction of polarization of the polarized light passing through and the changes are different for different colors.

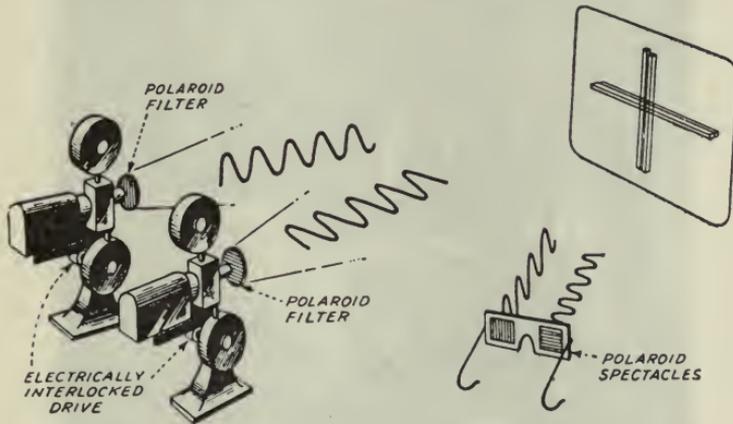
The diagram (Fig. 15) shows white light entering the first polarizer. It emerges as vertically polarized white light. As it passes through the quartz, the direction of vibration of each of the colors is turned by a different amount. With the polarizing axis of the second polarizer set so that it aligns parallel with the direction of vibration of the red, the red passes through and the blue and green are blocked.

Cellophane is a birefringent material. While the effect on polarized light passing through differs physically from that of the quartz, it, too, shows striking color patterns. Multiple layers of cellophane produce

multicolored patterns. This phenomenon has been used to create beautiful and striking displays. Sheets of cellophane are cut into patterns and pasted on glass. This assembly is placed between polarizers. As one of the polarizers is turned the color patterns change.

This stunt could find a use in the motion picture studio for special effects, for instance, in the production of color cartoons.

Application of Polarizers to Stereoscopy.—The projection of three-dimensional pictures of outstanding quality has been made possible on a large scale by using polarizers. Of course, Polaroid viewers must be used to sort out the dual polarized images so that each eye receives only the image it would see in normal vision.



Courtesy, Photo-Technique

FIG. 16. Diagram of a double projector installation using Polaroid.

One method successfully used has been by dual projection. In the case of motion pictures, two interlocked machines (Fig. 16) have been used; also, films can carry pairs of images and be run in a single machine. Lantern slides have been projected in dual machines (Fig. 17). In dual projection, each lens has its own polarizers. The polarizing axis of the left eye polarizer slants 45 deg to the right and that of the right eye polarizer 45 deg to the left. Viewers are assembled with the right-eye polarizer crossed with that of the left eye, and vice versa. A metallic surfaced screen is required, preferably a sprayed aluminum one.

Polarized light projection has been used in foreign lands as well as in the United States. In Europe they have been limited to small screen projection of stills before small groups. So far as can be learned

from the available literature, the only large screen use has been in this country, where stereo motion pictures and stills have been shown on screens up to 15 by 20 ft. It is most likely that more progress has been made in the United States in this application of polarizers than anywhere else.

The Vectograph.—To date, the most remarkable development in polarizing photo-materials is the Vectograph. The Vectograph promises a practicable approach to the simplification and wide use of the stereoscopic process.



FIG. 17. Dual lantern-slide projector for stereoscopic projection.

In this new film the image itself is a polarizing image. It polarizes the light passing through and does so in varying degrees. Fig. 18 shows a single image Vectograph picture, partially covered by a polarizer. In the region outside the polarizer the image is almost invisible.

In the picture the darkest areas are the result of almost complete polarization. Lighter areas are the result of partial polarization. In the white areas, there is virtually no polarization at all.

Two Vectographs, each having its own picture, can be combined. The polarizing axis of one is made to slant at right angles to that of

the other. By the polarizing filter the pictures can be made to appear alternately.

If a pair of stereoscopic images are printed in this kind of Vectographic form we have a method of producing three-dimensional pictures.

In the three-dimensional Vectograph the polarizing axes of the stereoscopic images are slanted 90 deg to each other. If the Vectograph is viewed through Polaroid viewers, the scene resolves into a natural two-eye view.



FIG. 18. A single Vectograph image, showing area brought to full contrast by a Polaroid filter whose axis is set at 90 deg to the polarization axis of the image.

It is evident that no special projectors are required for Vectograph films, the only special requirement being the screen. Incidentally, a large percentage of this country's theaters are equipped with so-called "silver screens" which are perfectly suited to the projection of polarized light images.

Vectographs can be made as reflection prints of large size as well as small. They were widely used by America's armed forces and a rapidly growing peacetime use for commerce and industry is in progress.

A fascinating application of the stereoscopic process is in three-dimensional drawings. Many of these have been made and they are

truly intriguing. John T. Rule, of Massachusetts Institute of Technology, can be credited as the pioneer in this field.

The three-dimensional animated cartoon may some day afford hilariously exciting moments for millions. For the historian who records the first of such events, I believe the birth of the three-dimensional cartoon to have been early in 1939, when Walter Ball, of our studios, animated a few short scenes for a three-dimensional movie made for an exhibitor at the New York World's Fair.

Now I should like to make a few predictions. The first is: Light control through polarization will find increasing use in photography, and uses not dreamed of today will enable photographers to devise new forms of pictorial expression. Second: Special lighting equipment, employing polarizers, will be developed to meet demands for new and improved lighting effects. Third: Polarized light control will make possible the three-dimensional film for which the motion picture industry has been waiting. And finally: Polarized light control in electronic picture reproduction will bring three-dimensional pictures to the television screen.

PRELIMINARY REPORT OF RESEARCH COUNCIL PHOTOCELL SUBCOMMITTEE*

LLOYD T. GOLDSMITH**

Those of you who were present at the Technical Conference of the Society of Motion Picture Engineers, held October 1945 in New York, may have heard the several excellent papers presented on the characteristics and early tests of the RCA *1P37* blue-sensitive photocell. This cell was developed at the request of several of the color-film companies to reproduce the dye-image sound tracks which will be associated with certain color motion pictures. These papers appeared in the May 1946 issue of the *JOURNAL*.

To review the problem briefly, it is well known that the silver-image tracks associated with all of the black-and-white pictures and at least one type of color picture, Technicolor, reproduce satisfactorily on the caesium-silver-oxygen photocell which is universally used for sound reproduction in theaters. Certain other color processes, however, find it advantageous to use a color sound track or a track which is a combination of colors.

Most of the dyes used for color tracks are relatively transparent to the infrared light which is emitted by the ordinary tungsten-filament exciter lamp in the sound head. This means that the photocell current is only weakly modulated by the dye-image, but scratches and dirt modulate it almost as much as they would through clear film. The *1P37* cell contains a blue-sensitive surface which does not respond at all to infrared light. It is being considered as a possible replacement for the caesium or red-sensitive cell, as it will reproduce *both* silver-image and dye-image sound tracks.

In July 1946, the Research Council of the Academy of Motion Picture Arts and Sciences established a subcommittee of its Basic Sound Committee called the Photocell Subcommittee. It was

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

** Chairman, Subcommittee on Photocells, Research Council, Academy of Motion Picture Arts and Sciences, Hollywood.

charged with investigation of the desirability and practicability of replacing the red-sensitive cell in theaters with the blue-sensitive cell. If the change could be recommended, the committee was to be sure that the blue cell gave satisfactory results with the dye-image tracks and, just as important, it was to make certain that the black-and-white or silver-image track would suffer no loss in the change.

On the committee are representatives of all of the interested color companies, several of the film laboratories and sound-equipment manufacturers, the major theater service organizations, and representatives of the studio sound departments. The members from the color companies are making certain that their test material is representative of their latest color processes, and are advising the committee on future trends in sound track. This is particularly important as certain compromises in the make-up of the track may have to be made.

The representatives of the theater service organizations are advising us on the problems which might be encountered in the theaters during the changeover. The questions of whether there is adequate gain in the various amplifier systems, whether older systems can be simply and inexpensively modified to take the blue cell, whether the older optical systems are sufficiently well corrected in the blue portion of the spectrum, and so on, are under study. The studio representatives are interested in the problem of quality control in color tracks as well as the problems in the theater. All concerned are working together to arrive at a conclusion as quickly as possible without overlooking any factors which might prove embarrassing in the future.

The committee is attacking the problem on three fronts simultaneously. With the help of RCA and Western Electric, it is preparing test material in the form of recorded sound-track negatives. These are both variable-area and variable-density tracks which will be processed and printed by the color companies and the black-and-white laboratories. The test negatives will supply comparative data when reproduced on both the red and the blue cells as to sound output level, signal-to-noise ratio, high-frequency loss, gamma or relative level change, harmonic distortion, and cross-modulation and inter-modulation distortion. In the case of variable-area track, a direct positive is being supplied as well.

In addition to the measured test data, listening tests are being made on a variety of representative samples of color track which are run in

comparison with the Academy Theater Test Reel on both types of cells. Record is being kept on the relative reproduced volume, quality, and surface noise of the samples. The tests are made on various types of reproducing equipment with cells which are representative of their type, and the results are judged by a fairly large group of listeners. No comparison or comment is made on the quality of the picture, as this is not within the scope of the committee.

Meanwhile, a limited number of theaters have been equipped with the blue cells and the theater service groups are reporting on their performance in the field.

Not only are valuable performance data being gathered on the photocells, but these tests and comparisons are of value to the color companies in maintaining quality control of their product. I cannot speak too highly of their co-operation and guidance.

The committee is not yet prepared to make any recommendations with regard to the cell. Color sound tracks representative of Ansco Color, Cinecolor, and several types of Magnacolor have been reviewed in addition to those with black-and-white tracks. The purpose of this preliminary report is to acquaint you with the existence of this committee, and to assure you that any data relative to the reproduction of existing or proposed color sound tracks would be welcomed.

A DE LUXE FILM RECORDING MACHINE*

M. E. COLLINS**

Summary.—This paper describes a new 35-mm film recorder designed to meet the operational and performance requirements of the major Hollywood studios. Features which simplify operating the machine are described. Serviceability has been stressed throughout the design, and the many figures illustrate what has been accomplished. Performance compares favorably with any recorder yet built, and values of flutter are presented.

The PR-31 recorder has been designed to provide the motion picture industry with an improved de luxe film recording machine. Chief features of the design are improved performance, thoroughly dependable operation, sturdy construction, and accessibility for servicing.

In designing this recorder, consideration was given to a great many factors, among them the following:

- (1) Dependable performance
- (2) Simplified and convenient operation
- (3) Low flutter
- (4) Low maintenance and ease of servicing
- (5) Quiet operation
- (6) Simplified gearing and general construction
- (7) Beltless take-up
- (8) Ease of adding accessories
- (9) Long life
- (10) General appearance

Because of the many factors involved, no significance should be attached to the relative importance of the considerations as listed.

Keeping in mind the considerations indicated, the recorder (Fig. 1) as designed consists of the following units:

- (A) A base assembly containing the plugs, electrical control equipment, and carrying handles
- (B) A head assembly containing the film drive and handling equipment

* Presented Oct. 24, 1946, at the SMPE Convention in Hollywood.

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

- (C) An optical system
- (D) A counter assembly
- (E) A driving motor—synchronous or Selsyn
- (F) A gear reduction unit
- (G) A take-up and holdback assembly
- (H) A compartment for accessories
- (I) Covers for the optical system and driving mechanism

In addition, all provisions have been made for the easy installation of a photographic slater and solenoid punch.

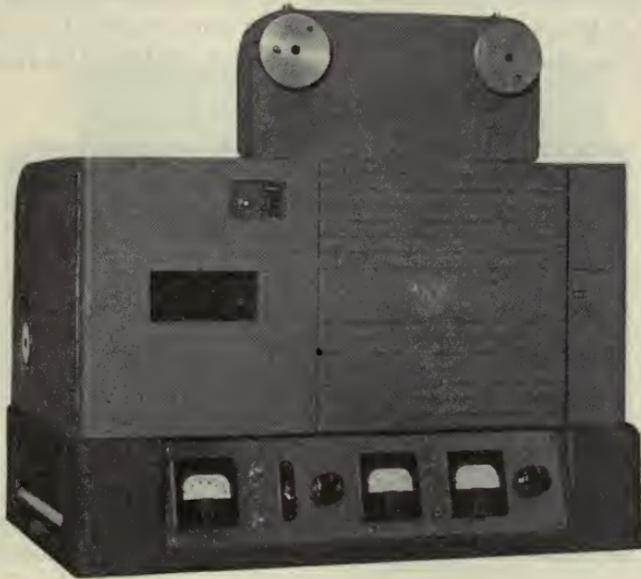


FIG. 1. *PR-31* de luxe recorder less magazine.

The machine is 28 in. long, $18\frac{3}{4}$ in. deep, and 29 in. high with the magazine in place, and weighs approximately 175 lb. The magazine used is the Bell and Howell type. Other type magazines could be used with a suitable magazine adapter.

The base is finished deep umber gray and the units above the base are finished light umber gray, both metalustre wrinkle. The control panel and trim are finished satin chrome.

The base, as well as all other structural castings, is made of stabilized magnesium alloy. This alloy has been selected because of several important characteristics including:

- (A) Light weight (specific gravity 1.8 as opposed to 2.8 for aluminum alloy)
- (B) Excellent machining characteristics
- (C) High damping capacity as compared with other light alloys

The base assembly (Fig. 2) contains the plug panel, the control panel, and most of the electrical equipment. The casting is equipped with built-in drop-type handles and shear-type resilient mounts. The mushroom heads of the resilient mounts may be removed and replaced with hold-down bolts so that the recorder can be bolted to a frame for truck use while retaining the resilient mounting feature.

A special nichrome rheostat, edge-wound and continuously variable, is provided on the control panel for controlling the recording lamp. This rheostat provides stepless lamp control and is used as a vernier. A series dividohm is provided and adjusted at time of installation for dropping the lamp voltage to within the range of the

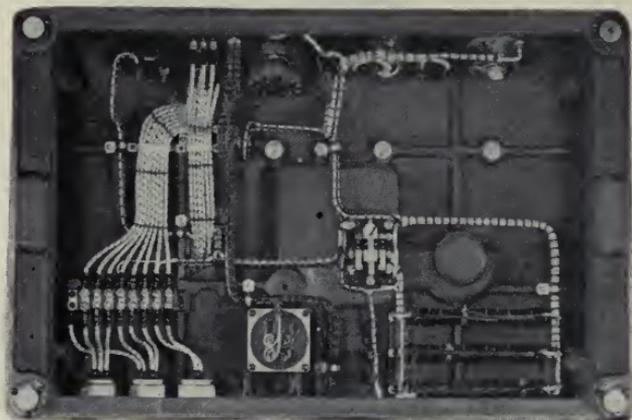


FIG. 2. PR-31 base and wiring.

lamp rheostat. A lamp holding circuit is provided for reducing the lamp current to approximately one-half recording value between takes. This circuit is relay operated from the motor circuit and is arranged so that it is not possible to record with reduced lamp current. A manual switch is also provided in order to check light intensity without running the recorder.

The same relay is used to disconnect the slater and punch circuit automatically when the recorder is operating.

The head assembly, shown in Fig. 3, contains all the film driving and handling equipment except the motor and the reduction gear box. A vertical casting wall divides the film compartment from the drive equipment. The film compartment is extra large and is equipped

with a light-tight door with a positive lock (Fig. 4). Lubrication of all gears and shafts is by wick feed from one central oil reservoir.

The film drive consists of a driven 32-tooth sprocket, a magnetic drive, two sprung rollers, and sprocket pad rollers; the sprung rollers are provided with position stops. Threading is done with one roller in its normal position as held by its spring and with the other roller held against its stop opposing the spring action. The pad rollers, kept in position against the sprockets by detent plates, are held open for threading by spring action. The recording drum is provided with

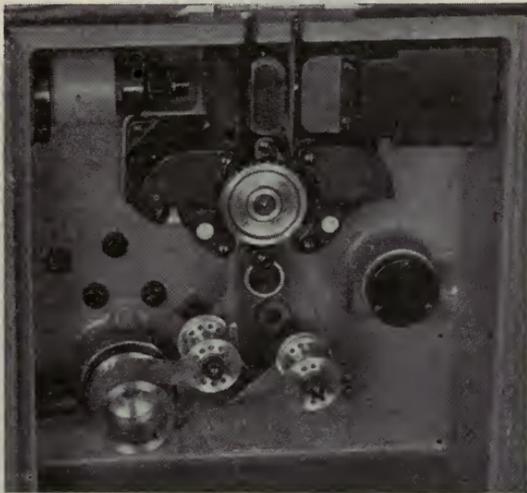


FIG. 3. PR-31 film compartment with slater and punch in place.

a taper of 0.001 in. per in., and a back flange. This arrangement has reduced film weave to a negligible value.

Threading is very simple and the design is such as to provide the same length film loop each time the machine is threaded. Damping is provided by the magnetic drive. However, both of the sprung arms are undamped. The magnetic drive also provides rapid starting and film stabilization so that recording may begin within three seconds after starting the recorder. The magnetic drive has been designed to provide a maximum of one per cent overdrive and is not critical to field current. A change in field current from 1.0 to 2.0 amp necessarily increases the damping, but makes no material difference in the performance of the machine. The bronze bearing used with the recording

drum is provided with a bearing heater and a thermostat set at 75 F. This permits the use of a precision sleeve-bearing with the drumshaft without the necessity of a bearing warm-up period. The heater and thermostat are located in the head casting below and above the drumshaft bushing. The heater is operated from the 220-v motor supply when a synchronous motor is used. When the recorder is driven by a Selsyn motor, the heater is operated from an auxiliary 110-v supply.

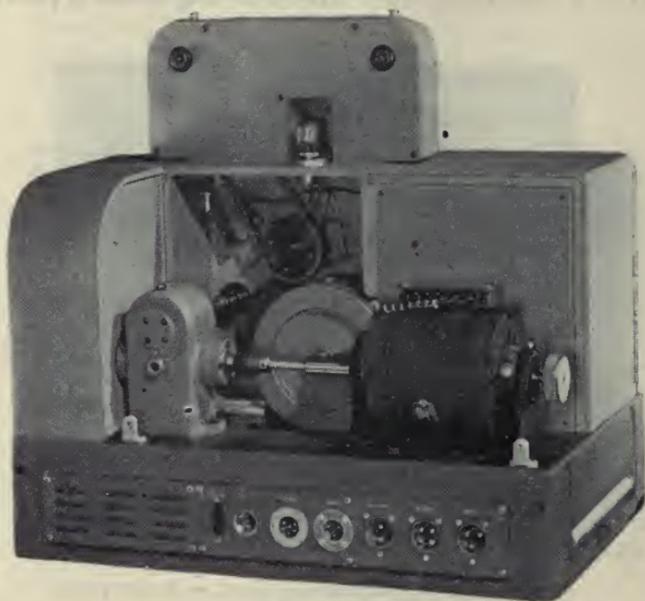


FIG. 4. *PR-31* rear view, cover removed.

Fig. 4 shows that the take-up assembly is mounted to the head assembly and is driven by a silent chain from the head gearing. A holdback device for the feed side of the magazine is provided. Both the holdback and the take-up are easily adjusted; the take-up drive chain is provided with an adjustable chain tightening shoe.

The accessory compartment, located to the right of the film compartment seen in Fig. 1, houses the footage counter and provides storage space for operating and maintenance items.

The optical system compartment is equipped with a hinged door through which all normal operating adjustments are made to the optical system. However, the complete optical system housing is removable by loosening two thumbscrews located in the compartment.

The door is equipped with an opening for observing the visual monitor, a plunger for operating the illumination meter, and an opening for operating the film punch and slating device which is available as accessory equipment. Terminal boards have been located in the optical system compartment for the purpose of connecting the optical system, bearing heater, and the slater and punch assembly to the base wiring.

Controls for the photoelectric cell monitor are also located in the optical compartment.

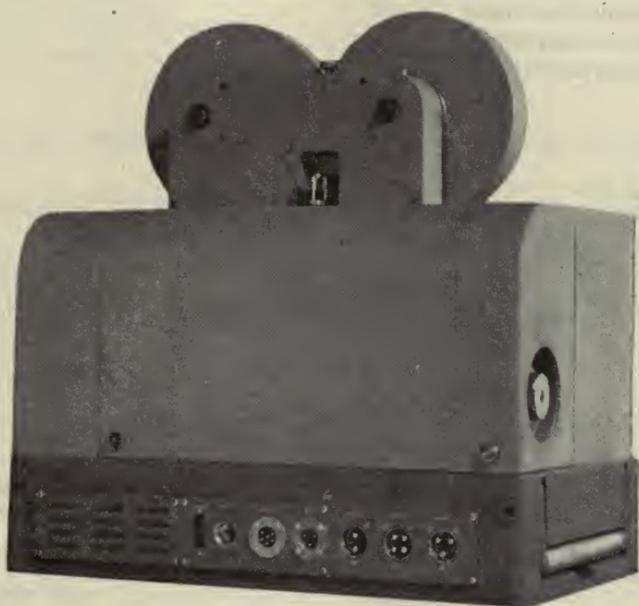


FIG. 5. PR-31 rear view, magazine in place.

The back cover, Fig. 5, removable by releasing two thumbscrews, completely encloses the rear of the machine. A recess is provided in the end of this cover for the motor handwheel. The machine has been designed so that either the optical system cover or the rear cover may be removed independently of each other.

Both Selsyn and synchronous motors are available and all recorders are wired for either type of operation. The synchronous motor used is a 6-pole, resilient mounted unit designed with a split winding so as to provide soft starting without the use of auxiliary starting equipment. A 6-pole synchronous motor is used; therefore, it is not necessary to change any gears when changing from synchronous to

Selsyn drive of the same frequency. When changing from 60-cycle to 50-cycle operation, it is necessary to change the reduction gear box. This gear reducer is used to eliminate high-speed gearing from the recorder head proper and to simplify frequency conversion. A multidity motor is also available if this type of operation is required.

As standard equipment the recorder is provided with the following desirable features in addition to the so-called essentials for a satisfactory machine:

- (1) A helical edge-wound nichrome rheostat
- (2) An illumination meter
- (3) A lamp holding device
- (4) A bearing heater

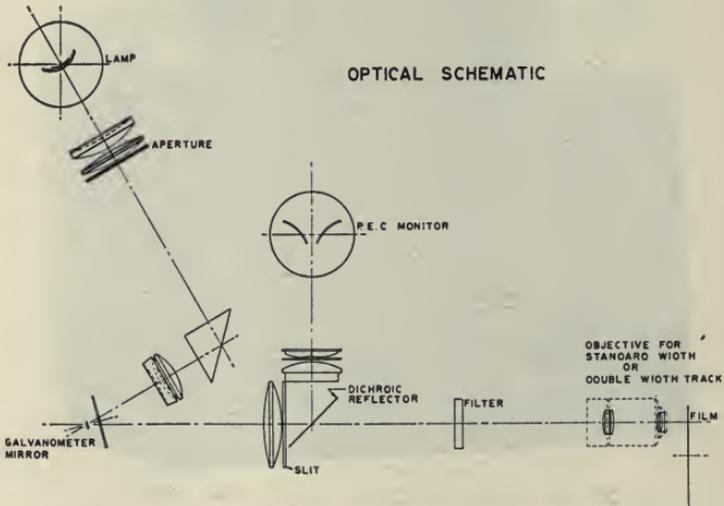


FIG. 6. PR-31 basic optical schematic.

Accessory Equipment.—As accessory equipment we have provided a photographic slater and solenoid punch shown on the slides and a photocell monitor.

Optical System.—The optical system of new design, seen schematically in Fig. 6, provides for visual monitoring as standard equipment and photoelectric cell monitoring may be added without any machining. Additional hand room has been provided by relocation of the recording lamp and the shutter which is now located adjacent to the recording slit. The visual monitor adjustments and the shutter adjustments have been greatly simplified. The recording

lamp is a prefocused 10.5-v, 7.8-amp, curved, coiled filament lamp. The lamp socket is provided with the necessary vernier adjustments. An improved modulator has been used. The area-type optical system is extremely flexible in application and may be supplied for any of the listed types of recordings:

- (A) Standard area
- (B) Class B push-pull
- (C) Class A push-pull
- (D) Class AB push-pull
- (E) Double width recording
- (F) Direct positive

A variable intensity type optical system can be provided if desired.

Performance.—The film motion, even better than that of previous RCA recorders, compares very favorably with any film recorder yet built.

The total flutter for all frequency bands is not greater than ± 0.05 per cent. The high-frequency component and all 96-cycle disturbances have been reduced to a negligible value. The low-frequency flutter has been reduced to an even lower value than that obtained with the *PR-23* recorder, which was remarkably free from low-frequency flutter.

In addition to these desirable features, the entire construction of the recorder is sturdy, assuring long, trouble-free operating life.

Conclusions.—In the design of this recorder every consideration has been given to the problems of operation and maintenance. In this connection, additional hand room in the film compartment has been provided and threading has been simplified as much as possible. All parts have been ruggedly designed. Adjustments have been eliminated wherever feasible, though all necessary adjustments have been retained and made as accessible as possible. For example, the magnetic drive brushes are accessible from the film compartment and the pad roller-sprocket clearance is a simple screwdriver adjustment.

We believe that the *PR-31* recorder will meet studio requirements for a de luxe recording machine that combines improved performance, ease of operation and maintenance, and a maximum of desirable features.

DISCUSSION

Dr. J. G. FRAYNE: I notice you have included a photocell monitor. Is a visual monitor also provided? I did not see it on the optical schematic.

MR. COLLINS: Yes, Dr. Frayne, a visual monitor is standard equipment as it has been with previous RCA recorders. The photoelectric cell monitor is considered as accessory equipment and will not be supplied as standard, but it will be available and can be added to the machine. In the design of the optical system, all steps have been taken so that the addition of the photocell monitor becomes a simple field installation.

DR. FRAYNE: Is the addition of photocell monitoring based on customer requirements or sound engineering, or both?

MR. COLLINS: We feel that the photocell monitor is a useful tool and it is one, I am sure, which some customers, some licensees, will want to make use of; we are making it available for any or all who wish to use it.

Dr. MARVIN CAMRAS: Do you have figures on the over-all flutter?

MR. COLLINS: Yes, I have some figures on over-all flutter. I stated ± 0.05 per cent maximum or total flutter. This matter of flutter is sort of a touchy subject, as you appreciate. Flutter just as a value does not mean too much. First of all, you have to set up a definition for flutter, and after the definition has been established it then becomes necessary to tie down the method of measurement, and the equipment used for measuring. In other words, I would not be too concerned about a figure representing the percentage of flutter unless this figure could be compared to the figure obtained from another recording machine when the same measuring equipment had been used for both machines.

MR. JOHN HAWKINS: I do not know whether this is the time and place to discuss this aspect of flutter question, but I know some definitions say just 0.05, some say the ± 0.05 . Does the plus or minus case correspond to 0.1?

MR. COLLINS: Plus or minus is the type of flutter definition that everyone in Hollywood is using, whereby the measured deviation is plus or minus and not the total deviation.

MR. HAWKINS: Is that rms or peak flutter usually as we express it?

MR. COLLINS: The ratings that we are giving here represent peak value.

DR. FRAYNE: I think I can amplify your remarks, Johnny, by saying that the ± 0.05 actually means 0.05, not 0.1. The variation is actually either way.

MR. J. W. THATCHER: I would like to ask if you can further amplify what you meant by driving through magnetic drive? I did not quite follow how you meant that drive to be accomplished.

MR. COLLINS: First of all, the magnetic drive is a type of drive whereby we have a rotating electromagnet. The field coil and the magnetic structure are gear driven. It is a little difficult to see that structure (referring to the slide), but it is immediately behind the flywheel and is driven by the gear train of the recorder. The flywheel itself is connected mechanically to the recording drum shaft, and is in no way connected to the gear train. The recording drum and flywheel are driven by the flux setup in the air gap of the rotating magnetic structure, the flywheel having a copper ring which runs in the air gap of the driven rotating magnet. Therefore, we refer to this flywheel, or drum shaft, as being magnetically driven, and we call it the RCA magnetic drive.

A NEW 16-MM PROFESSIONAL CAMERA*

FRIEND F. BAKER**

Summary.—The new Mitchell 16-mm camera has been designed as an all-purpose double-system camera, suitable for high speed or sound when used in a blimp. This paper describes briefly some of the features incorporated in the new camera.

The expanding fields of 16-mm film used in advertising, science, education, and television have created a demand for a strictly professional 16-mm camera. To satisfy that demand, the Mitchell Camera Corporation has designed a 16-mm camera along the lines of their 35-mm models.

Diversified production and limited budgets call for an all-purpose camera, operating equally well either on high or low speeds and quiet enough when housed in a blimp to meet the present requirements of sound. Special effects, too, are an all-important factor demanding perfect registration for multiple exposure work and ease in lining up all types of trick shots. As positive registration requires two pilot pins, it is necessary to use double perforated negative in the camera.

The features of the Mitchell 16 are very similar to the features of the 35-mm camera. They include:

- A positive register pin movement;
- Means for focusing without disturbing the lens position;
- A shutter opening of 175 deg;
- Frictionless light trap for magazines;
- Veeder footage and frame counter;
- Automatic buckle trip;
- Large sprocket with safety clutch and a turret to accommodate four lenses.

By the use of double perforated negative, the established practice of a double pull-down claw and standard registration pins can be maintained; that is, one pin fits the perforation in both directions while the other one acts as a paralleling pin and allows for shrinkage of the film.

* Presented Oct. 23, 1946, at the SMPE Convention in Hollywood.

** Mitchell Camera Corporation, Glendale, Calif.

The movement is driven by a ball-bearing mounted shaft on which are ground two three-point cams, one to actuate the claw while the other operates the two register pins. These pins may be withdrawn for threading by the rotation of a small knurled cam lock.

A pressure plate having two bakelite rolls held by hardened and ground side rails is set for film thickness, and holds the film in plane by a small leaf spring. An extension handle makes it easy to remove the pressure plate for cleaning.



FIG. 1. Three-quarter front view of camera.

An aperture plate milled from a block of stainless steel is hard chrome plated and polished. It is held in place by a cam lock to a single stud at the bottom, and a simple guide at the top. It may be removed easily for cleaning without the use of tools when the register pins are in the threading position. Light baffles are provided around the aperture. Two rollers are suitably placed to prevent film loop vibration.

A 20-tooth "dural" feed sprocket is driven through helical gears from the shutter shaft. Contained within the sprocket is a clutch which governs the tension of the take-up roll. This tension may be

changed quickly by the use of a scribe or small punch after removing one screw.

Two pairs of film guide rollers hold the film to the sprocket. They are disengaged for threading by rotating the knurled eccentric mount. There are safety pins which prevent closing the door unless the eccentrics are in place. Strippers top and bottom are provided.

Magazines are of 400-ft capacity similar to the Mitchell standard magazine. They have a roller light trap composed of three velvet

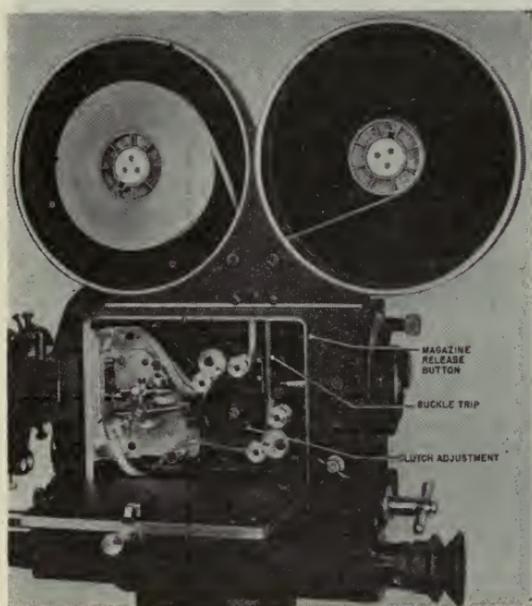


FIG. 2. Magazines and film moving mechanism.

rollers. Spindles take the standard film spools. The magazines have a corduroy lining, and they are belt-driven. They are released by pushing a button just inside the door.

Built into the rear of the camera is a buckle trip switch which breaks two lines of the circuit. It may be reset by pressing a button on the outside without opening the door.

The shutter opens to 175 deg by a hand dissolve lever in the back, and the shutter may be set in 10 deg steps. A visual miniature shutter is seen through a window, and indicates its relation to the film

aperture. This greatly facilitates the lining up of projection-back-ground shots.

A Veeder frame and footage counter is mounted in the back plate within easy eye position.

The rack-over of the camera in relation to the base is typically Mitchell, as is the erect image focus tube. It is provided with a sliding objective giving five or ten times magnification as desired.

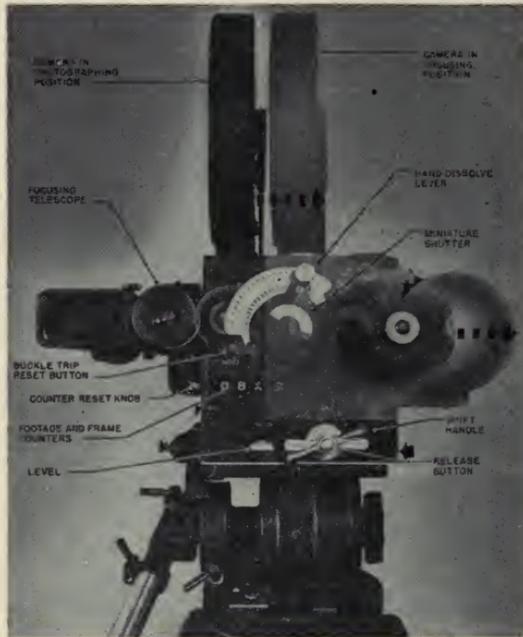


FIG. 3. Rack-over operation and focusing features.

Either of two finders is optional. The standard Mitchell erect image finder is fitted with a bracket which allows it to be folded up out of the way of the door; or a smaller model may be had which uses celluloid mattes. This smaller finder has a focusing mechanism actuated by the parallax arm.

The turret carries four lenses and has a lock operated by a small lever near the bottom.

A completely new set of short focal length Baltar lenses has been designed by the Bausch and Lomb Optical Company for this camera.

They consist of 15-, 17.5-, 20-, and 25-mm lenses having a quality equal to anything now used on 35-mm cameras. Lenses above the 25-mm length will be the same as those now used in professional work.

Lens mounts are similar to the standard Mitchell, except smaller and a finer pitch thread is used in order to obtain the correct amount of rotation in focusing.

A choice may be had in matte boxes; either the Mitchell standard with its various holders, or a smaller and simpler version which will fill most needs.

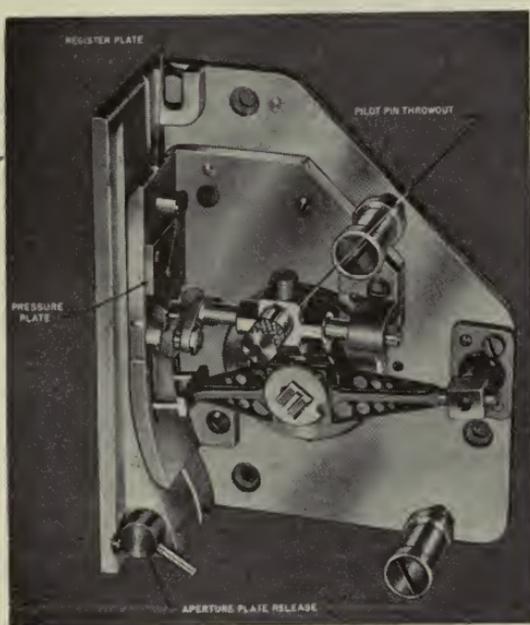


FIG. 4. Camera movement.

A crank door will be one of the accessories, geared such that when the crank is turned at 120 rpm, the camera will be running 24 pictures per sec.

A variety of motors will be available; variable speed, high speed, synchronous and interlocking. Their mountings are similar to those on the NC model; that is, integral with the door.

DISCUSSION

MR. LLOYD THOMPSON: I would like to ask what percentage of film shrinkage a camera will accommodate?

MR. BAKER: We know that it will handle present tolerances at 140 pictures per sec successfully, and the manufacturers, I believe, have expressed their willingness to tighten that tolerance at any time.

MR. H. O. HILLS: Can you tell us where the pilot pins are in this camera relative to the picture?

MR. BAKER: They are the first holes at the bottom of the aperture; that is, the top of the projected picture, and they are removed by just one picture from the claw engagement.

MR. HILLS: Is it possible to use present lenses (*C* mount lenses) on this camera?

MR. BAKER: The *C* mount does not fit the present Mitchell. It would take an adapter, which could be fitted.

MR. DAVIS: Is the pressure plate cam operated?

MR. BAKER: No, it is held by a spring. The plate is set at the thickness of film, and it is held there by light pressure sufficient to hold it up.

MR. JAMES A. LARSON: I would like to know whether the Baltar mount could be adapted to a *C* mount—will the Baltar lenses be mountable?

MR. BAKER: I see no reason why they could not be.

REPORT OF SECTIONAL COMMITTEE ON MOTION PICTURES, Z22*

During the past year the work of the American Standards Association Sectional Committee on Motion Pictures, Z22, has resulted in the reaffirmation of eight Z22 standards and adoption of fifteen Z52 War Standards as Z22 standards. This is part of a comprehensive effort by the committee to bring up to date all existing standards and consider any meritorious proposals for adoption as additional standards. Shortly after the end of the war, the membership of the committee was reviewed in order to ensure adequate representation by all interested parties.

A meeting of the committee was held on Oct. 17, 1945, in New York to discuss the disposition of existing Z22 standards. It was decided to submit the following directly to letter ballot of the committee since proposed revisions were minor and were accepted at this meeting:

- Z22.2—1946 Emulsion and Sound Record Positions in Camera for 35-Mm Sound Motion Picture Film
- Z22.3—1946 Emulsion and Sound Record Positions in Projector for 35-Mm Sound Motion Picture Film
- Z22.9—1946 Emulsion Position in Camera for 16-Mm Silent Motion Picture Film
- Z22.15—1946 Emulsion and Sound Record Positions in Camera for 16-Mm Sound Motion Picture Film
- Z22.21—1946 Emulsion Position in Camera for 8-Mm Silent Motion Picture Film
- Z22.28—1946 Dimensions for Projection Rooms and Lenses for Motion Picture Theaters
- Z22.29—1946 Dimensions for Theater Projection Screens
- Z22.31—1946 Definition for Motion Picture Safety Film

On the recommendation of a subcommittee, the following Z52 War Standards were submitted directly to letter ballot of the committee since they had been the subject of extensive study during the war and appeared to be suitable for peacetime standards (the newly assigned Z22 numbers are given here in place of the Z52 numbers):

* American Standards Association, New York; submitted Jan. 13, 1947.

- Z22.40—1946 Sound Records and Scanning Area of 35-Mm Sound Motion Picture Prints
- Z22.41—1946 Sound Records and Scanning Area of 16-Mm Sound Motion Picture Prints
- Z22.42—1946 Specifications for Sound Focusing Test Films for 16-Mm Sound Motion Picture Projection Equipment
- Z22.43—1946 Specifications for 3000-Cycle Flutter Test Film for 16-Mm Sound Motion Picture Projectors
- Z22.44—1946 Specifications for Multifrequency Test Film for Field Testing 16-Mm Sound Motion Picture Projection Equipment
- Z22.45—1946 Specifications for 400-Cycle Signal Level Test Film for 16-Mm Sound Motion Picture Projection Equipment
- Z22.46—1946 16-Mm Positive Aperture Dimensions and Image Size for Positive Prints Made from 35-Mm Negatives
- Z22.47—1946 Negative Aperture Dimensions and Image Size for 16-Mm Duplicate Negatives Made from 35-Mm Positive Prints
- Z22.48—1946 Printer Aperture Dimensions for Contact Printing 16-Mm Positive Prints from 16-Mm Negatives
- Z22.49—1946 Printer Aperture Dimensions for Contact Printing 16-Mm Reversal and Color Reversal Duplicate Prints
- Z22.50—1946 Reel Spindles for 16-Mm Motion Picture Projectors
- Z22.51—1946 Methods of Making Intermodulation Tests on Variable-Density 16-Mm Sound Motion Picture Prints
- Z22.52—1946 Methods of Making Cross-Modulation Tests on Variable-Area 16-Mm Sound Motion Picture Prints
- Z22.53—1946 Method of Determining Resolving Power of 16-Mm Motion Picture Projector Lenses
- Z22.54—1946 Method of Determining Freedom from Travel Ghost in 16-Mm Sound Motion Picture Projectors

All of the above standards were approved by the Z22 Committee, confirmed by the sponsor (SMPE), and adopted as American Standards during 1946. One of them, however (Z22.29—1946 Dimensions for Theater Projection Screens), has already been reconsidered at the request of the Research Council of the Academy of Motion Picture Arts and Sciences and is now in the hands of a subcommittee of Z22 for revision. The proposed revision is intended to clear up a question as to whether the standard dimensions apply to the entire screen or only the portion masked off for the picture.

Three standards (Z22.10—1946, Z22.16—1946, and Z22.22—1946) dealing with emulsion position of 8- and 16-mm films in the projector were referred to a subcommittee headed by E. A. Bertram. After circulation of the report of that committee and discussion at a meeting in Hollywood on Oct. 25, 1946, these standards are about to be submitted to letter ballot.

Two standards were submitted to the Academy Research Council for recommendations on revision. One (*Z22.32—1941 Fader Setting Instructions for Motion Picture Theaters*) was recommended to be withdrawn by the Research Council. The Z22 Committee concurred in this recommendation, which has been forwarded to the sponsor. The other standard (*Z22.33—1941 Motion Picture Nomenclature for Electrical Filters*) received an affirmative vote by a majority of members. However, since an objection was raised by several members that this standard did not conform with the practice in other industries using electrical filters, it was decided to withhold action until the matter could be investigated by other ASA committees.

No action was taken on the following standards since they were so recently adopted (1944):

- Z22.37—1944* Raw Stock Cores for 35-Mm Motion Picture Film
- Z22.38—1944* Raw Stock Cores for 16-Mm Motion Picture Film
- Z22.39—1944* Screen Brightness for 35-Mm Motion Pictures

The remainder of the Z22 standards of 1944, or previous years, were referred to the Standards Committee of the SMPE. This committee, under the chairmanship of F. T. Bowditch, has spent a vast amount of study on the revision of these 22 standards. Their work has already resulted in recommended revisions on the following standards which have been sent to letter ballot of the Z22 Committee:

- Z22.5—1941* Cutting and Perforating Dimensions for 16-Mm Silent Motion Picture Negative and Positive Raw Stock
- Z22.12—1941* Cutting and Perforating Dimensions for 16-Mm Sound Motion Picture Negative and Positive Raw Stock
- Z22.17—1941* Cutting and Perforating Dimensions for 8-Mm Motion Picture Negative and Positive Raw Stock
- Z22.35—1930* Dimensions for 16-Tooth 35-Mm Motion Picture Projector Sprockets
- Z22.36—1945* Cutting and Perforating Dimensions for 35-Mm Motion Picture Positive Raw Stock

One proposed standard (*Z22.55/44 Specifications for 35-Mm Sound Motion Picture Release Prints in Standard 2000-Foot Lengths*) has been submitted by the Academy Research Council. The proposed standard is now in use by most American 35-Mm motion picture producers. It has been submitted to letter ballot of the Z22 Committee.

At the last meeting of the Z22 Committee on Oct. 25, 1946, a subcommittee under F. L. Brethauer was set up to study proposed revi-

sions to Z52.6—1944 Method of Determining Picture Unsteadiness of 16-Mm Sound Motion Picture Projectors. Another subcommittee under M. C. Batsel was appointed to study suggested revisions of Z52.10—1944 Specification for Buzz-Track Test Film for 16-Mm Sound Motion Picture Projectors. A third subcommittee headed by J. A. Maurer was assigned to study Z52.7—1944 Method of Determining Uniformity of Scanning Beam Illumination of 16-Mm Sound Motion Picture Projectors. The Z52.2—1944 Specification for Test Film for Checking Adjustment of 16-Mm Sound Motion Picture Projection Equipment was referred to the Joint Committee on Test Films of the SMPE and the Research Council for the preparation of a specification to be considered for adoption as an American Standard. The Joint Committee on Test Films was also asked to prepare a specification for a warble test film. It was further agreed that Z52.14—1944, Nomenclature for Motion Picture Film Used in Studios and Processing Laboratories, should be submitted to the Z22 Committee by letter ballot.

The chairman wishes to take this opportunity to express his appreciation not only for the work of the members of the committee but also for the active co-operation by the Standards Committee of the SMPE and the Research Council of the Academy of Motion Picture Arts and Sciences.

C. R. KEITH, *Chairman*

K. F. ABEEL	A. S. DICKINSON	H. M. LESTER
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REPORTS OF SMPE COMMITTEES

SPECIFICATIONS ON MOTION PICTURE FILM FOR PERMANENT RECORDS*

JOHN G. BRADLEY**

The statement that follows is presented as a preliminary report from the Committee on Preservation of Film. Its preliminary character stems from the fact that the assignment connoted by the title of this paper represents a major undertaking, the aftermath of war work made certain demands on the work schedules of members of the committee, correspondence and travel have been difficult, and as a consequence the committee has not been able to complete its work. One meeting of the committee was held in Washington on Sept. 27, 1946, subcommittees have been set up, and the various problems before us are being resolved. It is hoped, therefore, that a full and useful report may be ready for the 1947 Spring Convention.

In view of these circumstances the committee has decided to present an outline of the various considerations before it as a means of stimulating further discussion and of enlisting any help that others may be in a position to give. Here are the considerations:

(1) The volume of film of a record character has greatly increased and is continuing to increase. The Government alone may have some 300,000 reels of such material set aside for permanent preservation within the next few years in the form of motion pictures, to say nothing of microfilm, still film, and aerial maps. It has been roughly estimated that storage space equivalent to 4000 or 5000 vaults will be required for such material.

(2) Expository film (sometimes referred to as *documentary* film) for training, teaching, and the dissemination of information, is making a major impact on our consideration and the people concerned with

* Presented Oct. 23, 1946, at the SMPE Convention in Hollywood.

** Chairman, SMPE Committee on Preservation of Film; Director, Motion Picture Division, The Library of Congress, Washington, D. C.

such activities not only need help and guidance but are making insistent demands for such help.

(3) The great entertainment field as roughly represented by Hollywood and related sources is becoming historically minded and will not be content in the future to live on a day-by-day or a hand-to-mouth basis but is looking both forward and backward on a longitudinal basis.

(4) Industrial firms are likewise setting up their own archives and need the help and leadership this committee can give in respect to preservation.

(5) Both records and lives are being lost through the use and misuse of nitrate film.

(6) The National Board of Fire Underwriters, the National Bureau of Standards, and this committee need to speak the same language and preach the same doctrine in respect to this problem; this is not presently the case.

(7) Standardization of vault construction, laboratory practices, and related problems in handling film is badly needed.

(8) A further investigation of the permanency of color dyes, of plastics for a possible new film base, cold lights (mercurial and fluorescent) pin-point lights (Zirconium), and rehumidifying techniques to prevent brittleness of acetate film is indicated.

(9) In carrying out the work of the committee it seems expedient to make contacts with other agencies sharing similar interests and responsibility. Therefore, your committee requests authorization to make appropriate contacts with the following people: (1) National Board of Fire Underwriters, with a view to formalizing its recommendation covering the size of vents in ratio to the film storage load; (2) Federal Fire Council, seeking its co-operation in giving effect to the committee's recommendations, as well as receiving the aid of its engineering staff. *Note:* The Chairman of the Federal Fire Council Construction Committee, for example, has recommended such liaison; (3) Other committees of the Society, such as the committees on Color, Laboratory Practices, Processing Photography, and Standards.

DISCUSSION

MR. J. I. CRABTREE: Did you plan to store all this film in Washington or in another location?

MR. BRADLEY: Already 81 vaults have been filled at Suitland, Maryland, temporary in character and to be torn down. The major storage plant will be at Suitland, Maryland, where about seven acres have been set aside by the Govern-

ment for a \$5,000,000 film facility, storage principally. Legislation has already been approved by the Senate, and is pending before the House, covering this project. However, we hope that many people will store copies of the same film in many parts of the country, because it is only through scattering of records, books, and other record material can we hope they will survive another war; bombing will be a factor.

MR. GEORGE TALLIAN: Is there any attempt made at the present time to treat film chemically before it is stored, or do you just put it away as is?

MR. BRADLEY: Attempts are being made and practices are being approved to treat the film in the laboratory to bring the salts up to a state of solubility, and therefore enable the maximum amount of hypo to be removed; and after that it will be a question of housekeeping in terms of temperature and humidity. But the question of coating and impregnation, embalming, and other techniques to put on the outside of the film has been considered and tested by the Bureau of Standards. I find I must be very cautious in what I am about to say because I realize that commercial interests are at stake; so I will merely say this: chemically we have found that none of those things add to the life of the film. As to mechanics and to wear and tear on the film, that is another matter.

MR. CRABTREE: During your many years of experience at the Archives, what percentage of the films have you had to duplicate because of incipient or partial decomposition?

MR. BRADLEY: I could not give you an exact percentage, Mr. Crabtree, but a considerable body of that film has deteriorated in our hands, because we were not able to duplicate because of lack of funds, equipment and personnel. We found in many cases, when the film was brought out of storage, unwrapped and unwound, the moisture in the air immediately precipitated deterioration; overnight, almost. Mr. Gregory, my former assistant at The National Archives, can bear witness to this fact. We have developed tempering techniques, bringing the film out and letting the temperature rise slowly by radiation. Care should be taken to prevent exposure of the film to the air until the temperature of the film is in balance with the temperature of the air; otherwise, moisture condensation on the surface of the film will result.

MR. CRABTREE: To what extent do you plan to store the film at low temperatures—say around 50 F—and to what extent do you plan to isolate the films in individual compartments as against mass storage in a unit vault?

MR. BRADLEY: On the nitrate film of high record value, we intend to store it in cabinets, reducing the unit of risk to a minimum, perhaps, one reel instead of a vault full of reels. We intend, for the same film of high record value, to maintain temperatures of about 50 F and about 50 per cent relative humidity. That is about as low a temperature as people can work in. We will have the tempering cans in which we will bring the film out of the vaults, set them in the workroom, and let radiation lift the temperature so it will be safe to unwind the film. Film of less record value can be stored without the cabinets. However, our entire program contemplates the transfer of record film to acetate stock as fast as funds will permit, so all of the Government record film will ultimately be on the safety stock, which has a much longer life than the nitrate film.

MR. CRABTREE: Has any estimate been made as to the life of the film in storage?

MR. BRADLEY: Three to five hundred years for acetate film, at which time it can be copied and perpetuated for perhaps three to five thousand years.

MR. CRABTREE: Has any progress been made in the transfer of images to metal films?

MR. BRADLEY: It does not seem necessary. The only metal used in this connection above an experimental stage has been aluminum which will pit under the influence of sulfur fumes. It also has a bad fault in that it crinkles and has to be ironed out. It is also opaque and projection has to be by reflection, but so far no other metal has been used widely. When acetate film has preservation characteristics better than the best rag paper, we do not feel the need for metal.

MR. CRABTREE: With regard to the vaults at present in The Archives Building, are the cabinets of 18-8 stainless steel, and have you observed any corrosion of the metal? In other words, will it be necessary to construct them of molybdenum stainless steel instead of ordinary 18-8, or what construction material have you found most desirable?

MR. BRADLEY: The cabinets are of molybdenum stainless steel. There has been some corrosion on them owing to the fluxing material when they were welded and fabricated. However, that is a seepage process, and we believe that that seepage will expend itself in a few years. We are simply wiping it off with lemon oil and watching it, but the main body of the cabinets themselves seem to be holding up nicely. A new cabinet has been developed which is called the Cascade Cabinet, previously mentioned in some of our reports, which can be made out of ordinary furniture steel at considerably less cost, and which can be thrown away when it rusts over a period of time, and be much cheaper than the stainless steel cabinets. The stainless steel cabinets cost us about \$30 per reel to put the film away. Cabinets for eight vaults (about 2000 rolls) cost us about \$60,000, which is much above the reach of the average film library. The Cascade Cabinet can be built for about \$2 per roll (wholesale cost), and by painting and by having proper air we feel that they will not rust for over a decade at least; and at that time, if they did rust, new cabinets could be put in. They avoid insulation and other excessive expenses.

REPORT OF THE COMMITTEE ON STANDARDS*

F. T. BOWDITCH**

A perusal of the occasional JOURNAL issue which records the membership of the various committees of the Society shows that the Committee on Standards, with approximately 50 members, is the

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

** Chairman; National Carbon Company, Cleveland, Ohio.

largest one of all, and that by a substantial margin. Moreover, this large membership is not confined to a limited field of interest, as are the other engineering committees. On the contrary, every important phase of the motion picture industry is represented. The reasons for this may not at first be apparent, since the diverse interests of such a large group would seem to make the study of a single subject a very cumbersome procedure. Actually, this is not the case, since the entire committee acts as a unit only on matters of general policy, and in final balloting on the recommendations of its subcommittees. It is these subcommittees which do the work, in small groups of perhaps a half-dozen individuals, chosen to be representative of those phases of the industry directly concerned in the field under study.

The large total membership thus acts effectively as a reservoir from which capable subcommittees can be drawn; and equally important, when the recommendation of a subcommittee is presented for final ballot, a completely representative expression of opinion is assured which strengthens any Standard that survives such a critical review. Other papers scheduled for this Convention make apparent the fact that Standards can be a very important factor in the advance of a technological industry such as our own. This can only be so if these standards are carefully worked out to recognize all points of view, so that the industry comes to recognize this fact, and accepts the Standards accordingly. The wide representation of your Committee on Standards has been chosen with this important end in view.

Eight subcommittees of the parent committee are active as this is written. The work of E. K. Carver's Subcommittee on 35-Mm Sprockets (which led to the recommendation of a 0.943-in. diameter sprocket giving double the film life obtained with the present 0.935-in. sprocket) is being continued, with the objective of recommending a more complete revision of the American Standard for 35-mm Motion Picture Film, 16-Tooth Projector Sprockets, *Z22.35-1930*. Even though it is thus agreed that other aspects of this Standard require consideration for revision, this will require sufficient time so that the parent committee has recommended the immediate revision of the diameter specification, giving the industry the benefit of this important revision at once.

Related to this work is that of Otto Sandvik's Subcommittee on 8-Mm and 16-Mm Projector Sprockets. This is developing into the specification of a design-formula, rather than the more conventional

tabular-type of specification, and has led to the preparation of a technical paper for presentation at this Convention under the title "Proposals for 16-Mm and 8-Mm Sprocket Standards."

D. R. White's Subcommittee on Photographic Density and Sensitometry has completed its consideration of American Standard *Z22.27—1941* on Photographic Density, and this has been referred to the parent committee where a letter ballot is presently being conducted. The Sensitometry Standard *Z22.26—1941* is still under discussion by the subcommittee.

D. F. Lyman's Subcommittee on Projection Reels is in substantial agreement on the draft for 8-mm and 16-mm reels. The 35-mm reel specification is requiring more detailed study.

The Subcommittee on 8-Mm and 16-Mm Camera and Projector Apertures under the chairmanship of J. A. Maurer, is considering the revision of the six present standards, but has not advanced any of these for consideration by the parent committee.

The Subcommittee on Film Splices, under the chairmanship of W. H. Offenhauser, Jr., has submitted an initial report which was published in the *JOURNAL*.¹ A new proposal was published, for a trial period of one year, as specified on page 8 of this reference. It was agreed by the members of the subcommittee that the war standard which formed the basis for this new proposal had not been in effect long enough to prove its value. The response to this report, while encouraging, is by no means complete, and the subcommittee wishes particularly to invite comments by parties interested in this field.

Dr. Carver's Subcommittee on Cutting and Perforating Raw Stock has completed its consideration for revision of five standards, and drafts have been submitted for letter ballot to the parent committee. In addition, this subcommittee has just recently been given the task of preparing a standard on the cutting and perforating of 32-mm film.

Other projects which are being studied with the prospect of early subcommittee activity are those for daylight-loading spools and lens aperture markings. In the first case, F. L. Brethauer has been appointed chairman of a subcommittee to study the standardization of daylight-loading spools for 35-mm and 16-mm motion picture film. Pending the organization of his subcommittee, he is determining the correlation of this project with work previously done by ASA Committee *Z38* in the preparation of standards for microfilm spools.

With regard to lens aperture markings, it has been agreed that a study should be made of the problem of marking lenses on the basis of measurements of actual light transmission. The Research Council of the Academy of Motion Picture Arts and Sciences and the Society are reviewing the prior art in this field to form a sound basis for the new work.

REFERENCE

¹ "Report of the Subcommittee on 16-Mm Film Splices," *J. Soc. Mot. Pict. Eng.*, 47, 1 (July 1946), p. 1.

REPORT OF THE COMMITTEE ON THEATER ENGINEERING, CONSTRUCTION, AND OPERATION*

HENRY ANDERSON**

The Theater Engineering, Construction, and Operation Committee of the SMPE has been formed for the purpose of rendering to motion picture theaters the same type of technical and scientific service that the Society renders to the other branches of the industry.

It is inconsistent that the best scientific and technical skills should be concentrated upon the development and manufacture of the product, and its end use be left to chance.

The Film Projection Practice Committee has made a substantial contribution to the motion picture theater through its standards and other activities.

There are, however, many factors other than projection that contribute to the comfort, enjoyment, and safety of the theater patron and the efficiency of theater operation. It is these factors, not covered by any other committee of the Society, that the Theater Engineering, Construction, and Operation Committee proposes to study.

One of the important matters that may come to the committee at any time is that of building codes regulating motion picture

* Submitted Dec. 20, 1946.

** Chairman, Paramount Pictures, Inc., New York.

theaters. There are in development many revisions of existing codes, and new codes are being formulated locally from time to time. The Building Officials Conference of America is formulating a recommended national or uniform code, and this organization will, when it reaches the theater code, welcome our co-operation. We may thus be helpful in developing a code which will combine every element of safety and comfort, and at the same time be entirely practicable.

The committee is "trying its wings" on an investigation of theater carpets. This subject might at first glance appear to be of minor importance and involve little scientific knowledge. Upon investigation, however, we find some of the highest technical skills involved in the manufacture and development of carpets. We have been in contact with the Research Committee of the Carpet Institute of America, and may develop substantial improvements through co-operation with them.

We find an outstanding need for greater technical skill in the laying of carpets and the preparation of the theater by the architect for the installation of carpets. We propose to prepare standards for carpet installation covering, among other things, recommended thicknesses and type of carpet linings for various locations, size and locations of insets in floors and steps for securing carpets, types and depths of depressions to receive carpet.

We further propose to develop standards for maintenance and cleaning of carpet.

Enormous amounts are spent by the industry annually for carpet, and we are told that adoption of proper practice in selection, installation, and maintenance of carpet may prolong its life 25 per cent. This would represent a substantial dollar and cents saving.

We have under way, and practically completed, a study to develop an electric heater suitable for motion picture booths. Installation of electric heaters in motion picture booths has heretofore been prohibited. We are about to obtain the approval of the National Board of Fire Underwriters, and we trust that the approval of the various authorities will follow.

We also have under way a study of gas or gasoline-driven diesel-type generators for theater emergency lighting. These devices have been developed to a high degree of effectiveness and reliability. The industry has indicated some degree of interest in this development.

We are seriously handicapped by a lack of clerical and technical help. We have already collected more information on the subject

of theater carpet than, we believe, is available anywhere else. Arranging and co-ordinating this information requires more time than committee members themselves have available. With some technical and clerical assistance we could at this time release some valuable information, in tentative form, at least.



61st SEMIANNUAL CONVENTION

THE DRAKE HOTEL
Chicago, Illinois

April 21-25, 1947

☆ ☆ ☆

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Membership and Subscription Committee (Midwest Section).....	TOM RESS, <i>Chairman</i>
Ladies Reception Committee Hostess.....	MRS. A. SHAPIRO
Projection Program Committee—35-mm.....	S. A. LUKES, <i>Chairman, assisted</i> by Members Chicago Projec- tionists Local 110
16-mm.....	H. WILSON, <i>Chairman</i>

HOTEL RESERVATIONS AND RATES

The management of The Drake, located at Lake Shore Drive and Upper Michigan Ave., Chicago 11, Illinois, Convention Headquarters, extends SMPE members and guests the following per diem room rates, European plan:

Room with bath, one person.....	\$4.55-5.50
Room with bath, two persons, twin beds.....	\$7.50-8.50-9.00-10.00-12.00
Parlor suites with connecting bedrooms, two persons.....	\$18.00-20.00-22.00-25.00

Note.—Room accommodations must be booked early and direct with W. M. Cowan, Assistant Manager, The Drake, prior to April 15. When making reservations be sure to advise Mr. Cowan that you are attending the SMPE 61st Semiannual Convention. No rooms will be assured or guaranteed at The Drake unless confirmed.

TRANSPORTATION

With travel conditions still not normal, the Eastern and West Coast members who are contemplating attending the 61st Semiannual Convention should consult their local railroad, Pullman and plane agents regarding effective schedules and rates at least 30 days prior to your departure.

REGISTRATION

The Convention Registration Headquarters will be located in the French Room Foyer of The Drake. Members and guests are expected to register. The fee is used to help defray the Convention expenses.

TECHNICAL PAPERS AND SYMPOSIUMS

Members and others who are contemplating the presentation of papers at the Chicago Convention can greatly assist the Papers Committee in the early scheduling and assembly of the program by mailing in the title of paper, name of the author, and an abstract to the Papers Committee Chairman, or to the Society's offices in the Hotel Pennsylvania, New York, *not later than March 15*. Complete manuscripts must be received by *April 7* to be included in the final program. Your co-operation in this regard is solicited.

The Convention business and technical sessions will be held in the Grand Ballroom located on the lobby floor of the hotel.

SMPE GET-TOGETHER LUNCHEON

The usual Get-Together Luncheon will be held in Gold Coast Room on Monday, April 21, at 12:30 P.M.

The luncheon program and eminent guest speakers will be announced in later bulletins. Guaranteed seating at the luncheon will be assured only if tickets are procured *prior to 11:00 a.m.* on April 21. Assist the Committee and hotel in providing accommodations by complying with this request.

INFORMAL BANQUET AND DANCE

The SMPE 61st Semiannual Banquet and social get-together will be held in the palatial Gold Coast Room of The Drake on Wednesday evening, April 23, at 8:00 P.M. (Dress optional.)

A Cocktail Hour for holders of Banquet tickets will be held in the French Room preceding the banquet from 6:46 to 7:45 P.M.

Banquet tickets should be procured and tables reserved at the Registration Headquarters prior to *noon on April 23*. The Banquet program will be announced in later bulletins.

Luncheon and Banquet tickets may be procured in advance of the dates of these functions through W. C. DeVry, Chairman of the Luncheon and Banquet Committee, located in Chicago, or through W. C. Kunzmann, Convention Vice-President, who will be at The Drake several days prior to the opening date.

Note.—All checks or money orders issued for registration fee and luncheon or banquet tickets should be made payable to W. C. Kunzmann, Convention Vice-President, and *not to the Society*.

LADIES REGISTRATION AND RECEPTION HEADQUARTERS

Ladies attending the Convention should register with Mrs. A. Shapiro, the hostess, and members of her Committee in their headquarters, Parlor H, which is adjacent to the Grand Ballroom where the Convention sessions will be held.

Ladies' entertainment program will be announced later by the Ladies Committee.

RECREATION

Convention recreational program will be announced later by the Local Arrangements Committee. Consult the hotel bulletin board or Registration Headquarters for other local amusements available in Chicago during the Convention dates.

MOTION PICTURES

Convention identification cards will be honored through the courtesy of the Balaban and Katz Corporation at the following *deluxe* theaters located in the Loop, namely: Chicago, State Lake, and United Artists Theaters.

The H. and E. Balaban Corporation extends their courtesy and will honor these cards at their Esquire Theater located in the immediate vicinity of The Drake Hotel.

RKO Theaters (Chicago Division) extends their courtesy of honoring the Convention identification cards at their *deluxe* RKO Palace and Grand Theaters, located in the Loop.

TECHNICAL SESSIONS SCHEDULED

Monday, April 21, 1947

Open Morning.

- 9:30 a.m. *French Room Foyer:* Registration. Advance sale of Luncheon and Banquet tickets.
- 12:30 p.m. *Gold Coast Room:* Get-Together Luncheon (Speakers).
- 2:00 p.m. *Grand Ballroom:* Business and Technical Session.
- 8:00 p.m. *Grand Ballroom:* Evening Session.

Tuesday, April 22, 1947

- 9:30 a.m. *French Room Foyer:* Registration. Advance sale of Banquet tickets.
- 10:00 a.m. *Morning Session:* Location to be announced later.
- 2:00 p.m. *Grand Ballroom:* Afternoon Session.
- Open Evening.

Wednesday, April 23, 1947

- 9:30 a.m. *French Room Foyer:* Registration. Advance sale of Banquet tickets.
- 10:00 a.m. *Morning Session:* Location to be announced later.
- Open Afternoon.
- 8:00 p.m. *Gold Coast Room:* SMPE 61st Semiannual Banquet and evening for social get-together will be held in the palatial Gold Coast Room (dancing and entertainment). Cocktail Hour for holders of banquet tickets, 6:45-7:45 P.M. The program for this evening will be announced later by the Banquet Committee. Tables may be reserved at the Registration Headquarters prior to noon on April 23.

Note.—The Registration Headquarters will be open on this afternoon for those desiring to make final arrangements for the Banquet.

Thursday, April 24, 1947

Open Morning.

- 2:00 p.m. *Grand Ballroom:* Afternoon Session.
- 8:00 p.m. *Grand Ballroom:* Evening Session.

Friday, April 25, 1947

- 10:00 a.m. *Grand Ballroom:* Morning Session.
- 2:00 p.m. *Grand Ballroom:* Afternoon Session. Adjournment of the 61st Semiannual Convention.

Note.—All sessions during the five-day Convention will open with an interesting motion picture short.

Important

Book your room accommodations early and direct with W. N. Cowan, Front Office Manager, The Drake, Chicago, Illinois. All reservations are subject to cancellation prior to April 10.

Co-operate with the Luncheon and Banquet Committee by procuring tickets well in advance of the dates for these functions, so that hotel arrangements can be made accordingly.

This is a tentative schedule and is subject to change.

W. C. KUNZMANN
Convention Vice-President

SOCIETY ANNOUNCEMENTS**SECTION DISCUSSES MAGNETIC RECORDING**

Marvin Camras, of the Armour Research Foundation, Chicago, discussed magnetic sound for motion pictures before the Atlantic Coast Section of the Society at a meeting held on January 16, 1947. Mr. Camras described the principles of sound recording using a material having magnetic properties coated in a matrix onto motion picture film.

The recording and reproduction of sound is carried out by point-to-point magnetization of the material. The coating can be applied in various ways such as, for instance, to the edge of motion picture film already completed, or in a form that will produce multiple sound tracks for sound use only.

A portion of the presentation was conducted by the use of a recorded track on film. Demonstrations were also made of sound quality and the wire recorder developed by the Armour Research Foundation was also shown and demonstrated.

The discussion period following presentation of the paper brought out many interesting points. About 300 members and guests attended the meeting, held in the *Salle Moderne* of the Hotel Pennsylvania, New York.

EDDY DESCRIBES OPERATION OF STATION WBKB

Capt. William C. Eddy, director of television station WBKB, Chicago, spoke on "Recent Developments in the Field of Television" at the January 9, 1947, meeting of the Midwest Section of the Society in Chicago. Capt. Eddy based much of his talk on material collected in the operation of station WBKB, stating that there are 853 sets in the telecast area of Chicago with average audiences of eleven persons per set (72 per cent of the sets are in private homes). During 1946 station WBKB was on the air 1088 hours, and a total of 77 motion picture films was shown in December 1946.

Coleman lanterns were used during the coal strike for street telecasts, although incandescent light is generally preferred. Other aspects of television operation were discussed including programming, relay systems, color, studio equipment, and audiences. A lively question period was enjoyed, with such subjects as screen brightness, resolution, screen life, and contrast control being discussed.

NOMINATIONS FOR ANNUAL ELECTIONS

A Committee on Nominations has been appointed by President Ryder, in accordance with By-Law VII of the Constitution and By-Laws, to recommend nominations for offices expiring December 31, 1947. General elections are held prior to the October convention; offices expiring and incumbents are given on the reverse of the contents page of this issue of the JOURNAL.

Voting members of the Society (Honorary, Fellow, and Active) are invited to submit recommendations for candidates to the Nominating Committee, sending names to the Chairman, E. A. Williford, 230 Park Ave., New York 17, N. Y., or to members of the committee as follows: Emery Huse, E. I. Sponable, H. W. Moyses, J. W. Boyle, E. W. Kellogg, K. F. Morgan, J. K. Hilliard, and M. G. Townsley, whose addresses are given in the last Membership Directory.

Only Honorary, Fellow, and Active members may hold office. A report of the Nominating Committee will be submitted to the Board of Governors at the July 1947 meeting.

FLASHTUBES FOR MOTION PICTURE PHOTOGRAPHY

The first meeting of the Pacific Coast Section of the Society in 1947 under W. V. Wolfe, chairman-elect, opened with a paper by F. E. Carlson on "Flashtubes, A Potential Illuminant for Motion Picture Photography," read by Ralph E. Farnham on January 17. The paper presented a preliminary appraisal of flashtubes from the point of view of motion picture studio photography. Such sources have been widely and successfully used for still photography for several years. In this field the short duration and high intensity of the flash, its color quality and high efficiency have been important factors in its favor. Most of these advantages, while equally important in the motion picture studio, cannot necessarily be realized to the same degree in this field.

There remain many problems in the use of flashtubes, the magnitude of which cannot be predicted at this time, and will undoubtedly require thorough analysis before a final evaluation is possible.

This paper will appear in the JOURNAL at an early date. Much interest was shown in the discussion period by the large group of Section members and guests present in the review room of Electrical Research Products Division of Western Electric, Hollywood.

Terry Ramsaye, Editor of the Motion Picture Herald, says...

¶ "The Technique of Motion Picture Production is the first unified presentation of modern technical practices in motion picture production . . . Compact and complete . . . In plain terms that any interested layman can understand. . .

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Indexes to the semiannual volumes of the JOURNAL are published in the June and December issues. The contents are also indexed in the *Industrial Arts Index* available in public libraries.

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No. 3

STATEMENT OF SMPE ON REVISED FREQUENCY ALLOCATIONS*

Ed. Note.—The Society of Motion Picture Engineers on Oct. 27, 1944, and on Mar. 2, 1945, through its representative, Paul J. Larsen, submitted recommendations for allocations of frequencies for a national theater television service. The Federal Communications Commission on May 25, 1945, granted such allocations of frequencies for a national theater television service on an experimental, "parity of opportunity" basis with television broadcasting.

On July 19, 1946, and Oct. 22, 1946, the FCC submitted a proposed revised frequency allocation for frequencies between 1000 and 13,000 megacycles, which eliminated allocation of frequencies for the service of theater television.

In view of this proposed revised frequency allocation, the SMPE, through its representative, Mr. Larsen, submitted opposition thereto on Feb. 4, 1947, which is presented here.

Mr. Chairman, Members of the Commission:

My name is Paul J. Larsen. I am a Radio Engineer, associated with the Johns Hopkins University and with the Bureau of Ordnance, U. S. Navy, in technical activities associated with the National defense of our country. I appear before the Commission today as the representative of the Society of Motion Picture Engineers, to present their opposition to the revised frequency allocations between 1000 and 13,000 megacycles to nongovernment fixed and mobile services as proposed by the Commission in their Public Notice Nos. 95700 and 99615, dated July 19, 1946, and October 22, 1946, respectively.

The Society of Motion Picture Engineers, through my representation, appeared before the Commission during the original hearings on recommendations for frequency allocations in this docket concerning request for frequency allocation requirements for a theater television service. The statement made by the Society of Motion Picture Engineers, presented on October 27, 1944, is on record as Federal Communications Commission Exhibit No. 431, and the statement

* Presented before the Federal Communications Commission (Docket No. 6651) by Paul J. Larsen, SMPE representative, on Feb. 4, 1947.

presented by the Society of Motion Picture Engineers on March 2, 1945, is on record as Federal Communications Commission Exhibit No. 598. Copies of these exhibits as reprinted from the JOURNAL of the Society of Motion Picture Engineers, Vol 44, Nos. 2 and 4, are attached hereto as Appendix B for reference purposes. [Exhibits not reprinted here.—*Ed.*]

The Society of Motion Picture Engineers is composed of engineers from every group interested and active in furthering the engineering perfection of Motion Pictures as presented to the public. This art of Motion Pictures encompasses all engineering phases relating to visual and oral presentations, whether on film or by other means, such as television. The engineers of any industry are the ones whom that industry relies upon to guide them in determining the technological developments which the industry must prepare itself for, to improve or to enlarge the scope of their product to the public.

The Motion Picture Industry of the United States of America is the largest of such industries in the world and one of the important industries in America. The American Motion Picture Industry has a responsibility far surpassing that of any other industry, because of the fact that that industry presents to the public through visual and oral means a flow of entertainment and news which can guide the educational, economic, and moral trends of the population. Motion pictures are well known to be the major means of entertainment and instruction to the public at large. They are brought into urban and rural areas, and motion pictures are a great factor in the advancement in understanding, education, and entertainment. Motion pictures, as the words imply, are a presentation of any picture in motion, whether such presentation is carried on a film or transmitted through radio waves to the ultimate viewer, the visual presentation is still a motion picture. The Motion Picture Industry, therefore, has a direct interest in television, as television is another medium for presenting to the public motion pictures for the same purpose; namely, advancement and understanding, education, and entertainment.

The Federal Communications Commission, during the earlier hearings in this docket, recognized the Society of Motion Picture Engineers' request for frequency allocations for a theater television service by allotting for this service certain bands of frequencies for experimental purposes. This grant by the Federal Communications Commission opened the door for the Motion Picture Industry in the postwar period to initiate experimentation in the field of theater

television on a parity basis with other services which were granted the same rights. The Commission did not allocate any of these frequencies to any specific service for three basic reasons, which are as follows:

(1) Inadequate data were available regarding propagation characteristics in these frequencies to determine their usefulness for the specific services requesting these frequencies.

(2) Very little information was available concerning equipment development in this frequency range, as most of the equipment developed was under military security, and the Federal Communications Commission therefore requested further information as to development and availability of equipment suitable for this frequency range.

(3) The need by the respective Services for the frequency allocations requested should be proved after practical experience under actual operating conditions.

The Society of Motion Picture Engineers has been extremely active in television, which covers broadly the two services in this field; namely, broadcasting to the public, and theater television. The Society of Motion Picture Engineers is a contributing sponsor to the Radio Technical Planning Board and has been active in all of the Radio Technical Planning Board's deliberations, having representatives on most of its panels. The two television committees of the Society of Motion Picture Engineers, the Television Engineering Committee and the Television Projection Practice Committee, have been active in all engineering phases of the television art.

The membership of these committees consists of most of the outstanding television engineers of the Industry, as well as members from producers and exhibiting companies of the Motion Picture Industry. An alphabetical list of the membership of these committees and an alphabetical list of the companies whom these members represent is attached as Appendix A. The engineering deliberations of the Television Projection Practice Committee of the Society of Motion Picture Engineers have been reported to all of the technical television committees of The Institute of Radio Engineers, the Radio Manufacturers Association, and the Radio Technical Planning Board. Many of the technical decisions made by these other engineering bodies have been based upon the work conducted by the Television Committees of the Society of Motion Picture Engineers. Reference to this engineering activity by the Society of Motion Picture Engineers Television Committees has been cited from time to time in hearings before the Federal Communications Commission in this docket and also in the present hearing on "Color Television" (Docket No. 7896).

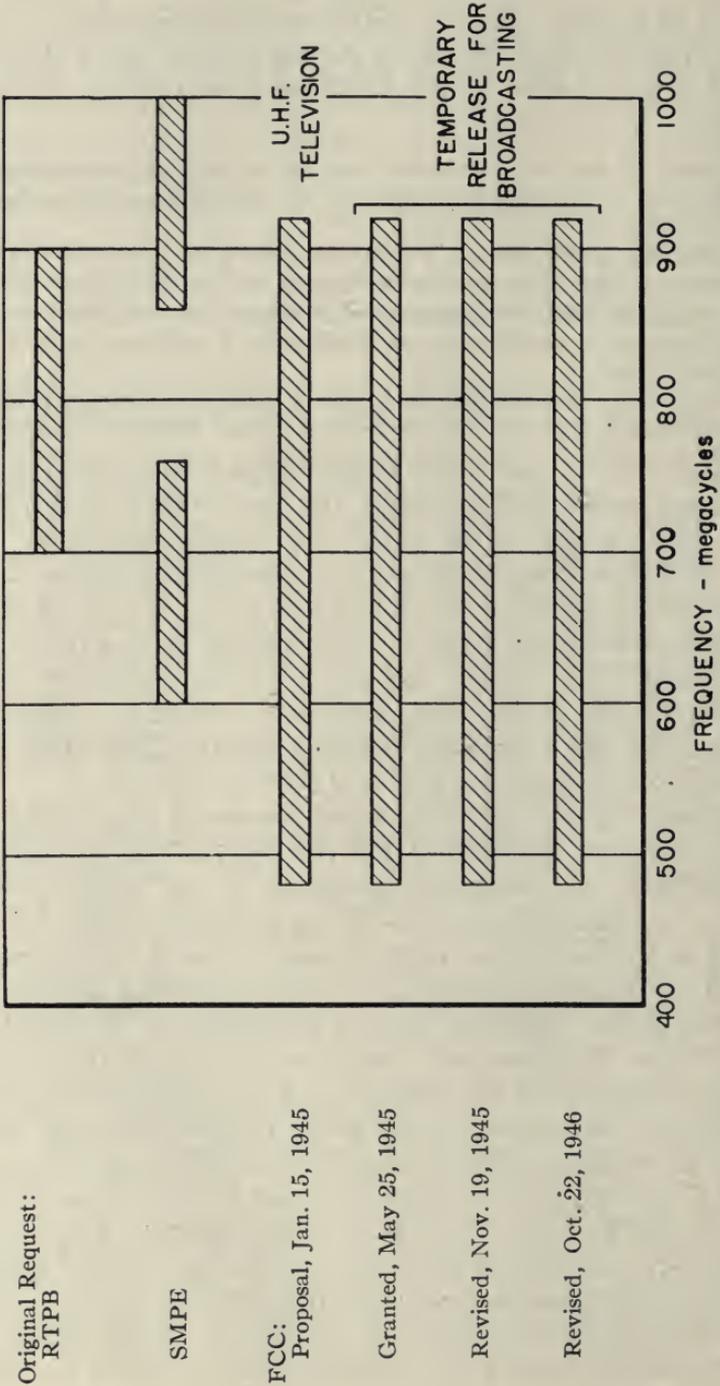


PLATE 1. Frequency service allocations (experimental). (Docket No. 6651.) Requests and allocations, 400-1000 mc band.

The allocation of frequencies by the Federal Communications Commission between 1000 and 13,000 megacycles to specific nongovernment fixed and mobile services, as proposed in Public Notice No. 99615, removes for experimental purposes all frequencies up to 13,000 megacycles. For purposes of comparing this proposed frequency allocation with (1) the allocation granted by the Federal Communications Commission in their report, dated May 25, 1945 (Public Notice

TABLE 1

ORIGINAL FREQUENCY ALLOCATIONS, MAY 25, 1945 (PUBLIC NOTICE 82387)
Between 1000 to 13,000 Megacycles

Services	Band 1000 to 5000 Mc		Band 5000 to 13,000 Mc		Band 1000 to 13,000 Mc	
	Mc	Per Cent	Mc	Per Cent	Mc	Per Cent
Total Band	4000	100	8000	100	12,000	100
Government	1025	25.63	2950	36.9	3,975	33.13
Amateur	250	6.25	900	11.25	1,150	9.58
Aviation, Navigation, <i>etc.</i>	550	13.75	250	3.13	800	6.67
Navigation Aids	945	23.62			945	7.88
Not Assigned						
Television Relay	8.0	2.0			8.0	0.66
Television STL						
Television Pickup						
Mobile General						
Fixed Circuits						
Common Carrier						
Nongovt.						
Experimental	1150	28.75	3900	48.72	5,050	42.08

The "Nongovernmental Experimental" frequency allocation above was made available to all nongovernmental services for experimental purposes until such time that a showing of need for definite assignment of specific frequencies in bands of frequencies above 1000 megacycles can be established. Such need to be based upon (1) practical experience under actual operating conditions; (2) further data regarding propagation characteristics; and (3) further information concerning equipment development.

No. 82387), and (2) the original requests made by the different services and the Radio Technical Planning Board during the original hearings in this docket, the following tables are submitted:

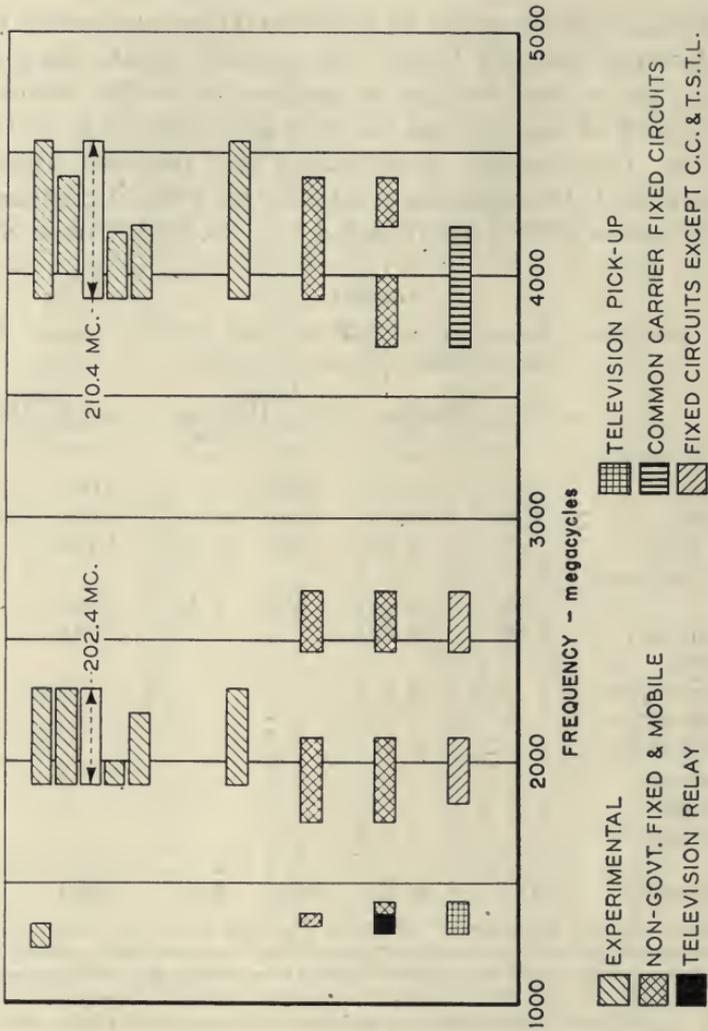
Table 1—Original Allocations May 25, 1945 (Public Notice No. 82387).

Table 2—Original Requests by different nongovernment services.

Table 3—Original Requests classified as to basic type of facility.

Table 4—Original Requests by Society of Motion Picture Engineers and Common Carriers and Allocations for Experimentation.

Table 5—Proposed Allocations classified as to basic type of facility.



Original Request:
 RTPB
 AT&T
 WU
 RAYTHEON
 SMPE

FCC:
 Proposal, Jan. 15, 1945
 Granted, May 25, 1945
 Revised, Nov. 19, 1945
 Revised, Oct. 22, 1946

PLATE 2. Frequency service allocations. (Docket No. 6651.) Requests and allocations, 1000-5000 mc band.

TABLE 2

ORIGINAL REQUESTS BY DIFFERENT NONGOVERNMENT SERVICES AND RADIO
TECHNICAL PLANNING BOARD*Between 1000 to 13,000 Megacycles*EXCLUDING AMATEUR, AVIATION, NAVIGATION, ETC. FROM "REPORT OF
PROPOSED ALLOCATIONS" DATED JANUARY 15, 1945

Item	Panel	Service	Band 1000 to 5000 Mc Mc	Band 5000 to 13,000 Mc Mc	Band 1000 to 13,000 Mc Mc
1	8	Fixed Circuits Remote Control	100		100
2	8	Fixed Circuits Short Toll		150	150
3	4	Broadcast Pickup	100 ^a		100 ^f
4	4	Broadcast S.T.L.	9.6 ^b	16 ^d	15.6 ^f
5	6	Television Relay	400 ^b		400 ^f
6	13	Police	100	200	300
7	13	Forestry	5	2	7
8	13	Forestry and Conserva- tion	1	2	3
9	13	Railroad Relay, etc.	190		190
10	13	General Mobile Bus	15		15
11	13	General Mobile Truck	10		10
12	8	Rural Telephone		160	160
13	9	Relay-Portable and Mobile	100 ^a		100 ^f
14	9	Relay-General	850 ^b		850 ^f
15	9	Relay-Intercity Tele- vision	100 ^c		100 ^f
16	9	Relay-Exp. Intercity Television		400 ^e	400 ^f
17	9	Relay-Exp. Nonexclu- sive		2650 ^d	2650 ^f
18	9	SMPE	600 ^{b, c}	600 ^{d, e}	1200 ^f
19	9	AT&T	800 ^b	1000 ^d	1800 ^f
20	9	Western Union	413.6 ^b	465.6 ^d	879.2 ^f
21	9	Raytheon	392 ^b	262 ^d	634 ^f
Total Requests			1471	3564	5035

^a Request Item 3 included in request of Item 13.^b Requests Items 4, 5, 18, 19, 20, and 21 included in request of Item 14.^c Request for 100 megacycles in Item 18 included in request of Item 15.^d Requests Items 4, 18, 19, 20, and 21 included in request of Item 17.^e Request for 400 megacycles in Item 18 included in request of Item 17.^f Requests Items 3, 4, 5, 18, 19, 20, and 21, totaling 5028.8 megacycles, included in Requests Items 13, 14, 15, 16, and 17 totaling 4100 megacycles.

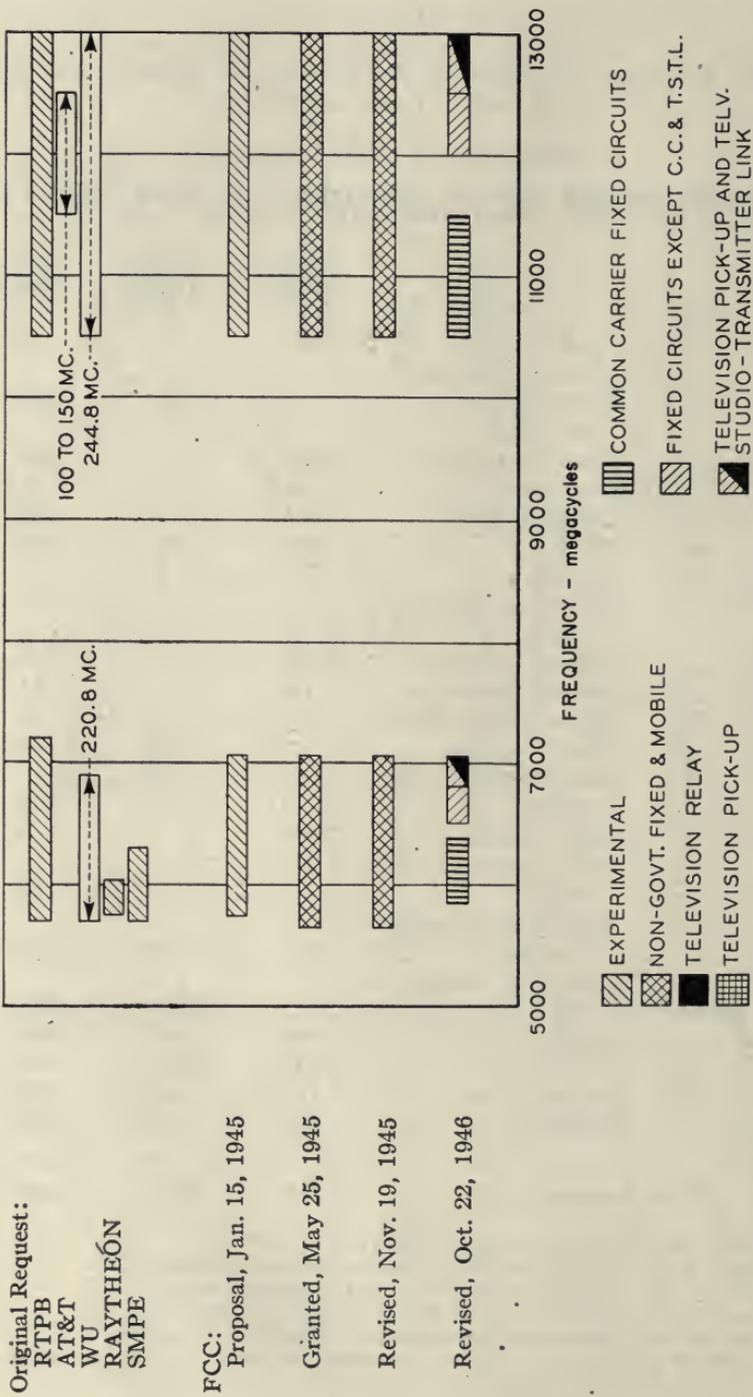


PLATE 3. Frequency service allocations. (Docket No. 6651.) Requests and allocations, 5000-13,000 mc band.

These tables list the requests, original allocations, and proposed allocations by frequencies for the different services, and the percentage that these frequency or allocation requests represents to the total frequency bandwidth.

To assist in further study of the proposed allocations with those formerly granted on an experimental basis, three charts are attached hereto as follows:

Plate 1.—Frequency Service Allocations, Frequency Band 400 to 1000 megacycles.

Plate 2.—Frequency Service Allocations, Frequency Band 1000 to 5000 megacycles.

Plate 3.—Frequency Service Allocations, Frequency Band 5000 to 13,000 megacycles.

TABLE 3

ORIGINAL NONGOVERNMENTAL SERVICE REQUESTS TABLE 2 CLASSIFIED ACCORDING TO THE FOUR BASIC TYPES OF FACILITIES OUTLINED IN PUBLIC NOTICE 99615, DATED OCTOBER 22, 1946

Between 1000 to 13,000 Megacycles

Items	Service	Band 1000 to 5000 Mc		Band 5000 to 13,000 Mc		Band 1000 to 13,000 Mc	
		Mc	Per Cent	Mc	Per Cent	Mc	Per Cent
	Total Band	4000	100	8000	100	12,000	100
14	Broadcast—STL	109.6	2.75	16	0.2	125.6	1.05
13	Broadcast Pickup						
10-11	Mobile General	25	0.62			25	0.2
1-2-6-							
7-8-							
9-12	Fixed Circuits	396	9.9	514	6.4	910	7.6
14-15-							
16-17	Common Carrier ^a	940.4	235.1	3034	37.9	3974.4	33.1

^a Includes request of SMPE, on basis that request of SMPE for frequencies for a Theater Television Service is considered Common Carrier because of its private nature not open to public correspondence.

It will be noted from the above five tables and the attached plates that all nongovernmental experimental bandwidths according to the Federal Communications Commission's proposal of October 22, 1946 (Public Notice No. 99615), have been allocated to specific services, leaving no bands available for experimentation for new services.

The Society of Motion Picture Engineers, representing all of the engineers of the Motion Picture Industry, strongly oppose this

proposal by the Federal Communications Commission, as the allocations are not in the best public interest, and are contrary to the general principles the Commission employed in making the original allocations; and further, to the best knowledge of the Society of Motion Picture Engineers, no need for this allocation at this time has been shown by any of the services to whom the Commission is allocating these frequencies. Referring to Table 3, it will be noted that the service "Mobile General" originally requested only 25 megacycles

TABLE 4

ORIGINAL REQUESTS BY SMPE AND COMMON CARRIERS FOR RELAY *Etc.*, SERVICES AND ALLOCATIONS FOR EXPERIMENTATION MAY 25, 1945, PUBLIC NOTICE 82387

Between 1000 to 13,000 Megacycles

Services	Band 1000 to 5000 Mc		Band 5000 to 13,000 Mc		Band 1000 to 13,000 Mc	
	Mc	Per Cent	Mc	Per Cent	Mc	Per Cent
SMPE Request	600	15	600	7.5	1200	10.00
W.U. Request	413.6	10.34	465.6	5.82	879.2	7.5
Raytheon Request	372	9.3	262	3.27	634	5.28
AT&T Request	800	20.0	1000 ^b	12.5	1800 ^b	15.0
RTPB Recommendation	1150	28.75	3950	48.8	5100	42.5
FCC Allocation	1150 ^a	28.75	3900 ^a	48.75	5050 ^a	42.08

^a Experimental operation with intra- and intercity relay of theater television, including multiple address purposes permitted in following bands: 1325-1375¹, 1750-2100, 2450-2700, 3900-4400², 5650-7050, 10,500-13,000, 16,000-18,000, and 26,000-30,000 megacycles.

¹ Revised November 19, 1945, Public Notice No. 86131 to band 1375-1425.

² Revised November 19, 1945, Public Notice No. 86131 to bands 3700-4000 and 420-4400.

^b Original request by AT&T was ? channels ? wide in band 11,500-12,500 megacycles.

for experimental purposes in the band from 1000 to 13,000 megacycles, whereas in the proposed allocation the Federal Communications Commission is allocating 925 megacycles to that service in this same band. The service "Fixed Circuits" originally requested only 910 megacycles in the band of 1000 to 13,000 megacycles; whereas the proposal allocates 1525 megacycles in this band to this service. The services "Television, Studio Transmitter Links (STL) and Pickup" originally requested only 125.6 megacycles in the band of 1000 to 13,000 megacycles; whereas the proposal allocates 880 megacycles in this band for these services.

From Tables 2 and 3 it will be noted that all nongovernment services requested a total of 5035 megacycles in the band between 1000 to 13,000 megacycles. This request was determined after joint

conference between Panels 2, 4, 5, 6, and 9 of the Radio Technical Planning Board on November 1, 1944, during the original hearings before the Commission in this docket. The Radio Technical Planning Board Panel 2 submitted recommendation for 5100 megacycles

TABLE 5

PROPOSED FREQUENCY ALLOCATIONS OCTOBER 22, 1946 (PUBLIC NOTICE NO. 99615)

Between 1000 to 13,000 Megacycles

(CLASSIFIED ACCORDING TO BASIC TYPE OF FACILITY)

Services	Band 1000 to 5000 Mc		Band 5000 to 13,000 Mc		Band 1000 to 13,000 Mc	
	Mc	Per Cent	Mc	Per Cent	Mc	Per Cent
Total Band	4000	100	8000	100	12,000	100
Government	975	24.4	2650	33.1	3,625	33.21
Amateur	230	5.7	900	11.25	1,130	9.42
Aviation—Navigation						
Meteorological	350	8.75	250	3.13	600	5.0
Navigation Aids	815	20.4	300	3.76	1,150	9.3
Not assigned 5650 to 5850 mc			200	2.5	200	1.66
Television Relay						
Television STL			750 ^a	9.38	880 ^d	7.33
Television Pickup	130	3.25				
Mobile General	275 ^d	6.9	650 ^a	8.13	925 ^a	7.71
Fixed Circuits	725 ^b	18.1	800 ^b	10.0	1,525 ^b	12.71
Common Carrier	500 ^c	12.5	1500 ^c	18.75	2,000 ^c	16.66
Nongovt. Experimental	0	0	0	0	0	0

^a *Mobile except Television Pickup* which denotes all types of mobile operations except for television pickup ... etc.

^b *Fixed Circuits except Common Carrier and Television STL* which includes fixed control circuits (including those controlling fixed public service circuits) and radio-relay systems not open to public correspondence which are operated by and for the sole use of agencies exclusively in the safety and emergency services such as police, aviation, railroad, petroleum, and others.

^c *Common Carrier Fixed Circuits* which include not only those communications common carriers furnishing message service to the general public, but also those rendering communications service to a limited class of users.

^d *Television Pickups and Television Studio Transmitter Links (STL)* which are radio facilities where wire service is not economically practicable and will be licensed only to licensees of television broadcast stations and to common carriers.

(Table 4) and the Commission in their report dated May 25, 1945 (Public Notice No. 82387), allocated 5050 megacycles on an experimental basis for "nongovernment fixed and mobile service" (see Table 4 and Plates 2 and 3) in the band of 1000 to 13,000 megacycles.

From Table 3 it will be noted that, after deducting 1060.6 megacycles for other services, 3974.4 megacycles of the 5035 megacycles requested in Table 2, based upon classification in Public Notice No. 99615, remains for "Common Carrier" service which includes the Society's request for Theater Television. From this total 400 megacycles should be deducted for the service "Television Relay" requested by Panel 6 (Item 5, Table 2), for Television STL and Pickup, leaving 3574.4 megacycles for the Society of Motion Picture Engineers, Western Union, Raytheon, and American Telephone and Telegraph requests totaling 4513.2 megacycles (Table 4 and Plates 2 and 3): On a percentage basis based upon the original requests of these organizations, frequency allocations to these organizations on a parity basis if public need can be proved would be as follows:

Organization	Original Requests, Mc.	Per Cent	Allocation Based on Only 3574.4 Megacycles Being Available, Mc.
SMPE	1200	26.6	950.8
WU	879.2	19.5	697
Raytheon	634	14	500.4
AT&T	1800	39.9	1426.2
Total	4513.2	100	3574.4

The proposed allocation of *only* 2000 megacycles to the service "Common Carrier" in the band of 1000 to 13,000 megacycles does not seem adequate on this basis of computation, and seems to limit this service in view of proposed excessive proposed allocations to other services beyond their original requests.

The opposition by the Society of Motion Picture Engineers to the proposed allocation is mainly based upon their not having knowledge as to the type of radio facility the Federal Communications Commission considers theater television. In the original request by the Society of Motion Picture Engineers, Federal Communications Commission Exhibit 431, the Society directed the attention of the Federal Communications Commission to the fact that *theater television involves communications of a private nature*, and therefore such service should be accordingly classified to differentiate it from standard television broadcasting. It is the Society's opinion that theater television should be classified under the following two basic types of facilities referred to in Public Notice No. 99615, namely:

- (1) Common Carrier Fixed Circuit, and
- (2) Fixed Circuits except Common Carrier and Television Studio Transmitter Links.

Theater television is a communication which renders a service to a limited class of users and therefore comes under the definition of a "Common Carrier". The definition that the Commission has made for the second class of service, "Fixed Circuits except Common Carrier and Television Studio Transmitter Links", namely, that "radio-relay systems not open to public correspondence which are operated by and for the sole use of agencies operating exclusively in the safety and emergency services, such as police, aviation, railway, petroleum, and others", is excepted to, in view of the proposed allocation. The Society objects to the proposed allocation of 1525 megacycles to the service "Fixed Circuits" in the band 1000 to 13,000 megacycles, in view of this service having only requested 910 megacycles, and further because of the fact that, to the best knowledge of the Society of Motion Picture Engineers, no need for any definite assignment to this service for even their original request exists at this time.

The Society of Motion Picture Engineers also takes exception to the statement in Public Notice No. 99615 that, "*Television Pickup and Television STL stations will be licensed only to licensees of television broadcast stations and to common carriers*", unless the Commission definitely classifies theater television service as a "Common Carrier" service.

The Society of Motion Picture Engineers also strenuously opposes the following statement by the Commission in Public Notice No. 99615:

"...since the Commission believes that there is not sufficient spectrum space available in the nongovernment fixed and mobile bands between 1000 to 13,000 megacycles to accommodate an inter-city television relay service and at the same time provide adequate space for other nongovernment fixed and mobile services with a requirement for frequency in this range, no provision for such a service has been incorporated in this proposal..."

This opposition is made by the Society of Motion Picture Engineers as the statement would imply that no intercity television relay service of any kind for either television broadcasting or theater television can be established in any frequency band between 1000 to 13,000 megacycles. Does this statement imply that no *television relay networks* for coast-to-coast programming for either television broadcasting purposes or theater television purposes can be established, and that such

programming on a national scale must be limited to coaxial cable or wave guide circuits which are technically limited and controlled by a single organization? If such is the case, the proposed allocation for the service "Common Carrier" of 2000 megacycles does not seem to be supported by requirements of that service.

The Commission also states in their proposal, "that allocations for Television Pickup and Television STL services are radio facilities. . . *which are used where wire service is not economically practicable.*" Although there are no basic radio services, except ship-to-shore, automobile and airplane service which cannot be accomplished by other means than radio, radio has gained its position in the field of communications because it has given more immediate and better service at lower cost. Existing services have been encouraged, guided, and protected during their development and commercialization. Some of these services might never have existed had allocations and legislation blocked the road to their development and success. The new services, including theater television, should be encouraged and protected during their development and ultimate commercialization; and, therefore, no limitations during these periods should be placed upon them.

The Society of Motion Picture Engineers has assumed that the Commission's proposed allocation is undoubtedly made at this time on the basis that multiple use of channels may better meet such congestion as may arise in the future in this band of 1000 to 13,000 megacycles. This multiple use of channels may be correct thinking today if television, whether for broadcasting or for theater use, is only to be transmitted a few hours a day. However, it can be assumed that, if television for broadcasting and for theater use is to be commercialized to the same extent as present sound broadcasting, such service must be available on a twenty-four hour basis to meet a National Service. Theater television to evolve into an economically sound business must be very extensive, necessitating nation-wide distribution. Sound broadcasting would never have been an economically sound business unless it had this extensive nation-wide service.

Motion pictures using films would never have been an economically sound business unless it had its nation-wide distribution to the theaters. Television Broadcasting will never be an economically sound business unless it has nation-wide distribution. Theater television will undoubtedly require circuits which will be special in nature and much time will be lost in gaining co-ordination between a common carrier,

who has other services to supply, and a client such as the Motion Picture Industry, that cannot make a profit unless it can gain wide utilization. Allocating the frequencies at this time to specific services, before such services have shown an actual need, seems in error and prejudicial to the best interest of the American people. Technological progress should not be stifled and this generation should not be deprived of a service such as theater television or television broadcasting to which they are entitled.

The Motion Picture Industry has been very active in the field of television. Many companies have established separate divisions to delve into the technical problems, and other divisions to assist television broadcasters in the employment of film for television use. The Commission may question whether or not the Motion Picture Industry, up to this time, has taken advantage of the experimentation offered to them in the radio spectrum for this field. It is true that no member of the Motion Picture Industry has applied for licenses to experiment with transmission of television programs from point to point, or with intermediate links. The Industry, however, has been active in engineering considerations of the problems that confront them.

During the past year, industrial readjustments have been necessary which have affected not only the Motion Picture Industry but every other industry which has been before the Commission. Equipment developments by the electronic manufacturers have not progressed sufficiently to provide microwave relaying for this service. The terminating equipment at the theater has been under development for many years, by members of the Motion Picture Industry and by radio manufacturers; and until such terminating equipment is available embodying all of the technical requirements and capable of producing the brightness necessary to present a television picture on a large screen in a Motion Picture Theater, no need for the radio facilities arises. It would be surprising, indeed, if the Motion Picture Industry were able, in this short time, to tie together with terminating equipment all of the practical equipment for the accomplishment of a microwave relaying television service, when the simpler and less exacting service of television broadcasting is still in its earlier stages of development and commercialization.

Motion pictures are this nation's "number one" form of entertainment and relaxation. It is a service important to the happiness, the well-being, and the health of our people. It should not be deprived

of the opportunity of improving that service to the people through the greater use of technical developments in electronics and the peacetime utilization of developments and applications still to be conceived. The public is concerned with what goes into the electronic input equipment and what comes out at the receiver, whether that be television broadcasting or theater television. This is a field in which the Motion Picture Industry has spent millions and as of this date is spending more millions in a sincere effort to gain the desired form of visual expression through the avenues of television.

One of the general principles that the Commission followed in making the original allocations was its concern over the total number of people who would receive benefits from the particular service, and where other factors were equal, the Commission attempted to meet the requests of those services which proposed to render benefits to large groups of the population, rather than of those services which aid relatively small groups. This principle is one that the Society of Motion Picture Engineers stressed at its original presentation. It will be found that only the telephone and sound broadcasting serve the equivalent of more than the 90 million people who attend the motion picture theaters every week. On this fact alone, theater television should have the same parity of right for frequency allocations as television broadcasting.

Another principle that the Commission followed in the original allocations was to determine whether such newer services met a substantial public need; and if frequencies are granted, that the service could be established on a practical working basis. The Society of Motion Picture Engineers concurs in this principle, and for that reason opposes the allocation or "freezing" of frequencies in the band 1000 to 13,000 megacycles to any service at this time, as it does not believe that any of the services to date have proved that they could be established on a practicable working basis and that these services meet a public need.

Another principle that the Commission followed in considering the proper place in the spectrum for the services in question was the inadequate information on radio-wave propagation characteristics of the various portions of the spectrum. The Society of Motion Picture Engineers is of the opinion that information as to the propagation characteristics of frequencies within the band of 1000 to 13,000 megacycles is still inadequate to determine definitely the proper place in the spectrum for the respective services.

The frequency band under consideration, 1000 to 13,000 megacycles, is 12,000 megacycles wide, which is 12 times larger than the 0-to-1000 megacycle band, which prior to World War II carried all radio transmissions of every description throughout the world. The frequency range under consideration is almost entirely line-of-sight and transmission, therefore, can be very directional, thus making it possible for many services to use the same frequencies within the same line-of-sight areas and to repeat over and over again the use at these same frequencies in areas beyond line-of-sight interference.

The inadequate experience under actual operating conditions and limited equipment development in this band of 1000 to 13,000 megacycles to date should leave the door open for continued experimentation to all services and not limited to a few. Freezing of this band at this time to the services indicated in the proposal will discourage and/or stop research or development which potentially can make this band of much greater use and value. Retaining this band for experimental purposes may prove that the bandwidth is adequate for all services without congestion when considering the propagation characteristics and directional capability of transmission at these frequencies.

The Society of Motion Picture Engineers respectfully submits to the Federal Communications Commission the following recommendations:

- (1) Classify, under a basic radio facility, a theater television service which involves communications of a private nature.
- (2) Retain present nongovernment fixed and mobile experimental bands in the frequency spectrum between 1000 and 13,000 megacycles on same basis of experimental authorization to all services as allocated in the "Report of Allocations from 25,000 kilocycles to 30 million kilocycles", dated May 25, 1945 (Public Notice No. 82387), and as modified by Public Notice No. 86131, dated November 19, 1945.

The Society of Motion Picture Engineers, on behalf of the Engineers of the Motion Picture Industry, respectfully requests the Federal Communications Commission to grant the above recommendations so as to permit the American Motion Picture Industry to experiment for the purpose of initiating theater television and to assist it to maintain its world leadership in the visual and oral entertainment field.

Appendix A

MEMBERSHIP ON THE TELEVISION COMMITTEES OF THE SOCIETY OF MOTION PICTURE ENGINEERS

Name	Affiliation	Television Projection Practice Committee	Television Engineering Committee
D. R. WHITE	E. I. du Pont de Nemours & Co., Inc.	M	Chairman
P. J. LARSEN	Johns Hopkins Univ. & U. S. Navy	Chair- man	M
F. G. ALBIN	RCA Victor Division	A	..
H. ANDERSON	Paramount Pictures, Inc.	M	..
R. B. AUSTRIAN	RKO Television Corp.	M	..
M. W. BALDWIN, JR.	Bell Telephone Labs., Inc.	X	..
H. BARNETT	International Projector Corp.	M	..
M. C. BATSEL	RCA, Camden, N. J.	M	..
G. L. BEERS	RCA, Camden, N. J.	M	M
M. F. BENNETT	RCA Victor Division, New York	A	..
T. S. BILLS	Pathe News, Inc.	M	..
F. T. BOWDITCH	National Carbon Co.	..	M
H. E. BRAGG	Fox Movietone News, Inc.	A	..
F. E. CAHILL, JR.	Warner Bros. Pictures, Inc.	M	M
F. E. CARLSON	General Electric Co.	M	..
A. W. COOK	AnSCO	..	M
E. D. COOK	General Electric Co.	..	M
L. W. DAVEE	Century Projector Corp.	M	..
C. E. DEAN	Hazeltine Electronic Corp.	..	M
J. EBERSON	J. & D. Eberson, Architects	M	..
D. W. EPSTEIN	RCA Laboratories, Inc.	X	..
B. ERDE	Columbia Broadcasting Co.	..	M
R. FELDT	A. B. DuMont Labs., Inc.	A	..
J. FRANK, JR.	National Theatre Supply Co.	M	..
P. M. GARRETT	General Electric Co.	A	..
E. P. GENNOCK	Television Productions, Inc.	M	..
N. GLYPTIS	Sperry Gyroscope Co., Inc.	M	..
F. P. GOLDBACH	International Projector Corp.	A	..
P. C. GOLDMARK	Columbia Broadcasting Co.	M	M
A. N. GOLDSMITH	Consultant	M	M
T. T. GOLDSMITH	A. B. DuMont Labs., Inc.	M	M
E. D. GOODALE	National Broadcasting Co.	A	..
R. E. GRAHAM	Bell Telephone Labs., Inc.	X	..
H. GRIFFIN	International Projector Corp.	..	M
W. HERRIOTT	Bell Telephone Labs., Inc.	X	..
C. F. HORSTMAN	RKO Service Corp.	A	M
D. E. HYNDMAN	Eastman Kodak Co.	A	..
L. B. ISAAC	Loews, Inc.	M	M
A. G. JENSEN	Bell Telephone Labs., Inc.	M	M
H. E. KALLMAN	Consultant	M	..
R. KINGS LAKE	Eastman Kodak Co.	X	..

Name	Affiliation	Television Projection Practice Committee	Television Engineering Committee
J. J. KOHLER	Projectionist, Local 306	M	..
C. C. LARSON	Farnsworth Telev. & Radio Corp.	..	M
N. LEVINSON	Warner Bros. Pictures, Inc.	..	M
J. LIVADARY	Research Council, A.M.P.A.S.	..	M
G. T. LORANCE	General Precision Labs., Inc.	A	..
W. W. LOZIER	National Carbon Co.	M	..
H. B. LUBCKE	Don-Lee Broadcasting Co.	..	M
J. A. MAURER	SMPE (Engineering Vice-Pres.)	Y	..
PIERRE MERTZ	Bell Telephone Labs., Inc.	M	M
W. C. MILLER	Metro-Goldwyn Mayer, Inc.	..	M
E. R. MORIN	State of Conn., Dept. of Police	M	..
B. NEMEC	SMPE (Engineering Secretary)	Y	..
M. E. O'BRIEN	Loews, Inc.	A	..
J. POPPELE	Mutual Broadcasting Co.	..	M
P. RAIBOURN	Paramount Pictures, Inc.	A	M
W. B. RAYTON	Bausch & Lomb Optical Co.	X	..
A. J. RICHARD	Television Production, Inc.	A	..
P. D. RIES	National Carbon Co.	A	..
A. H. ROSENTHAL	Scophony, Inc.	M	..
H. RUBIN	Paramount Pictures, Inc.	M	..
O. SANDVIK	Eastman Kodak Co.	..	M
G. E. SAWYER	Research Council, A.M.P.A.S.	..	M
B. SCHLANGER	B. Schlanger, Architect	M	..
R. E. SHELBY	Natl. Broadcasting Co.	M	M
H. SMITH, JR.	SMPE (Executive Secretary)	Y	..
E. I. SPONABLE	Twentieth Century-Fox Film Corp.	M	M
C. S. SZEGHO	Rauland Corp.	M	..
G. R. TINGLEY	Columbia Broadcasting Co.	A	..
V. A. WELMAN	I.A.T.S.E., Cleveland, Ohio	M	..
H. E. WHITE	Eastman Kodak Co.	M	M
R. S. YEANDLE	General Electric Co.	M	..

M—Member
A—Alternate
X—Consultant
Y—Ex-Officio Member

**COMPANIES REPRESENTED BY MEMBERSHIP OF TELEVISION COMMITTEES OF
THE SOCIETY OF MOTION PICTURE ENGINEERS**

Anso Division, General Aniline and Film Corp.
Bausch and Lomb Optical Co.
Bell Telephone Laboratories, Inc.
Century Projector Corp.
Columbia Broadcasting Co.
Don-Lee Broadcasting Co.
A. B. DuMont Laboratories, Inc.
E. I. du Pont de Nemours & Co., Inc.

Eastman Kodak Co.
J. & D. Ebersson—Architects
Farnsworth Telev. & Radio Corp.
General Electric Co.
General Precision Labs., Inc.
Alfred N. Goldsmith, Consultant
Hazeltine Electronics Corp.
International Projector Corp.
I.A.T.S.E. (Cleveland)
Johns Hopkins University
H. E. Kallman, Consultant
Loews, Inc.
Metro-Goldwyn Mayer, Inc.
Mutual Broadcasting Co.
National Broadcasting Co.
National Carbon Co.
National Theatre Supply Co.
Paramount Pictures, Inc.
Pathe News, Inc.
Projectionist, Local 306
Radio Corporation of America
RCA Laboratories, Inc.
Rauland Corp.
Research Council, Academy of Motion Picture Arts and Sciences
RKO Service Corp.
RKO Television Corp.
B. Schlanger, Architect
Scophony, Inc.
Sperry Gyroscope Co., Inc.
State of Conn., Dept. of Police
Television Productions, Inc.
Twentieth Century-Fox Film Corp.
Warner Bros. Pictures, Inc.

REPORT OF THE GENERAL SECRETARY*

JANUARY 1, 1946, TO DECEMBER 31, 1946

INCREASE IN MEMBERSHIP

Increased interest in the work of the Society is shown by the large increase in membership during the year. The net increase for the year for all grades is 466, which is the largest increase in the history of the Society. Total membership now stands at 2432, which includes 6 Honorary, 64 Sustaining, 154 Fellow, 561 Active, 1588 Associate, and 59 Student Members.

INCREASE IN FINANCIAL SUPPORT

Through the efforts of the President, D. E. Hyndman, the financial support provided by Sustaining Members has been more than doubled. From a total of \$8087.50 received from this source in 1945, the receipts rose to \$20,250 in 1946. This increase is the result of both larger subscriptions from previous Sustaining Members and a considerable increase in the number of such members. Notable among the new Sustaining Members is the Motion Picture Association of America.

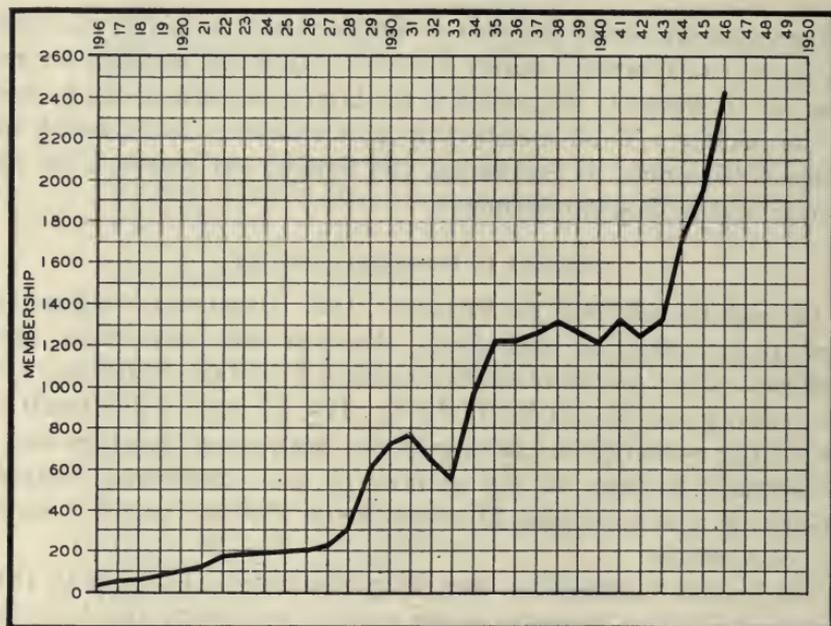
The Society membership dues have also increased income in 1946 by about \$2750. However, rising costs of publishing the JOURNAL and increased expense in maintaining the larger office staff required to handle expanded membership and committee activities have more than used up all this increased income, so it has been necessary to raise the annual dues of Associate and Student Members to \$10 and \$5, respectively. Dues of Active Members and Fellows were not increased, since it was felt by the Board of Governors that the dues of these grades had been increased proportionately more than the other grades at the last change. Sales of test films continued to be considerable, although not so great as in the previous year. A settlement was made with the supplier, J. A. Maurer, Inc., whereby the special equipment used in making these test films becomes the

* Submitted Feb. 4, 1947.

property of the Society. Total income from all sources exceeded the total expenses by over \$3000.

RE-ESTABLISHMENT OF MIDWEST SECTION

An active Midwest Section has been organized in Chicago, after a period of three years in which the Section was discontinued. Under the leadership of A. Shapiro, Chairman, and R. E. Lewis, Secretary-Treasurer, the Section has held nine meetings since its organization



Membership Growth of the Society.

in March. Meetings are ordinarily held in the rooms of the Western Society of Engineers, and frequently are attended by a capacity audience. The Section is now actively working on arrangements for the Spring Convention to be held in Chicago, April 21-25, 1947.

INCREASE IN OFFICE STAFF

In order to handle the very large increase in Society business, it has been necessary to increase the General Office staff as follows: Boyce Nemec has been appointed Engineering Secretary to assist the various engineering committees, and provide technical advice on questions arising in office correspondence. Miss Silvyva Roth has been engaged

for general secretarial work and stenotype service. Mrs. Winifred Carrière has been engaged as part-time editorial assistant. These additions to the staff have helped, but have not entirely relieved the overload of work at the General Office. The office space, previously crowded, is now seriously overcrowded, but so far it has not been possible to obtain larger quarters. The many details involved in the sale of test films and American Standards have added to the work which had already increased owing to larger membership. Every effort is being made to overcome the handicap of insufficient space and secretarial assistance but, in the meantime, members are asked to be patient when the JOURNAL does not arrive on time or correspondence is delayed.

INCREASE IN COMMITTEE ACTIVITY

The past year has been one of unusual activity for most of the engineering committees but particularly for the Standards Committee. Under the chairmanship of F. T. Bowditch, the Standards Committee has had under consideration 22 standards referred to it for revision by the American Standards Association Sectional Committee on Motion Pictures, Z22. Among these a number, such as the standards on 8- and 16-mm sprockets, were completely revised so that the data could be presented in more useful form. New standards for 8- and 16-mm film splices have been proposed and published. A considerable amount of work was done on a revision of the pitch diameter of 35-mm sprockets. Edge numbering, 16-mm apertures, cutting and perforating standards, and photographic density have also received considerable attention. Recommended revisions for five standards have been referred to the Z22 Committee. A report of this committee is given on page 110 of the August 1946 issue of the JOURNAL.

The Committee on Television Projection Practice under the chairmanship of P. J. Larsen was organized in 1945 for the purpose of making recommendations on the design, construction, installation, maintenance, and operation of equipment for projection of television pictures in theaters. Three Task Groups were formed to gather information on (a) engineering details of television projection equipment; (b) dimensions and other data on theater auditoriums, stages, and projection booths; (c) projection television picture quality; and a fourth is planned to work on distribution and commercial problems. Preliminary reports of the first three of these groups have been of considerable use to the Radio Technical Planning Board, and the IRE

and RMA Television Committees, and will be published in an early issue of the JOURNAL.

The Committee on 16-Mm and 8-Mm Motion Pictures is working on a comprehensive report which is expected to take the form of recommendations on the use of 16-mm motion picture equipment in educational and industrial fields. This will replace the "Report of the Committee on Nontheatrical Equipment", issued in 1941, the distribution of which has reached over 1000 copies.

The Committee on Studio Lighting issued a report giving considerable data on the light intensity and distribution for seven types of lighting units commonly used in motion picture studios. This report, published in the August 1946 issue of the JOURNAL, also gives data on key-light levels for black-and-white and for color cinematography.

PRESERVATION OF FILM

The Committee on Preservation of Film, under the chairmanship of J. G. Bradley, is considering the expanding problem of film preservation caused by the vast quantities of film exposed for military purposes during the war, estimated at possibly 300,000 reels. Proposals are being considered for revised recommendations on the construction of film vaults. Also under discussion are storage containers and cores, more permanent film base materials, and processing technique for permanent record films.

THEATER ENGINEERING

Under the chairmanship of Henry Anderson, the Committee on Theater Engineering, Construction, and Operation is preparing a comprehensive report on the selection, installation, and care of carpets. Also in preparation are reports on electric heaters for projection booths, and gas or gasoline generators for emergency theater lighting.

PRODUCTION AND DISTRIBUTION OF TEST FILMS

An important development in 1946 was the establishment of a Joint Committee on Test Films, with the following members from the Society and from the Research Council of the Academy of Motion Picture Arts and Sciences: Merle Chamberlin and L. T. Goldsmith representing the Research Council, and J. G. Frayne and J. A. Maurer representing the Society. This committee is to make recommendations on the types of test films needed and the organization best suited

for production of particular films. By avoiding duplication of effort, it is anticipated that both the number and quality of test films can be improved. Working with this committee, the SMPE Projection Practice Committee has brought out a new 35-Mm Picture Projections Test Film which should be of great value to all those interested in keeping picture projection equipment operating at highest efficiency. The film consists of four parts designed to indicate and measure (a) size of projector aperture and screen masking; (b) travel ghost; (c) picture unsteadiness; and (d) lens distortion.

As rapidly as possible, specifications will be drawn up for test films in use but not previously standardized so that these can be submitted to the ASA Z22 Committee for consideration as American Standards. All test films will be distributed by both the Society and the Research Council.

AWARDS

Progress Medal.—E. A. Williford, Chairman of the Progress Medal Award Committee, reported that the committee had no nominations to propose for 1946, so no award was made.

Honorary Membership.—On the recommendation of the Honorary Membership Committee, the Board of Governors voted to place the names of Theodore W. Case, Edward B. Craft, and Samuel L. Warner on the Honor Roll of the Society. This action was approved by unanimous vote of qualified members present at a business session of the Society in Hollywood on Oct. 21, 1946. It was also provided that the names of Honorary Members should be published in the JOURNAL with the listing of Society committees whenever the latter are published.

Fellow Award.—Following the recommendation of the Fellow Award Committee the following Active Members were elevated to the grade of Fellow: R. B. Austrian, E. A. Bertram, J. W. Boyle, T. T. Moulton, W. H. Offenhauser, Jr., L. T. Sachtleben, and A. Shapiro.

Citations.—In commemoration of the 50th anniversary of the first commercial exhibition of motion pictures, a citation was voted for Thomas Armat. A Scroll of Achievement bearing the citation was accepted at the Dinner-Dance of the May convention by Lt. Brooke Armat on behalf of his father.

A citation and Scroll of Achievement were also presented at the same convention to the Warner Brothers for their achievements in commercializing sound motion pictures. The award was accepted by Maj. Albert Warner.

At the Hollywood convention, additional citations were made to the following organizations which contributed to the first commercial use of talking motion pictures and the technical progress of the industry during the last twenty years:

Bell Telephone Laboratories
Lee de Forest
General Electric Company
Metro-Goldwyn-Mayer Studio
Radio Corporation of America
Twentieth Century-Fox Film Corporation
Western Electric Company
Westinghouse Electric Corporation

SMPE Samuel L. Warner Memorial Award.—The Board of Governors accepted the generous offer of Warner Brothers Pictures, Inc., to establish a fund for an annual award to be given to an individual contributing to engineering or technical improvement of the motion picture industry. The conditions upon which the award is made will be determined by the Society. The following committee has been appointed to make recommendations for the conditions and the form of award: C. R. Keith, Chairman, T. T. Moulton, and Nathan Levinson.

ADMINISTRATIVE CHANGES

In accordance with a recent amendment to Article IV of the Constitution, the terms of office of the Secretary and of the Treasurer are now two years each. In order to comply with a provision of the same article, that election to these two offices should be held in alternate years, the Board of Governors ruled that the term of office of the Treasurer elected in 1946 should be one year, and thereafter two years.

Numerous revisions were made in the Administrative Practices to bring them up to date. Since the Administrative Practices are simply a collection of resolutions by the Board of Governors defining duties of officers in more detail than in the By-Laws, these changes were not submitted to a vote of the Society. One of the more important of these changes is the delegation to the Past-President of the duty of soliciting dues from Sustaining Members.

The procedure for formally adopting standards has been revised in an effort to encourage discussion of proposed standards and also to expedite consideration. The principal changes call for publication

of the proposed standard, with a digest of the preliminary committee discussion, before final voting by the Standards Committee.

ESTABLISHMENT OF STUDENT CHAPTERS

By unanimous vote, members of the Society at the Hollywood convention adopted By-Law XIII, which provides for Student Chapters in colleges, universities, or technical institutions. A Student Chapter



Staff of SMPE General Office, left, standing, MARGARET C. KELLY, Financial Assistant; HELEN KRAWCHUK, Secretary; SILVYA ROTH, Technical Secretary; BEATRICE MELICAN, Secretary; seated, left, HARRY SMITH, JR., Executive Secretary; and BOYCE NEMEC, Engineering Secretary.

has been proposed at the University of Southern California and the Board of Governors authorized the expenditure of necessary organization expenses. The President appointed the following committee to give further study to problems involved in the establishment of Student Chapters: L. L. Ryder, Chairman, M. R. Boyer, C. R. Daily, A. C. Hardy, C. R. Keith, and R. E. Lewis.

MISCELLANEOUS PROJECTS

A ten-year index of the JOURNAL from 1936 through 1945 is being prepared. Owing to the pressure of work at the General Office it is

not possible to say when the 1936-'45 index will be distributed, but every effort is being made to complete it in 1947. Hereafter it is planned to prepare indices every five years.

During the year, a revised membership list was issued. Revision of the list was impractical during the war because of many frequent changes of address, particularly by those in the Armed Services, but now that most members are in relatively permanent locations, it is planned to issue a revised membership at more frequent intervals.

A special loose-leaf binder has been made available to hold American Motion Picture Standards. This has been furnished to members at cost, together with the provision that each purchaser is notified whenever new motion picture standards are available.

A comprehensive list of educational institutions giving courses on subjects relating to motion pictures has been prepared by the Committee on Motion Picture Instruction under the chairmanship of J. G. Frayne. This report, published in the August 1946 issue of the JOURNAL, also lists the courses, semester hours, and credits for each subject at each institution.

Respectfully submitted,
C. R. KEITH,
Secretary

A NEW SERIES OF CAMERA LENSES FOR 16-MM CINEMATOGRAPHY*

W. B. RAYTON**

Summary.—A new series of highly corrected anastigmatic lenses with an aperture ratio of $f/2.3$ is offered for 16-mm motion picture cameras. Surfaces are given antireflection coatings. A new type of mount guarantees centration.

Sixteen-millimeter motion picture equipment was designed primarily for the amateur with the inevitable result that cost was one of the principal guiding considerations. This involved both the optical systems as well as the mechanical design. The possibilities inherent in 16-mm motion pictures for more serious work engaged the attention of the camera makers before it received adequate attention from the projector designers, and yet it seems as if even the camera makers have not realized the full possibilities of the 16-mm art until very recently. We have heard a description of a new 16-mm camera¹ designed not for the amateur but for the professional—one that can stand beside its big brother, the 35-mm camera, and do everything the latter can do except for such limitations as may be imposed by the grain size of the emulsion.

With such a conception of the 16-mm camera it is logical to equip it with lenses in every way comparable to those used on the professional 35-mm camera, and it was to make this possible that the series of lenses described in this paper was designed.

This is a series of Baltar lenses containing focal lengths of 12.7, 15, 17.5, 20, and 25 mm, of which the four latter focal lengths can be carried on the turret of the new Mitchell 16-mm camera. Their relative aperture is $f/2.3$ for all focal lengths. They are designed to produce pictures not only equal in sharpness to those produced by the longer focus Baltars in the 35-mm cameras, but pictures that exhibit the same indefinable characteristics of excellence that produce an impression of something more than mere mechanical perfection.

* Presented Oct. 23, 1946, at the SMPE Convention in Hollywood.

** Bausch and Lomb Optical Co., Rochester, N. Y.

The lens design is a familiar one consisting of four meniscus-shaped components with each of the two inner components consisting of two elements cemented together (see Fig. 1). Advantage has been taken, however, of new high index glasses, developed since the war began, to obtain practical perfection in the correction of spherical aberration, astigmatism, and curvature of the field. Each lens in the series has been independently designed for the field of view it was required to cover with the exception of the 25-mm which is the same construction as is used for the 35-mm film. In this case no improvement seemed necessary or possible for the 16-mm frame.

We will now go into more detail in respect of performance and correction of aberrations for the 17.5-mm lens, for this is the median focal

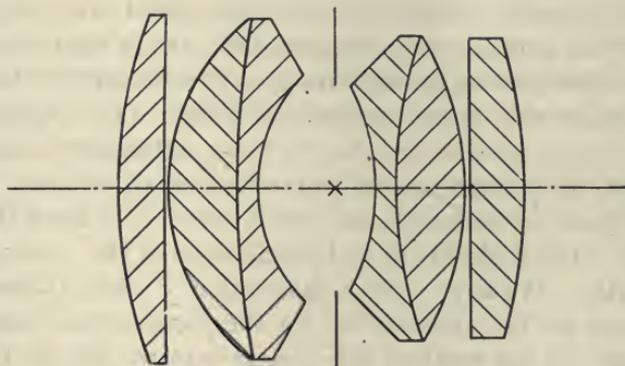


FIG. 1. Bausch and Lomb Baltar 17.5-mm, $f/2.3$ lens.

length of the series. The residual spherical aberration is so insignificant that when this iris is closed to $f/2.8$ the image of a star is a pure diffraction pattern. Actual tests with red, green, and blue filters reveal no change in the plane of best focus and the difference in the size of the images formed by these three primary colors differs by not more than one part in a thousand. At the corners of the frame the images of tangential lines lie on the focal plane and for radial lines about 0.001 in. in front of it. In more technical language, the mean curvature of field is half a thousandth of an inch and the astigmatism one thousandth.

The variation of chromatic aberration with distance from the axis or, to put it in another way, the variation of spherical aberration with wavelength is insignificant. This is a characteristic of lenses of this general type not found in any other type in so far as I know. While

I do not recall having seen the history of this lens form traced back to Gauss' work on telescope objectives, it seems to me the line of descent is clear. Early opticians had several solutions to offer for disposal of the fourth variable presented by a two-element telescope objective after the three primary requirements of given focal length, corrected chromatic aberration, and corrected spherical aberration had been met. Gauss proposed that the fourth condition be that spherical aberration be corrected for two colors and showed that this condition could be met with two meniscus elements—one positive and one negative—all surfaces being concave towards the image space.

In 1889, Alvin Clark, America's most accomplished telescope objective maker, was granted a patent (USP 399,499) on a photographic objective consisting of four meniscus elements and comprising substantially two Gauss telescope objectives mounted with all faces curved towards the diaphragm. This lens was manufactured by the Bausch and Lomb Optical Company for several years.

The deviations from this basic construction are large in number and exceedingly diverse in performance characteristics. They include process lenses, wide-angle lenses, and high-speed lenses. And they all approach reasonably well the original thought of Gauss, *viz.*, that spherical aberration should be equally well corrected for two colors.

The best efforts of the designers, however, are of no value unless the execution of the design in manufacture is equally carefully and competently controlled. One of the fundamental requirements in assembling a lens system is to achieve exact alignment on a common axis of all the lens elements. The commonest lens construction consists of a front member and a rear member, each mounted in threaded mounts that screw into the two ends of a lens barrel which contains the iris diaphragm. The difficulty of getting these units to screw together so that the two members are truly coaxial is formidable. It is true that many excellent lenses have been made in this way but we think there is a better way.

For these short focus lenses we have mounted each lens component in an individual cell with a smooth, cylindrical wall and the iris diaphragm in a similar way. Ring-shaped spacers are used where necessary and the whole assembly is accomplished by pushing the components into a barrel the inside of which is a true cylinder, very accurately fitted to the diameter of the lens cells. The whole assembly

is held in place with a single retaining ring (*A* in Fig. 2). This is the manner in which we have mounted microscope objectives with the utmost satisfaction for many years and our experience convinces us that we can maintain coaxial alignment by this method to a higher degree than can be accomplished with the older method.

The diaphragm actuating pin *B* is screwed in place after the assembly has been effected—a set-screw, not shown in the diagram, is installed to lock the diaphragm ring in place, and the covering ring *C*, carrying the stop opening scale, is slipped over the outside and held in place by the spring ring *D*.

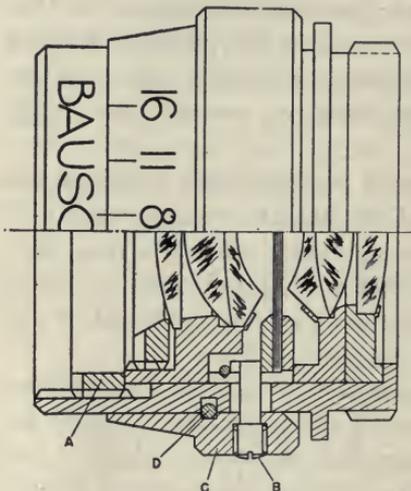


FIG. 2. Precision mounting for short-focus Baltars.

To disassemble for cleaning, the ring *C* can be pushed off the mount, a setscrew that locks the diaphragm ring in place is removed, retaining ring *A* is removed, and the whole assembly can then be pushed out from the back.

Finally, in order to reduce to a minimum the stray light in the image plane, all surfaces are coated with a hard, durable coating of magnesium fluoride.

REFERENCE

- ¹ BAKER, F. F.: "A New 16-Mm Professional Camera", *J. Soc. Mot. Pict. Eng.*, 48, 2 (Feb. 1947), p. 157.

DISCUSSION

MR. JESS DAVIS: Do these lenses have completely closing iris?

DR. RAYTON: No, I do not think they do.

MR. DAVIS: Didn't some of the 35-mm lenses have this feature?

DR. RAYTON: Yes, some of them have been made with completely closing iris, but investigation into the matter some years ago indicated that the requirement was encountered in such few cases, so few people were interested in it, that we decided to discontinue it. A completely closing iris is possible only by exerting a quite undesirable force on the diaphragm leaves, so it was discontinued.

MR. HAWK: Can you tell us anything about coma in these lenses?

DR. RAYTON: I am sorry I cannot tell you quantitatively. It is exceedingly small, a matter of hundredths of a millimeter.

DR. F. G. BACK: I would like to know about zonal spheric aberrations of the 0.707 zone.

DR. RAYTON: As I said in the course of the paper, by stopping the lens to $f/2.8$ it gives a pure diffraction pattern. From the standpoint of the use of the lens, that is the answer. It could not be any better.

MR. J. A. LARSON: That is the critical aperture?

DR. RAYTON: Yes.

MR. LARSON: I would like to ask whether it is not possible to expand the f -stop scale on lenses to the point where either half or third stops can be calibrated on them, or where the scale can be expanded to cover the full circumference of the lens? It is quite a problem from a practical standpoint to get f /stops set correctly and usually when you are shooting exterior on Kodachrome, for example, the correct f /stop runs between $f/8$ and $f/11$, and often it lies between $f/11$ and $f/16$. It is a serious problem from a practical photographer's viewpoint to expand that scale, particularly in the smaller stops, so that you can set the aperture accurately.

DR. RAYTON: It is a real point, particularly in short focus lenses. Perhaps Mr. Baker could answer the question as to how that is handled in the focusing mounts employed on the Mitchell camera.

MR. F. F. BAKER: In the new Mitchell mounts, the diaphragm scale is carried out to a very much larger diameter, similar to the other standard Mitchell mounts. This makes the spacing at least double what it is on the lens.

MR. S. E. MOORE: In this connection we find you get quite a different exposure if you set the stop, say at $f/11$ or $f/16$, going from wide open to closing down than if you start with it closed down and open up.

DR. RAYTON: That is a fact, and the only remedy is to approach the stop from the same direction at all times. If an iris diaphragm were made with precision and without any backlash, I do not think it could be operated.

MR. MOORE: I wonder if it would be possible to use different pitch threads, so we would get about the same change in focus for the various focal length lenses, rather than using the same pitch thread and moving the lenses different angular distances? I believe the Fox camera has that.

DR. RAYTON: I am inclined to think that angular movement is completely different in these lenses from one focal length to another. The scales are proportional.

MR. MOORE: I was thinking of it particularly in connection with some automatic focusing device. Are the f /stops calculated mathematically or calibrated in terms of transmission of light?

DR. RAYTON: These are calculated mathematically. So far there has been no basis established on which we would feel safe in calibrating them photometrically. We can do it if and when such a basis is established.

MR. C. R. SKINNER: I would like to ask if you would give us an approximate idea of how much the coating increases the transmission of this lens over a similar lens that is not coated?

DR. RAYTON: In this particular lens, the coating increases the transmission about 28 to 30 per cent. However, I do not regard the increase in transmission as being the main reason for coating. It is the improvement of quality and bringing out detail in the shadows which you cannot obtain without it.

MR. J. A. MAURER: In looking at the diagrams of this lens, I note what seems to me to be one unusual characteristic, that the elements are relatively thinner than they have been in most six-element lenses, as made by Zeiss and other European firms. Of course, we have in the paper the fact that there is another change in that the newer high-index glasses have been used. The literature states that the worst outstanding trouble in the design of such lenses in the past has been the higher order aberration known as oblique spherical aberration. I want to ask whether the use of the new glass and any other departures from the orthodox design have made it possible to correct that specific aberration better than usual?

DR. RAYTON: It is certainly reduced to a very low level in these lenses. Undoubtedly the glass contributes to it. Every element in the design contributes to that final result.

WILBUR B. RAYTON

I. L. NIXON*

With the death of Dr. Wilbur B. Rayton on Oct. 31, 1946, while on a business trip to Los Angeles and San Francisco, the nation lost one of its top-ranking optical engineers. While in California he attended the Hollywood Convention of the Society of Motion Picture Engineers and presented a paper on 16-mm lenses, published in this issue.

As a member of the Bausch and Lomb Optical Company Scientific Bureau since 1908, and its director since 1926, Dr. Rayton was actively interested in all phases of the optical industry and contributed definitely to the development of optical systems in the fields of human vision, microscopy, photography, gun fire control, and particularly to the requirements for optical devices in the field of motion pictures in all its ramifications. It is hard for one who has been so closely associated with him for so many years to say that his ability was more outstanding in one field than in another because of his recognition in so many fields, but he was recognized as one of the leading authorities on optical systems for gun fire control, and only two months before his death was awarded the Navy Ordnance Development Award for "Distinguished Service to Research and Development of Gun Fire Control Equipment" during World War II.

Among his many other accomplishments, Dr. Rayton was a lens designer of outstanding ability, and particularly so in the photographic field. He was interested in aerial photography and aerial mapping. He designed a number of the very long focus telephoto lenses used during World War II and designed the now well-known Metrogon lens, which has become the standard for use in aerial mapping in conjunction with multiplex equipment.

Dr. Rayton was early interested in the problems of motion picture photography and became active in the Society of Motion Picture Engineers in the early days of its organization. He was elected a Fellow of the Society on Jan. 1, 1934. Dr. Rayton contributed greatly to the

* Manager, Scientific Instrument Division, Bausch and Lomb Optical Company, Rochester, N. Y.; received Feb. 20, 1947.

rapid improvement of the art from the standpoint of designing both lenses to make better motion pictures and optical systems to project better motion pictures. He was particularly intrigued by the possibility presented in the early days of sound recording and reproduction on film and in the need for better illumination and optical projection systems. His contributions in this direction included such items as the now famous Baltar lens for the professional 35-mm



DR. WILBUR B. RAYTON

cameras and the equally famous Super Cinephor lens so extensively used in the leading theaters throughout the country. His other developments in this field were special reflectors and condenser systems, polarizing photometer for measuring light intensity and density.

In addition to the direct developments which he contributed, he gave generously of his time both as a contributor of special articles published in the *JOURNAL* and other technical journals and to serving on executive boards and committees. In 1932 he was on the Fellowship Committee which decided to have the University of Rochester work on the subject of visual fatigue. A paper was prepared by

P. A. Snell on "An Introduction to the Experimental Study of Visional Fatigue", published in the May 1933 JOURNAL.

He was actively connected with the Standards Committee and took part in establishing many standards prepared by this group. One of the things which interested him greatly was the glossary section, and even at the time of his death he had certain problems which he was studying in this connection. He was more recently a member of the Theater Television Projection Practice Committee and gave valuable advice in this capacity. He was chairman in 1931 of the Projection Theory Committee and was a member of the Screen Brightness Committee, the Projection Practice Committee, and Sound Committee.

Another problem in which he was most recently interested was photometric calibration of lens speeds, and that problem was a subject of discussion with a special committee on his recent West Coast trip. He believed sincerely that this offered a consistent method of calibration of lenses for standardizing light transmission. Unfortunately, his untimely death prevented continuing his study and final recommendation, but it is to be hoped that this problem can be carried on by other committee members, who can be assured of the assistance in this direction from Dr. Rayton's associates in Rochester.

It was my great privilege to be intimately associated with Dr. Rayton during all of his years with the Bausch and Lomb Optical Company, and in his death comes a loss not only of a great engineer, but of a man whose devotion to truth and the advancement of science could never be questioned.

THE SOUNDMAN*

GEORGE R. GROVES**

Summary.—This paper outlines the tools and means that are at the disposal of the motion picture production mixer to enable him to fulfill his prime responsibility of being the director's assistant in all matters pertaining to sound. A parallel is drawn between the work of the soundman and the cameraman. Particular emphasis is placed on the artistic capabilities and qualifications required by the mixer to ensure the degree of confidence and co-operation that must exist among the soundman, the director, and the cast in order that sound may contribute its full share to the realistic quality of the final product.

With the introduction of sound into motion pictures, revolutionary changes took place in all branches of the industry. The silent picture had relied upon pantomime and printed titles to tell its story. Now, with the addition of the spoken word, musical accompaniment, and realistic sound effects, the motion picture presented to the public, for its enjoyment and education, real life as experienced by each of us from day to day.

This new medium of expression called for new techniques in writing, acting, photography, set design, stage construction, laboratory processing, and all the many phases of motion picture production. A new science, the science of the transmission and recording engineer, had wrought a change in an art and only by the complete and proper welding of this science and art could the motion picture realize its full capabilities.¹

During the twenty years of its growth, therefore, it is to be expected that the sound picture would produce many and varied changes in the personnel manning its production staffs and crews. By no means the least significant of these has been the evolution of the sound engineer from a man of mathematics, transmission circuits, recording equipments, and gadgets, with a foreign language of decibels and gammas, to the artist in whose hands rests the full dramatic impact which sound can impart to the motion picture of today.

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

** Warner Bros. Pictures, Inc., Burbank, Calif.

Who is this sound engineer who has contributed so much during the past twenty years to the revitalization of the motion picture industry? What are his functions, and what does he accomplish?

First, let us glance at the organization of a typical sound department. This group is headed by the director of sound recording, whose position is both administrative and technical in character. He has complete authority with respect to the operations of his department, and it is his responsibility to secure the best recording possible at a reasonable cost of operation under a wide variety of recording conditions. He must co-ordinate the technical efforts of his department with the functions of other studio groups, and he is vitally concerned with the quality of sound reproduction of his product in the theater. In handling the many operations with which his department is concerned, he is assisted by a chief engineer, who is responsible for all of the technical phases of sound department operation, including the installation, operation, and maintenance of studio recording and reproducing equipment and the development of improvements in technical facilities.

The functions of the personnel of the department may be roughly divided into four major classifications:

- (a) Production recording;
- (b) Music recording;
- (c) Rerecording or dubbing;
- (d) Engineering and maintenance.

The operating groups in each of classification (a), (b), and (c) are headed by men known as "mixers", a designation derived from their operational function of mixing together the various sounds picked up by a number of microphones, or transmitted to a control panel from an assortment of sound tracks during the rerecording process.² It is with the mixers that we are here primarily concerned.

These men were originally recruited largely from the telephone and radio engineering fields, and in the majority of cases have reached the present state of efficiency in their art as a result of fifteen or twenty years of training and experience in the recording of sound for motion pictures.

Let us consider the production mixer. In the early days of sound recording, one of the greatest limitations imposed upon the director was the restriction in movement of the actors by virtue of their having to speak in specified fixed positions at which microphones were

suspended and hidden from the camera view. The only way in which an illusion of freedom of movement could be obtained was by the use of many microphones positioned along the path traveled by the actor. By smooth fading or switching from one microphone to another, a reasonably smooth and continuous recording was obtained.

Of necessity, this type of microphone pickup technique required that the mixer be extremely expert in the noiseless, rapid, and accurate manipulation of the microphone switches and controls. The actor had to speak the dialogue exactly as written in the script, word for word, and switching from microphone to microphone had to be accomplished with split-second timing between words and during pauses for breath. The mixer's attention was focused entirely on the operation of his equipment; and if the dialogue could be understood and was recorded with sufficient volume, all was well.

With the development of microphones that could be used at some distance from their associated amplifiers, and with the advent of microphone booms that could move the microphone rapidly and silently about the set,³ the fetters were gradually removed from the director and actor until today scenes are staged with no restriction whatsoever from the recording system.

Let us briefly review the tools and means that are at the disposal of the soundman to allow this freedom of movement and to help him create the illusion of reality upon the screen.

First and foremost, of course, is the microphone, which may be regarded as the ear of the recording system. But there is one great difference between the microphone and the human ear. The human ear has a brain, while the microphone is a robot. The ear is the means of transmitting outside sounds to the brain, which selects that which we wish to hear, and within reasonable limits, discards the rest. This faculty of concentration makes conversation possible in the midst of a crowd at a football game and enables us to select, from amongst several voices all talking together, the voice we wish to hear. The fact that we have two ears and the binaural sense of hearing aids this power of concentration by enabling us to identify the location of a source of sound.

A microphone has no such powers of discrimination, and picks up all sounds equally well within its range. It is necessary, therefore, for the soundman to create, artificially, conditions surrounding the microphone, so that it picks up only those sounds which he wishes to be heard. In creating these conditions the soundman becomes the brain

of the microphone. For example, the loudness of extraneous noises such as footsteps, traffic noises, and crowd noises, must be reduced to a level which sounds unnaturally low to the ear in order to sound like a natural background through the microphone. To simulate further a sense of concentration, the microphone itself has been designed to have directional properties.

Various types of microphones are available for the soundman's use, depending upon the conditions under which they are to be used and the type of material to be recorded. The unidirectional microphone^{4,5} is so designed that it has a maximum sensitivity to sound waves originating in the front or operating side of the microphone, while sounds generated at the rear of the microphone are considerably attenuated, giving approximately a 10:1 ratio of desired to undesired pickup. This type of microphone is, therefore, most useful in reducing the level of such undesirable noises as camera noise, floor squeaks, dolly noises and sounds reflected from walls and other reflecting surfaces.⁶

The dynamic-type microphone also is widely used in production recording.⁷ While fundamentally nondirectional, it may be given certain directional characteristics by the addition of directional baffles mounted in front of the microphone diaphragm. This type of microphone is usually smaller and lighter in weight than the unidirectional microphone, and is less sensitive to and more easily protected from wind pressures, with their resulting thudding and thumping noises. This microphone is, therefore, most suitable for exterior work, and its light weight permits it to be suspended from the end of a hand-held pole where the shooting conditions do not permit the use of a microphone boom. Long dolly shots, the cramped interiors of boats, airplanes, automobiles, and small sets are examples of such conditions.

A third type of microphone, widely used in the recording of music, is the velocity- or ribbon-type microphone.⁸ This microphone may be termed "bidirectional" in that sound waves approaching it from either front or back have the maximum effect, while sounds approaching from the sides have little or no effect upon it. Its directional characteristic being practically independent of frequency, it is admirably suited for high-quality music recording work.

A number of sound concentrators⁹ have been designed, and while the quality of sound picked up by them is inferior in some respects to that obtained with standard microphones, they have been used quite successfully in recording sound effects where the source of sound might

be in some inaccessible place or where extreme segregation of wanted from unwanted sounds is necessary.

It happens in the recording of sound for motion pictures that extraneous sounds may occur which are detrimental to the scene and are beyond the control of the mixer. For example, during the recording of exterior scenes, airplanes may pass overhead, wind may cause excessive rustling in the trees, quiet lapping of surf at the beach may turn into pounding waves. Here the director is dependent on the soundman's judgment for the best procedure from both the artistic and economical standpoint.

As previously mentioned, the microphone is a one-eared device which causes the apparent loudness of off-stage sounds to be exaggerated. The soundman, therefore, is the only one who can say whether extraneous sounds are unduly loud or annoying or detrimental to the scene. The soundman must decide whether such disturbance justifies another take, whether the disturbing noise could be eliminated in rerecording or whether it would be more economical to "post-synchronize" the scene.

When the soundman decides that it would be most advantageous to post-synchronize the scene, the recording that he makes while the scene is being photographed serves merely as a cue track which is played back to the actors at some later date and serves as a guide to them in synchronizing a new sound track to match the picture. The post-synchronizing work is done in a special recording room where the soundman has means for controlling the acoustical conditions so as to enable him to match the acoustical conditions prevailing at the time of shooting the original material.¹⁰

A number of auxiliary aids are available to the soundman to adapt his microphones further to unusual shooting conditions. He may use a fine-mesh silk cover, called "wind-gag", to enclose the microphone completely as a protection against wind; or he may use a specially designed sound absorbing waterproof hood over the microphone as a protection against rain. Special electrical networks, known as equalizers, can be used to change the character of the sounds picked up by the microphones, filters are used to attenuate or even eliminate certain sounds,¹¹ electronic compressors¹² may be inserted into the recording system to assist in keeping the lowest spoken syllables and the loudest shouts within comfortable audible range for the listening audience.¹³

Having determined the type of microphone to be used, microphone

placement, like camera angle, must be carefully chosen. The cameraman paints his picture with lights and shadows—composition and perspective are carefully chosen—a mood is created. And so with the soundman, acoustic conditioning of the set for optimum sound quality is done; correct sound perspective is secured; the necessary degree of sound “presence” to match the photographed image is determined; the loudness of extraneous sounds is so established as to create a sense of concentration upon the wanted sounds without losing the effect of reality. In other words, a sound picture is painted which, in all respects, is complementary to the optical picture captured by the camera lens.

While the cameraman is concerned solely with the quality and quantity of reflected light, the soundman is concerned with the quality and quantity of both incident and reflected sound and only by a critical and judicial blending of the two can the illusion of true sound perspective be obtained.

It may happen that considerations of cost and construction difficulties preclude the use of materials in the design of a set which will permit suitable acoustic characteristics. For instance, it would be impractical to build a cell block of concrete or a subterranean cave of rock. In such cases, the soundman resorts to the use of reverberation chambers and acoustic labyrinths which enable him to add any desired degree of reverberation to his recordings.¹⁴ But should the reverberation in his original material be excessive, it can never be removed, and consequently is to be avoided at all costs.

Close collaboration is, therefore, required between the soundman and the art director during the planning and construction of sets. Large parallel surfaces must be avoided; deep recesses and alcoves in which dialogue may be spoken must be acoustically treated to prevent the speech from sounding “boomy”; large glass reflecting surfaces may have to be substituted with fine-mesh silk cloth; ceilings visible to the camera must be made of sound-transparent muslin; overhead beams that may interfere with movement of the microphone must be made removable. And so the production soundman sets the stage, the acoustical pattern is set, the microphone silently follows the actors about the scene, twisting and turning to catch each whispered word and registering every tiny inflection with true fidelity, weaving in and out to avoid casting shadows from the multiplicity of lights, raising and lowering to preserve correct perspective.

In present-day motion picture practice, the great majority of scenes are recorded with a single microphone. At first glance this would seem to indicate that the work of the mixer has been greatly simplified, but this is not the case.

Simultaneously with the improvements in the production recording equipment, have come improvements in reproducing equipments which, in turn, have called for infinitely greater attention to those factors which contribute to life-like portrayals of character on the screen. First and foremost, the mixer of today is concerned with "performance". Not the performance of his equipment—this is assured by competent maintenance crews, skilled microphone boom and recording machine operators—but with the performance of the actors and musicians whose art he is preserving.

The prime function of the mixer of today is to be the director's assistant and advisor in all matters pertaining to sound. To fulfill this capacity adequately he must necessarily be as familiar as the director and cast with all phases of the script. He should be thoroughly familiar with the plot, the dialogue, the characterizations to be portrayed and the locale and geography of each individual scene. He should appreciate the mood and tempo in which scenes are to be played and should always be conscious of what the effect will be on the scene he is recording, of the music and sound effects that will be added later in the rerecording process.

Often, directors will devote early rehearsals to a discussion of the significance, distinguishing qualities, merits, and demerits of the script. During these early discussions between the director and his cast, the soundman should always be present, seeking an understanding of all the characters, the setting of the play in time and place, the historical background, the customs of speech and the mannerisms of the era, and above all, the thoughts and psychology that lie behind the spoken words. Having thus obtained a comprehensive picture of the scenes he is to record, and having secured a complete understanding of the director's desires, it is the soundman's function to observe, purely by what he hears in his monitoring headphones, whether by voice pitch, loudness, tempo intensity, emotional quality, and mood, the actor is delivering the performance desired by the director.

Since it is common practice, for reasons of economy and expediency, to shoot scenes out of continuity, the soundman must exercise the keenest judgment in matching the quality of sound performance from day to day. He must thus assure a smoothness in the finished

product that will convey the impression of the whole picture being made as one continuous play-like performance.

While critically monitoring the scene being recorded, the soundman must see that there is no obvious effort on the part of the actor at so-called tone production and theatrical voice projection. There must be no obvious cultivation of careful diction. The mannerisms of speech must be those of the character delineated. The soundman must carefully draw the line between poor articulation that will result in lack of audience understanding of the story and pedantic artificialities that will destroy the illusion of reality. The soundman can quickly detect such faults in speech delivery as huskiness, nasality, throatiness, breathiness, where these characteristics are not required and result from faults in breathing, nervousness, superficiality of reading, an unemotional state of mind, or fatigue. Conversely, he can equally well detect the lack of these characteristics where they are necessary attributes to the characterization involved.

Since most scenes are shot with one camera, it becomes necessary for the actor to repeat his performance many times in order to obtain coverage of the scene from a number of camera angles. This frequent repetition of the same dialogue can often result in a too glib reading of the lines, and the consequent superficiality of the scene becomes immediately apparent to the soundman. Since all the mixer's critical faculties are concentrated upon one thing—the sound of the scene—no one is better able than he to appreciate whether the actor is maintaining the feeling of spontaneity in his performance. Even though the scene may be rehearsed and played many times before the purely mechanical details of the shot may be considered perfect, at no time must the soundman permit the "illusion of the first time" to disappear from his recordings.

In many screen plays, the story covers the span of life of one or more characters. Here the soundman is confronted with the problem of guiding the actors through a smooth and logical aging of the voice. Make-up, costuming, and physical mannerisms can satisfy the eye in presenting an authentic visual passing of the years. The soundman must rely on a sensitive ear and keen judgment to be assured that the auditory illusion of the passing of time is equally convincing.

Outstanding examples of successful co-ordination of physical and aural aging have appeared in the performances of Paul Muni in "Louis Pasteur", Robert Donat in "Goodbye Mr. Chips", and Bette Davis and Claude Rains in "Mr. Skeffington".

In the shooting of pictures involving dual roles such as the two roles of "Kate" and her sister "Patricia", played by Bette Davis in "A Stolen Life", the difference in character of the two girls is largely dependent upon the differences in pitch, inflection, and tempo of their voices. In maintaining these individual characteristics, reliance was placed on the critical faculties of the mixer. He had to be certain that the differences once established were maintained from scene to scene and day to day.

It is frequently necessary for the soundman to see that voice quality and loudness conform to the geographical specifications of the scene. For instance, in the Warner Bros. picture "Cry Wolf", Barbara Stanwyck is thrown from her horse while riding in a lonely part of an estate. She is suddenly surprised by a man, her husband, whom she had thought dead. This scene could have been played in a fairly loud excitable voice, but when it is disclosed that the scene takes place near a caretaker's lodge in which her husband had been kept prisoner, we understand why the scene is played in the quieter and more emotional low, restrained voice.

It is the business of the actor to present to an audience overt behavior patterns which go under the name of emotion. The actor realizes that his voice is probably his most essential tool in reproducing these behavior patterns and it is to the soundman, therefore, that he looks for advice, assistance, and criticism in his efforts to create the inner life of the character he is portraying. Only by the closest cooperation among the director, the actor, and the soundman, and by the free and tactful interchange of ideas between them, can the last foot of film be sent to the laboratory for processing with the assurance that all is "OK for sound"

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¹³ MUELLER, W. A.: "Audience Noise as a Limitation to Permissible Volume Range of Dialogue in Sound Motion Pictures", *J. Soc. Mot. Pict. Eng.*, **XXXV**, 1 (July 1940), p. 48.

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DISCUSSION

Dr. J. G. FRAYNE: I would like to ask what sort of an educational background would be necessary to produce this apparent superman.

MR. GROVES: Our directors and producers feel that the soundman should have an education in dramatics. The question is always asked, "Should the soundman be an engineer?" I think the combination of the two would be ideal. The men who are now in the studios doing this work have had training in the best dramatic schools that can possibly be found, I think. As I said at the beginning of the paper, they have been working now for 15 or 20 years at this particular type of work, and they cannot help but have learned something from all the different types of actors, directors, and producers with whom they work.

Where a man would start out from scratch to become this kind of a man would be a problem. I do not think he could do it, really. The only place he could do it would be in the studio.

DR. FRAYNE: Isn't it possible some courses could be established in our universities which would lead to this?

MR. GROVES: Definitely yes, it would be a combination of engineering, covering the use of the equipment that is used, and also, of course, dramatics. The training would be equivalent to an engineering course plus the type of training that the average dialogue director gets. In fact, I think that a mixer should be the dialogue director. That is the sum and substance of the whole thing—a dialogue director with an engineering background.

MR. J. I. CRABTREE: To what extent is post-recording used? Are songs always post-recorded, or are they ever recorded at the time the picture is taken?

MR. GROVES: As far as songs are concerned, very few of them are post-

recorded. They are mainly prerecorded. That is, the song is recorded before the picture is shot, and the person is photographed mouthing to a playback of the prerecorded music, but post-synchronizing is used where, for some reason or other, it is impossible to get a sound recording at the time of photographing the scene. Then, the track is recorded in synchronism with the photographed picture. All foreign versions are made with a post-synchronizing technique. Sometimes an original sound track is used as a cue track and played back to the actors under more favorable conditions to obtain a better sound track. That is being used more and more.

MR. JOHN HAWKINS: I wonder if you would comment on the difficulty of communication between the mixer who speaks one language, the musical director who speaks another, the director of the set who speaks another, and lastly the producer?

MR. GROVES: I do not believe that a mixer on a production company, who is qualified to be responsible for the sound on that production, will necessarily speak a different language from the director. I think in most cases they do speak the same language, but it is quite possible in the music scoring work that they will speak a different language. The scoring mixer, I believe, should have quite a musical education, musical training, and should be fairly well conversant with orchestration so he can talk the language of the musicians. If he can speak their language, he necessarily inspires much more confidence, and they believe his criticisms of balance, and often will change orchestrations to obtain greater clarity in the recordings. I think it is very essential that the scoring mixer be able to speak the language of the musicians.

THE DEVELOPMENT OF AN INVISIBLE 16-MM FILM SPLICE*

ERNEST BAUMERT** AND JOSEPH V. NOBLE†

Summary.—All present 16-mm film splices standardized by the Society of Motion Picture Engineers, while possessing the necessary strength, have the undesirable characteristic of being visible on the screen. A new splice has been developed which does not encroach on the picture aperture area, and nevertheless retains sufficient strength for printing and projection operations. The principle, equipment, and abuse tests are described.

At the present time there are three basic types of 16-mm motion picture film splices. These three types of splices are represented in the standards and proposed standards of the Society of Motion Picture Engineers. W. H. Offenhauser's "Report of the Subcommittee on 16-Mm Film Splices", presented at the Technical Conference in New York in May 1946,¹ very aptly reviews the situation. There is a volume of approximately four hundred million linear feet of 16-mm release print produced per year. These four hundred million feet bear not only the picture and sound track, but also the printed image of every splice made in the original picture film, regardless of whether this original was a 16-mm negative or a 16-mm reversal positive. The prints also bear the splices which are made in the printing stock, and later the splices made in the print itself.

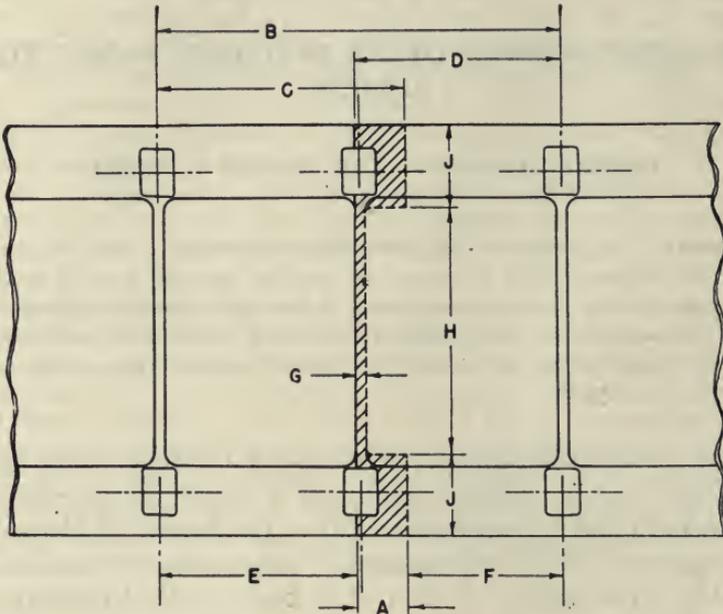
The printed image of the splice does not constitute a problem in 35-mm sound film production, because the width of the frame line has been standardized at 0.117 in., within which dimension it is possible to make a strong splice. The frame line is masked by the projector aperture plate and consequently the image of the splice does not appear on the screen. However, in 16-mm film the adjacent frames are photographed with a separation of only 0.006 in. The projector aperture, being slightly smaller than the camera aperture, increases the effective width of the frame line to 0.016 in. In 16-mm

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** Signal Corps Photographic Center, Long Island City, N.Y.

† DeFrenes and Company Studios, Philadelphia, Pa.

projection, the picture frame line of 0.006 in. plus a margin of 0.005 in. on both sides of the frame line are not visible on the screen. An



SPLICE AREA = 0.023 SQ."'

	M.M.	INCH EQUIV.
A	1.99	0.079
B	15.24	0.600
C	9.42	0.371
D	7.82	0.308
E	7.41	0.292
F	5.81	0.229
G	0.40	0.016
H	9.67	0.381
J	3.16	0.1245

FIG. 1. The dimensions of the invisible 16-mm splice.

attempt to imitate 35-mm practice and to splice within the effective frame-line width would fail because of the impractical weakness of a splice only 0.016 in. in width.

If we examine the existing three basic types of splices in relation to these figures, we find that in the case of the widely used 0.100-in. straight splice an overlap of 0.042 in. will be visible on the screen on two successive frames. In the 0.070-in. straight splice, an overlap of 0.027 in. will be visible on the screen on two successive frames. In the case of both the 0.070-in. curved splice and the 0.070-in. diagonal splice, even greater overlaps are experienced.

The function of a splice is to join two pieces of film together, and in doing so the splice must possess sufficient strength to withstand the

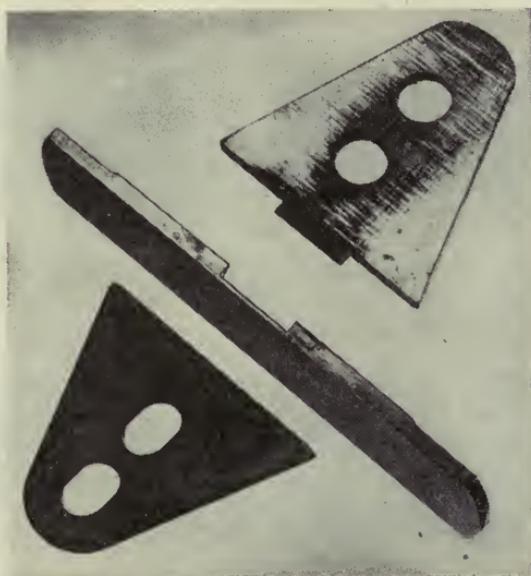


FIG. 2. The cutter blades and bar.

strain of printing and projection operations. However, inasmuch as the splice is a mechanical device which adds nothing to the context or enjoyment of the film, it should be as unobtrusive as possible or preferably invisible on the screen.

The authors, in co-operation with the Signal Corps Photographic Center, arrived at one solution to this problem of producing a 16-mm splice which would be invisible on the screen and yet retain a practical strength for printing and projection operations. Such a splice is illustrated in Fig. 1. It will be noted that the splice is cut in the form of a step. The film is cut above the sprocket holes, down the edge of the picture area, and across the top of the frame line. This allows

the splice to be 0.016-in. wide in the center, therefore invisible on the screen, and 0.079-in. wide along both edges of the film which reinforces the splice. The total area of the overlap is 0.023 sq. in., as compared with 0.037 sq. in. for the standard 0.070-in. straight splice.

It was realized that the new invisible splice would be practical only if it possessed a strength equivalent to that of the conventional 16-mm splice. Therefore, tests were made to determine the relative strength of the new splice and the standard 0.070-in. straight splice. Averaging the destruction tests of a number of splices, it was determined that the new invisible splice would withstand a straight pull

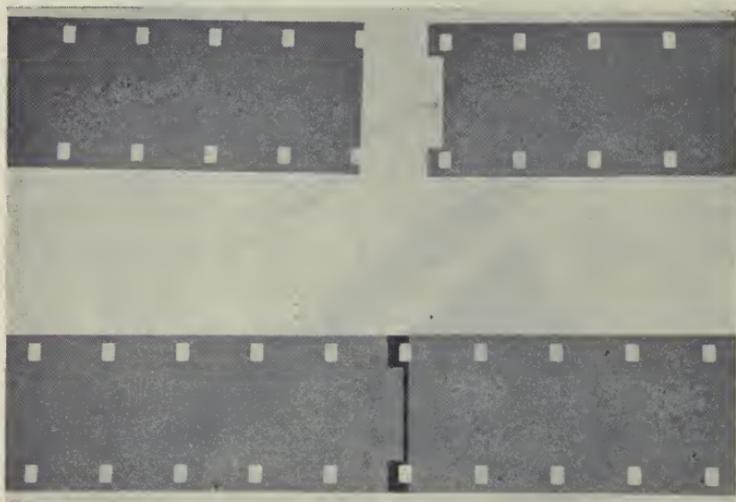


FIG. 3. The film parts and the assembled invisible 16-mm splice.

of 23 lb, and the standard splice would withstand a pull of 25 lb. It is interesting to note that a 38 per cent reduction of the overlap area in the invisible splice resulted in a reduced stress resistance of only 8 per cent. A possible explanation of this high ratio of strength to overlap area is that the new splice is particularly well reinforced at the film edges where the greatest stress may be expected.

A second test was conducted in which an invisible splice was mounted in a device which rapidly flexed the film in a manner which reproduced the action of the film in the loops above and below the pull-down claw of the standard 16-mm projector. The splice withstood a series of 50,000 consecutive flexings without any apparent

weakening. Such performance is certainly greatly in excess of anything required of the film splice in normal life.

The operation of the standard splicing cycle remains unchanged in making the new splice. One piece of film to be spliced is clamped, emulsion side up, in the splicer and cut straight across in the conventional manner. It is then moved to an out-of-the-way position. The other piece of film is placed in the splicer, emulsion side up, and scraped. It is important that the film be scraped before cutting, for ease of operation. Film cement is then placed on the scraped film. The action of cutting this film with the step-shaped cutter blade and superimposing the two pieces of film may occur in the same operation, as is often done in conventional splicers. Most existing splicing devices may be altered to make the new invisible splice by the replacement of the cutter blades and bar. Of course, it is possible and would be desirable to design a new splicer around this principle.

Fig. 2 illustrates the modification of the cutter blades and bar.

Fig. 3 illustrates the film parts and the assembled invisible splice.

The invisible splice, as developed at Signal Corps Photographic Center, has recently been put into general use at that installation with completely satisfactory results. The equipment used was a modified standard commercial splicer. No special training was needed on the part of the operator. It is at present contemplated to adapt the invisible splice as standard Signal Corps practice for all original 16-mm film.

The authors wish to thank the many departments of the Signal Corps Photographic Center for their co-operation and encouragement in the development of this splicer.

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¹ "Report of the Subcommittee on 16-Mm Film Splices", *J. Soc. Mot. Pict. Eng.*, 47, 1 (July 1946), p. 1.

DISCUSSION

(The foregoing paper was read by W. H. Offenhauser, Jr., in behalf of the authors.)

MR. C. H. DUNNING: In the case of Kodachrome raw stock, is it necessary to scrape both sides?

DR. E. K. CARVER: Yes, it is.

MR. DUNNING: Can you do the sort of scraping required for this splice on both sides of the film?

DR. CARVER: As I understand it, you can do so, if you scrape before you cut.

MR. DUNNING: Does the uneven contour of the splice cause the film to tear away at the sharp corners during projection?

MR. OFFENHAUSER: I understand that the authors have made extensive bending and other tests to check the performance of this new form of splice. If the splice is carefully made, they seem to feel that there should be relatively little more difficulty with it than there is now with the present narrow 0.070-in. splice.

With regard to picking up dirt, all splices are dirt traps and this form of splice would seem to be no better or no worse than others. The great advantage which would seem to far outweigh its disadvantages is that when this splice is used in original material, such as original reversal or original Kodachrome or Ansco Color, the splice can be almost completely invisible in the release print.

MR. DUNNING: If this proposal is pushed to a conclusion, it would represent an excellent contribution to laboratory technique because it is certainly needed. Visually, there is nothing more irritating than a diagonal splice in a picture.

MR. OFFENHAUSER: I quite agree with both thoughts, Mr. Dunning.

MR. BOYCE NEMEC: I might add that the modified splicer was a Griswold. I have seen the splicer itself. No parts were added, just a little bit was taken away. In reply to Mr. Dunning's question, the part of the film that normally comes up on the left-hand side of the splicer is the part that has the step in it. The step does not appear until the cement has been applied, and the right-hand side of the splicer is closed down.

MR. GEORGE FULTON: I do not know too much about the splicer, but I did see numerous samples of splices on Kodachrome, and no particular problem involved was mentioned in splicing Kodachrome as against any other film.

MR. NEMEC: I might add that the problem exists no matter how you make the splice with film that has emulsion on both sides. The splicer is no consideration one way or the other in that connection.

MR. OFFENHAUSER: As Chairman of the Subcommittee on 16-Mm Film Splices, we have had two contributions within this single convention on the subject for which the committee wishes to express its thanks. Despite the value of these contributions, we feel that the 16-mm splice problem is far from solved, much work needs to be done. We want to get more people thinking about better splices. We would like to obtain at least four papers on this subject for the next convention.

MR. GEORGE LEWIN: During the reading of the paper, Mr. Offenhauser indicated some doubt about the dimension of the 16 mils. I was wondering whether you would want to put something in the record as to what the doubt was?

MR. OFFENHAUSER: I have not studied the proposed dimensions closely with regard to the effect of frame line shift that occurs in the camera. Our present standards call for a tolerance of ± 0.005 in. for photographed frame line location; this figure was chosen as a somewhat unsatisfactory compromise. It seems to have been the thought of the committee studying the subject of frame line location in the 16-mm camera that a tolerance of ± 0.003 in. would be desirable but could not be readily obtained with many of the camera designs now on the market. Professional designs that have the claw and registration pin at the camera aperture can maintain this tolerance without too much trouble, but cameras such as the magazine and similar types which may have the movement claw as far away from the aperture as seven frames cannot be expected to do so. The difference is

aggravated if film is left in the camera overnight or for longer periods between the time the first scene on the film roll is photographed and the last scene on the roll is photographed. Suitable allowance must be made for film shrinkage.

At this moment, I am not prepared to say that this proposal will be entirely satisfactory although for splicing original 16-mm films it looks like the best proposal made so far. In any event, there is the question of practicable tolerances that need to be expressed.

A NEW MOTION PICTURE FILM SPLICER*

IRVING I. MERKUR**

Summary.—Although film splicers of conventional design produce serviceable splices when in the hands of experienced operators, they leave much to be desired in the way of operational ease. The splicer described in this paper is simple to use and because all operations are mechanized, including scraping the emulsion, good splices are assured. The 16- and 35-mm professional models are hot-splicers, having heating elements as integral parts of the stationary shear blade.

The film splice has long been regarded, even among technicians, as a comparatively minor aspect of motion picture technology. Recently, however, the lowly splice became the subject of renewed interest, largely because the SMPE Film Splice Subcommittee of the Standards Committee under the chairmanship of W. H. Offenhauser, Jr., brought the question into the open just six months ago. The report of the subcommittee said: “. . . with most existing splicing equipment the quality of the splice depends to a very large degree on the skill and dexterity of the operator”.¹ The quality of the splice also depends on the quality of the film cement used and on the splicer.

Then it is obvious that in any discussion of film splices or splicing we have three important factors to consider.

- (1) The splicer
- (2) The operator
- (3) The film cement

Each of these three factors has a number of variables, and each of the variables can contribute toward either a good or a bad splice.

For practical purposes we may avoid considering film cement in this discussion because it is one item over which we have very little direct control. Beyond using a cement recommended for a particular type of film and one that has given us good results in the past, we are

* Presented Oct. 24, 1946, at the SMPE Convention in Hollywood.

** Reeves Instrument Corporation, New York.

almost at the mercy of the people who compound it. Film cement, too, is a fit subject for an entire paper, and a timely one, I might add. Any superficial discussion would serve no purpose here.

The operator, as Mr. Offenhauser pointed out, is a very considerable factor in making consistently good splices, but regardless of how well a splicer is engineered or how well it is manufactured, we cannot hope to eliminate entirely the possibility for error. As long as we are dealing with people, that will be true. But the designers and manufacturers of any piece of truly modern equipment can do a great deal in the way of functional design and simplification. They owe this obligation to the people who will ultimately have to use that piece of equipment, and in discharging that obligation, they must do all they can to make its operation simple and obvious to a novice user.

These things were all considered in designing the new splicer. The chief aim, at the outset, was to take as many of the variables as possible (that is, opportunities for human error), out of the control of the operator and build them into the machine. The next step was to design the machine so that the majority of the variables could be held to tolerances well within the limits necessary to turn out consistently good splices.

To make the machine, rather than the operator, make the splice, that was the basic problem.

The next step was to study all of the manually operated splicers on the market to find from that study, just which of the operations in making a splice needed close control, and with a view toward simplification, to find out whether or not it would be possible to eliminate some of the precautions or controls normally observed.

Simple though this study was, it yielded some interesting results.

The sequence of operations of conventional splicers is not obvious to a beginner. It was felt that an improvement in that direction would be a distinct advantage and that it should certainly be possible to build a splicer that would indicate the operations in correct sequence.

Clean sharp cut ends of the film are important. Not so much in the process of making the splice, but a ragged cut or a cut with raised burrs is well on the way toward becoming a torn splice in the projector. Most splicers on the market fortunately do a good job in this respect and except as a general precaution, there is little improvement to be expected here.

The overlap area on the emulsion side of the film that becomes the inside of the "sandwich" must be scraped smooth and all emulsion removed. A great variety of scraping tools are in use today; knives, razor blades, scissors or almost anything with a sharp edge. Most splicers, now are supplied with separate little scraping tools but they have a great tendency to get lost and the improvised replacement at hand is always inadequate.

The study showed that, regardless of how well the rest of the operations are performed, unless the scraped area is clean clear to the edges beyond the perforations, and is flat, dry, and slightly roughened,

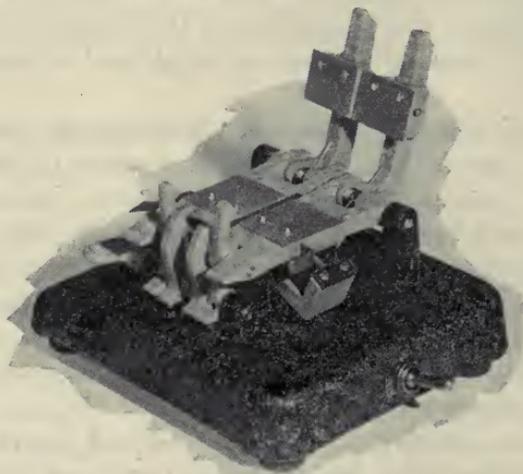


FIG. 1. Ace-Reeves film splicer.

a good splice is almost impossible to make. The rough surface, similar to what the printing trades speak of as "tooth", in connection with paper, seems most essential in securing good adherence.

The only answer here is to have the right kind of scraper built as an integral part of the splicer and to control the depth of cut to little more than a half-thousandth below the bonded surface of the emulsion. Tests seemed to indicate that an even deeper cut would produce a good strong splice, that had the advantage of being somewhat thinner, but lack of practical experience with such a thin splice made it seem advisable to continue on proved ground, at least for the present.

After the cement is applied both pieces of film must be pressed firmly together while the cement actually welds them into one piece

at the overlap area. Speed is important because the highly volatile solvents evaporate rapidly from the surface of the cement applied to the film, leaving an extremely thin skin resembling a blister. If this blister forms before the two films are joined, the splice will have a milky white appearance, and although it may seem strong at the time, it will most certainly break. A milky appearing splice, made on any splicer should be cut out and remade, because it is "stuck" together as though mucilage or glue had been used, rather than "welded" as it should be.

Besides speed, it is essential that a uniform heavy pressure be applied all over the splice area to force out any excess cement that may have been applied, and to assure that the weld is good over the entire area.

The question of the width of the splice lap has been discussed at some length recently from the standpoint of encroachment on the picture area, and doubtless everyone's judgment of correct width is tempered by the seemingly obvious conclusion that a wide lap will give a strong splice. That is not necessarily true. A poor bond, regardless of the reason, will not make a good splice, no matter how wide the film lap. Experience with good splices of several widths seems to indicate that the width of lap is relatively unimportant. The quality or durability apparently depend on securing a good bond or weld and provided there is enough of the film there to be spliced, it will hold.

Practical considerations, of course, limit the width to some extent and until the SMPE recommends a new standard width, or the Splice Committee reports improvement can be achieved in another direction, it will be best to stay with present lap dimensions.

Where time is a worth-while consideration, a hot splicer is a distinct advantage. Studios, laboratories, and exchanges make a great number of splices each day and a splicer, built to make a reliable splice under normal conditions will be able to make many more, at a faster rate with some improvement in the quality of the weld, by addition of a heating element to the stationary shear blade or anvil as we have built into ours.

Many splices made on conventional splicers are torn or weakened when they are stripped from the alignment pins. This, of course, is particularly true if the splice was not well made, and might very well be considered as a blessing in disguise because in some measure it controls the quality of the work turned out. It was not purposely

included as a desirable feature. Retractable alignment pins would eliminate this last source of splice trouble.

To summarize, a good splicer should produce a clean cut, scrape the emulsion away thoroughly, and hold the film "sandwich" firmly all over the splice area. For best results it should have its own built-in heating element and should have alignment pins that can be withdrawn before the finished splice is removed.

The Ace-Reeves film splicer was designed to meet all of these requirements together with that of simplicity and ease of operation. It is manufactured to tolerances well within the limits of accuracy required by the discriminating user.

REFERENCE

¹ "Report of Subcommittee on 16-Mm Film Splices", *J. Soc. Mot. Pict. Eng.*, 47, 1 (July 1946), p. 1.

DISCUSSION

DR. E. K. CARVER: Did you use a wet scraper?

MR. MERKUR: No, it is a dry scraper. We emphasize that a wet splice is not as good as one made by dry scraping.

DR. J. G. FRAYNE: Is this method of splicing only applicable to nitrate film?

MR. MERKUR: It can be used on safety and nitrate film. We have four models. It takes in 16-mm and 35-mm, amateur and theatrical.

MR. R. H. TALBOT: In the 35-mm splicer does the negative or Bell & Howell type of perforation fit cleanly, or do you have to wedge it on?

MR. MERKUR: You do not have to do that. It is made so precise the film will go right over it.

MR. TALBOT: Many splicers for 35-mm are correct for positive-type perforation, but not for the negative perforation on positive films as in some color processes.

MR. MERKUR: That is the reason we have four types of machines. When you use them in studios, you can use the type that is required for it.

MR. TALBOT: Well, in the exchanges the same thing will hold. You will be splicing both films with the positive-type perforations and also certain color films, with negative types.

BLUEPRINTING THE CLASSROOM FILM*

FRANK S. CELLIER**

Introduction.—Some twenty years ago, at a meeting of the SMPE, T. E. Finegan, who was then associated with the Eastman Kodak Company, presented a paper to you on "The Development of Classroom Films". This was before the introduction of the "talking picture" to the classroom, and in fact, it was in the very early days of classroom films of any kind whatever. And yet, even as far back as twenty years ago, Mr. Finegan was able to present a number of salient principles which are as valid today as they ever were. Some of these principles have not only been validated but strengthened and sharpened up by the experience of the past twenty years, as I hope to show you during the course of this discussion.

Definition of Classroom Film.—Let us begin by defining the classroom film. The classroom film is not a feature film. Nor is it a theatrical short. It differs from a feature film in much the same way that a history textbook differs from an historical novel. Someone who is making a study of the westward movement will find much useful material in Emerson Hough's famous novel, "The Covered Wagon". For a *systematic treatment* of the period, however, he will turn to a first-rate history textbook on the subject, such as Frederic L. Paxson's "The History of the American Frontier, 1763-1893". Both the novel and the textbook have their place. But the novel is not a textbook and the textbook is not a novel. Nor would it occur to anyone to say of Emerson Hough that he should have written textbooks and of Paxson that he should have written novels. In the same way, the classroom or text film is not and should not be a feature film, just as the feature film is not and should not be a text film.

A classroom film is an integral part of the existing school curriculum.

* Presented Oct. 16, 1946, at a meeting of the Atlantic Coast Section of the Society in New York.

** Associate Director of Research, Encyclopaedia Britannica Films Inc., New York.

That means that a classroom film on a given topic is made to fit into the curriculum between the discussions that normally precede and follow consideration of that topic. The classroom film is not made for the purpose of fitting into a three-hour program which begins with Donald Duck and ends with "The Lost Weekend". It contains material for schools presented in the way in which schools are accustomed to handle that kind of material.

Since the classroom film is a text film, and since it is as much an integral part of the curriculum as the textbook is, it has certain quite special characteristics. To begin with, it is meaty. It is packed with information. It is made to stand many screenings, and must avoid elements that become boring on second or third acquaintance, such as jokes.

Again, it starts cold. It needs no long motivating introduction for the purpose of getting the audience out of one mood and into another. The mood which the audience needs to appreciate the classroom film is created *by the teacher* before the film is screened, as "Using The Classroom Film" demonstrates quite clearly.

A definition of the classroom film would be incomplete without a reference to authenticity. The classroom film must be absolutely authentic. It must contain *facts*, and these facts must be presented with the same scrupulous regard for scientific validity that applies to the writing of the most rigorous textbook. For this reason, no classroom film worthy of the name is released without the sanction of as eminent an authority or panel of authorities in the field as it is possible to obtain.

The classroom film should also reflect everything psychology has been able to discover concerning the nature of the learning process. The type of step-by-step progression, the nature and timing of recapitulations, the decision to proceed inductively or deductively—all these, and a host of other facts must be implemented in a classroom film if it is to be worthy of its name.

Primary Purpose.—The primary purpose of a producer of classroom films is to teach—not to make films for films' sake; to teach by means of a powerful medium of communication, called the motion picture. It is as true of a text film as it is of a textbook, of course, that if its style is pleasant and fluent, it becomes easier to take. The producer of a classroom film, like the writer of a textbook, will therefore give every attention to style and mode of presentation. But the criterion on which the textbook or the text film stands or falls is not

that of style but rather that of whether the film does a teaching job or not.

This being so, it becomes the task of classroom film producers to select subjects to the teaching of which the film medium can make a major contribution. Among the subjects one can mention in this connection are phenomena that are microscopic, or hidden, or relatively inaccessible to the average student. In "bringing the world to the classroom" as the slogan of Encyclopaedia Britannica Films has it, the classroom film producer has frequently selected such phenomena as what the villi do during the digestive process, or what goes on inside a beehive, or family relationships in China—dynamic phenomena which the average student will never be able to go and look at himself. These the camera can record and quite literally bring to the classroom.

Another contribution which the classroom film makes to the teaching process is to present dynamic generalizations vividly. One of the primary tasks of the classroom film is to make it possible for students to see the forest as well as the trees. It is not enough to know only a series of isolated facts about a given subject. These facts become truly meaningful only if the dynamic generalizations which give them interrelationship and significance are clearly understood. This the film can do with the stroke of an airbrush or a snip of the cutter's scissors.

In making its contribution to the teaching process, the classroom film frequently takes phenomena which are superficially familiar to the audience and then organizes these and presents them in new ways so that the film highlights those aspects that make these phenomena make sense. From a gallery one can see Congress; through a film one can see Congress tick.

Staffing.—In the course of the twenty years that have passed since Mr. Finegan presented his paper on classroom films to you, experience has indicated that a very special type of staff member is needed to produce classroom films that really measure up in the classroom field. In his paper Mr. Finegan made the point that experienced teachers should sit in with writers of classroom films. His point was perfectly valid because it is obvious that only people who are thoroughly and intimately acquainted with the problems and the procedures of classrooms can produce material that is thoroughly useful in classrooms. Since the time that Mr. Finegan presented his paper we have gone a step further and have found that not only

should writers of classroom films sit in with practicing teachers but that *they should themselves be practical teachers.*

Mr. Finegan also points out that cameramen should not be sent out to secure a scene without being accompanied by a director; and in this connection he specified that the director should have sat in with the writer and be thoroughly acquainted with the script. Here, again, the experience of the past twenty years has led us to the logical next step: Just as the writer and the teacher should be one and the same person, so the writer and the director should be one and the same person.

The personnel experience of my own company, Encyclopaedia Britannica Films—or EBF—has been of great value to classroom film producers everywhere. As you will recall, the company was originally founded in 1929 as a Western Electric subsidiary, and was known as ERPI Classroom Films until 1943, when it became affiliated with The University of Chicago through its present parent company, Encyclopaedia Britannica. The personnel standards set up originally and refined in the light of seventeen years' experience have resulted in the development of a brand-new figure in the motion picture world—an individual who is, at one and the same time, an educator, a motion picture script writer, and a motion picture director.

If you tell me that such animals are very rare, I will immediately agree with you. One of the most challenging problems which classroom film producers face is securing the services of men and women who will qualify on all three points: teaching, writing, and directing. The experience of Encyclopaedia Britannica Films has shown that the ideal person for this type of assignment is someone who has had wide classroom teaching experience, who holds at least a Ph.D. degree or its equivalent in the field of his specialty, who has done considerable graduate work in education, and who has been carefully and systematically trained in all the relevant phases of motion picture craftsmanship. At EBF we prefer to give this training ourselves.

After the most careful screening of applicants, we finally select people who seem to show the greatest promise in these directions. They are usually people who have used films fairly extensively in their own teaching experience. They are people who have "been around", they are men and women of substantial academic standing, and they are still young enough to learn the techniques of film language after they come with us. After two or three years of careful and detailed training they are able to operate as unit producers, with complete

responsibility (under the supervision of our Research and Production Departments) for seeing a film through from its earliest inception to the finished 16-mm release print.

Experience has shown since the beginning of instructional sound motion picture making that the writing and producing should be in the hands of a single individual. Writing should not be farmed out to educators who have never made films and producing should not be farmed out to motion picture technicians who have never taught school. Many people have tried to do it that way; and while they have frequently produced films in gorgeous technicolor, schools just have not been interested. A number of classroom film producers had to "lose their shirts" before the field recognized that a classroom film should be seen through from beginning to end by a unit producer who is at one and the same time a teacher, a writer, and a director. It is also recognized today that the unit producer's work should be supervised by Research and Production Departments, headed up, if possible, by veterans in the field of classroom film making. Let us look at these functions of Research and Production.

Research.—The Research Department of an organization making classroom films conducts at least four types of research: Development Research; Continuity Research; Evaluation Research; and Utilization Research.

(1) *Development Research.* Before a classroom film is made and even before the topic itself is chosen, careful and painstaking development research is essential to determine curriculum content, pupil enrollment, current teaching techniques, textbook coverage, and finally, to come out with a decision regarding specific areas where the motion picture would make a definite educational contribution. Research of this type involves far more than a mere statistical survey which could be adequately done by a competent clerk. First rank development research brings a mature educational philosophy and a wide subject-matter competence to bear on statistical facts and trends. When it comes to interpretative educational research of this type, amateurs (even very sincere and well-meaning amateurs) just cannot make the grade.

(2) *Continuity Research.*—Once the topic has been selected, a vast amount of research needs to be conducted in the subject-matter field of the projected film. What holds true for the teacher in the classroom holds true for the writer of a classroom film—he cannot

teach something unless he himself has thoroughly mastered it. And mastery includes more than a superficial acquaintance with the ABC's. Mastery includes an understanding of the topic's relationship to the subject matter which in the teaching process precedes and follows it, and its interrelationships with the rest of the curriculum as a whole.

The unit producer must therefore, in a sense, go to school himself in order to achieve the familiarity with the material which must necessarily precede his writing an acceptable classroom film. In this process he should rely heavily not only on the advice and suggestions of practicing teachers in the field, but also on the guidance of an eminent specialist in the field—someone who is either a national or a world authority. At EBF we call this individual the "Collaborator". Each classroom film should bear the stamp of authenticity which only the sanction of a Collaborator of this type can give it.

After the subject-matter for the film is selected, continuity research involves its organization into acceptable motion picture form. It is here that it becomes essential to have as the writer someone who is at one and the same time a teacher, and a motion picture craftsman. It is impossible to separate the two in the creation of the teaching tool which we call the classroom film.

- (3) *Evaluation Research*.—Both during and after the production of a classroom film, a competent Research Department carries on research to evaluate the success with which the film does its intended teaching job. This involves carefully prepared experiments in actual classroom situations.

The evaluation procedure should be so rigorously set up that the results of these experiments are reflected in the final version of the film or its subsequent editions. The company should have no hesitation in making drastic changes in presentation or in cancelling production altogether if evaluation procedures prove the film to be inadequate.

The Research Department should also keep abreast of and encourage evaluation programs in related institutions, such as colleges and universities. Such a company as Encyclopaedia Britannica Films has had a consultative connection with the conduct of a great many evaluation experiments under the aegis of the country's leading universities.

- (4) *Utilization Research*.—Even though silent teaching films have

been used for over twenty years, and sound films have been used in classrooms for some seventeen years, a great deal of work remains to be done for and with teachers in order to discover the best ways in which this relatively new teaching tool can be used in classroom situations. This type of research we call utilization research, and it should be understood as embracing both classroom films as a whole and specific classroom films in particular. The film "Using The Classroom Film", with which this meeting was opened, is one example of the way in which a responsible classroom motion picture company makes a contribution to proper utilization.

A program of utilization research would include experiments designed to establish the relationship between a given film and the grade level on which it makes its maximum contribution. This is not always easy to do. There is one film in the EBF library which was designed for the first few grades of the primary school, as you will notice immediately I screen it. It is called "Gray Squirrel". And yet this same picture has been used on all levels of the elementary and high school and even in some universities. In fact, a professor of ecology at one of our outstanding institutions has said that, in his judgment, it is the best film on animal ecology ever made; and he regularly screens it before his advanced classes in the subject even though the narration begins as you will hear: "Good morning, Mrs. Gray Squirrel!"

Production.—The responsibilities of a realistically conceived production department in an organization which makes classroom films are determined to a large extent by the peculiar nature of the enterprise. In no sense of the word must the production department of a classroom film company be thought of as concerned exclusively with what one might describe as the technical aspects of picture making. Just as the research department has the final responsibility for the picture's content, the production department has the final responsibility for the picture's form.

It therefore is production's responsibility to see that nothing unproducable gets into the continuity in the first place. It is also production's responsibility to help the unit producer decide on techniques of pictorialization which will utilize the resources of the medium to the utmost. Experience has shown that a continuity should not be regarded as a final shooting script until the production department is ready to add its own approval to that of the research department.

Once the production script has been approved, it becomes the responsibility of the production department to assist the unit producer in his advanced planning which includes costing, location or studio arrangements, casting, and scheduling. In the production stages of the film, the production department should make available to the unit producer, who is directing the picture, the best camera crews and studio facilities and other technical resources obtainable within the budget.

A classroom film is shot in much the same way as any other film, with perhaps two noteworthy exceptions. In the first place, a very great deal of the work has to be done on location. If one is making a film about the pygmies of Africa, one goes to Africa and shoots the pygmies there, and if one is making a film on the production of shoes, one goes to a shoe factory for the purpose. Since the nature of the classroom film calls for a scrupulous attention to detail and a profusion of close-ups in which the camera stays on a process for many feet at a time, the location arrangements call for the utmost in tact and diplomacy. Nobody likes to have his factory disturbed by directors, assistant directors, cameramen, assistant cameramen, electricians, and grips, not to mention dollies, cameras, lights, lengths of cable, and all other paraphernalia of motion picture making. This is especially true if, as in all authentic classroom films, the factory has no monetary interest in the film whatever. People on piece work in such a factory present an especially challenging problem to the director.

Similarly, no scientist likes to have his laboratory routine broken up by film production, unless he is sure that the resulting film will make a definite contribution to education in his field of interest.

The other way in which the production of a classroom film differs from that of, let us say, "Forever Amber", is that we cannot afford the luxury of spending \$300,000 on a production and then calmly scrapping every foot we have shot and starting all over again. When you sell a classroom film at a given figure to a market of a given size, you stay within a budget—or lose your shirt. And staying within a budget means, for example, that you rarely, if ever, even get to see your studio rushes before you strike your sets. The producer of classroom films just does not know what it means to be able to see the rushes of today's shooting tomorrow morning, and to decide to go back and do the whole thing over again if he does not quite like the angle at which someone's tie was hanging in a close-up.

He shoots his scene once with as few takes as possible, and had better do it right, because that is the one and only time he will be able to afford the studio rental and the actors' fees and all the rest of the charges that go into even a single day's shooting. EBF recently completed a picture called "Public Opinion", for which much of the work was done in the studio. It is a fair example of the amount of careful planning and maximum utilization of the few precious hours which the budget allows for studio work.

After the film is shot, the production department of a classroom film company should continue to make available to the unit producer the most competent technical assistance procurable. Film editors and cutters should be people who really know their job; and while the unit producer retains responsibility for the film to the end, he will do what Laurence Olivier did in the production of "Henry V", and regard his film editor as a major colleague. When the classroom film is finally edited and ready for scoring, it should be the responsibility of the unit producer to secure the final approval of the research department and the subject matter collaborator, as well as the production department, before the narration is recorded.

The Market.—In thinking about the market for classroom films, companies in the field have to take a certain number of very hard facts into very careful consideration. To begin with, schools have limited budgets. I need hardly remind you that our schools are shockingly underfinanced.

In the second place, school people are conservative. They are accustomed to doing things in time-honored ways and they are especially allergic to frills and furbelows. It has taken twenty years to persuade even a small proportion of school people that the film is a legitimate teaching tool. A very great deal of teacher-education remains to be done.

But even those school people who are persuaded that the film is indeed a valid teaching instrument are still lamentably under-supplied with projectors. It is no exaggeration to say that of the schools which will be using films regularly ten years from now, only about ten or fifteen per cent have projectors available today.

All this adds up to the fact that schools are "tough to sell". Producers of classroom films should never kid themselves that school people are easy meat for any smart salesman. They just cannot afford to be. That is the main reason why the product had better be good if it is ever going to sell—good, not in terms of what the audience

in a neighborhood movie would call good or some of our long-haired friends would call good, but what practicing teachers on the everyday operational classroom level would call good.

Most schools that use films have by now realized that it is far better to own the prints than to rent them. The very nature of the classroom film makes it necessary for the teacher to have it instantly available at the precise moment when he needs it for the specific work in his class. No teacher is able to foresee months in advance that on a given Thursday morning at 10:30 A.M. he will require such-and-such a film. Yet, if he has to rely on a rental library, this is the type of decision he is required to make. In many of our better school systems, this point is realized so thoroughly that libraries have been established for individual schools rather than for the city as a whole. The day may no longer be too far off when it will be as simple a matter for a teacher to get a film for immediate projection out of the school's film library as it is today to get a reference book for immediate use out of the school's book library.

Already there are countries abroad that are using American made classroom films in large numbers. The Union of South Africa, for example, has been a customer of EBF for the past ten or twelve years, and has purchased many hundreds of both English and Afrikaans language prints of upwards of 150 subjects. One hundred twenty-five subjects have been translated by EBF alone into Spanish and upwards of one hundred into Portuguese. Classroom films in these languages have been distributed in Latin America for a number of years. Other languages into which Encyclopaedia Britannica Films have been translated include, Dutch, Norwegian, Czech, French, Greek, Turkish, Arabic, and Chinese.

Conclusion.—There is one prediction that one can safely make in conclusion: The considerable success which the armed forces achieved during the war with training films has given millions of people an inkling of the teaching potentialities of this medium. Virginia will not be the only state to launch a visual education program with a substantial appropriation. What we are witnessing today is but the dawning of the classroom film era.

CORRECTIVE NETWORKS*

F. L. HOPPER**

Summary.—A type of fully compensated constant resistance network is described which provides a larger family of equalization characteristics particularly suited to corrective use in rerecording as determined by aural monitoring.

Constant-resistance networks have found widespread application to equalization problems encountered in the motion picture industry. Such networks are used in recording systems for original dialogue and musical recording, and to a far greater extent in the rerecording process. The use of such networks has been discussed previously, and the design work undertaken has pointed to the desire for networks which afford a maximum degree of usefulness.¹⁻⁴

Generally, networks may be divided into two classes: those which have characteristics for specific application, such as dialogue equalization, film loss compensation, and modulator equalization; or those which are intended for corrective use (determined largely by aural monitoring of the material with the introduction of sufficient equalization to improve the sound quality or balance) or to provide other changes in quality to produce certain dramatic effects.

In the field of compensation may be included the correction of defects caused by the acoustical conditions surrounding the point of pickup, variations in microphone pickup which may cause apparent variations in an actor's voice, or the interfering effects of wind, stage, or other unwanted noises. Correction for dramatic effects will usually require the ability to raise or lower certain discrete frequency bands in amplitude. These problems are not only encountered in sound recording on film, but in the fields of disk recording, radio broadcasting, and television.

The choice of a particular type of network depends upon the required insertion loss, the impedance of the circuit in which it is to

* Presented Oct. 22, 1946, at the SMPE Convention in Hollywood.

** Electrical Research Products Division, Western Electric Company, Hollywood.

operate, and the reaction of the network's impedance characteristic upon the frequency response of the equipment associated with it.

The last factor is of considerable importance when a network is connected to the input circuit of an amplifier, since frequently the amplifier response is altered when working into an incorrect or varying impedance. A comparable condition may exist when a network is operated on the output of an amplifier, particularly if the amplifier output stage contains pentodes. In addition, if a number of networks are to be connected in tandem, the constant-resistance structure must be terminated ideally if terminal effects are to be made negligible.

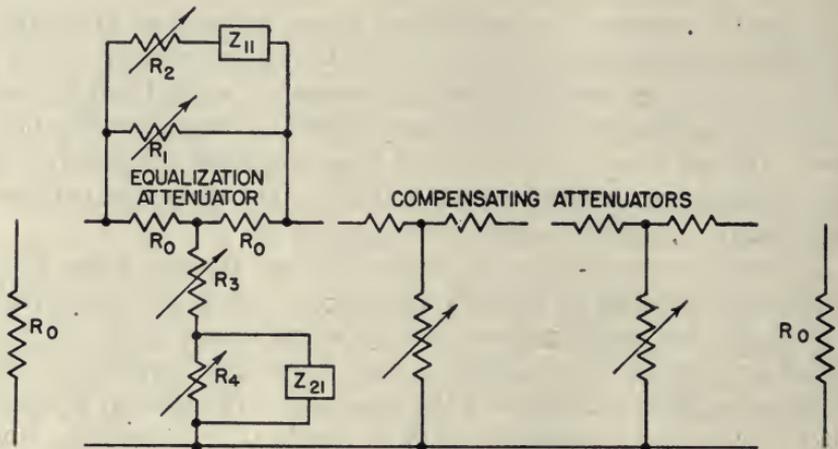


FIG. 1. Equalizer schematic.

Several constant-resistance networks in tandem will add their respective loss characteristics without interaction, provided they are designed for the same nominal terminating resistance, and are actually terminated in this resistance at one end. If neither end is well terminated, or if some nonconstant resistance network is included in the chain, the over-all loss characteristic will show interaction effects. The generally desirable features of networks of this type have resulted in their nearly universal use for modifying response characteristics in sound recording processes.

The type of constant resistance structure to be considered in this paper is included in the previously mentioned classification of corrective networks whose equalization characteristics in frequency and amplitude are primarily judged on the basis of aural monitoring of

the material in question. This type of network has taken two general forms: (1) a resonant circuit providing a broadly tuned characteristic which may be either additive or subtractive in its effect; or (2) shelf-type characteristics effected through the use of complementary sets of simple impedance elements; *e. g.*, an inductance and condenser. Various tuning frequencies for the resonant sections may be selected to conform to individual desires.

A specialized form of constant resistance structure which has desirable features will be described. A network of the type shown in Fig. 1 may be so designed that the half loss, *i. e.*, one-half of the total equalization for any attenuator setting, occurs at the same frequency. In this respect the network follows the same general design as that described by Miller and Kimball.² Such a network provides a family of equalization curves for various attenuator settings which do not overlap, provided the network is in series with a suitable compensating attenuator section. This is necessary since the equalizer's insertion loss is not constant for the various steps of the attenuator affording the variable equalization.

Since additive and subtractive conditions of equalization require different degrees of attenuation compensation, if the equalization is to occur plus and minus about a common reference, effectively three separate attenuators are required. One attenuator is associated with the impedance elements, and the other two provide the compensating functions. For purposes of convenience, in order to avoid the separate adjustment of three individual attenuators, the three attenuators may be ganged so that a common control will operate all three simultaneously.

Complementary equalization curves for additive and subtractive conditions utilizing the same impedance elements, except transposed, will occur only when the maximum equalization is 8.36 db. Since this is an odd figure, it appeared more convenient to choose 10 db as the maximum amount of equalization, and to accept the slight discrepancy in complementary characteristics so caused. The advantage of transposing impedance elements for additive and subtractive conditions is obvious, since it halves the required number of elements.

The design requirements may then be summarized as follows:

- (1) The network should provide both additive and subtractive types of equalization.

- (2) The degree of equalization about a reference should be ± 10 db, adjustable in 1-db steps.
- (3) Compensation to offset variable insertion loss for different amounts of equalization should be included.
- (4) Means should be provided to utilize only one set of impedance elements (tuned to the chosen frequency), with switching to transpose elements for the additive and subtractive conditions

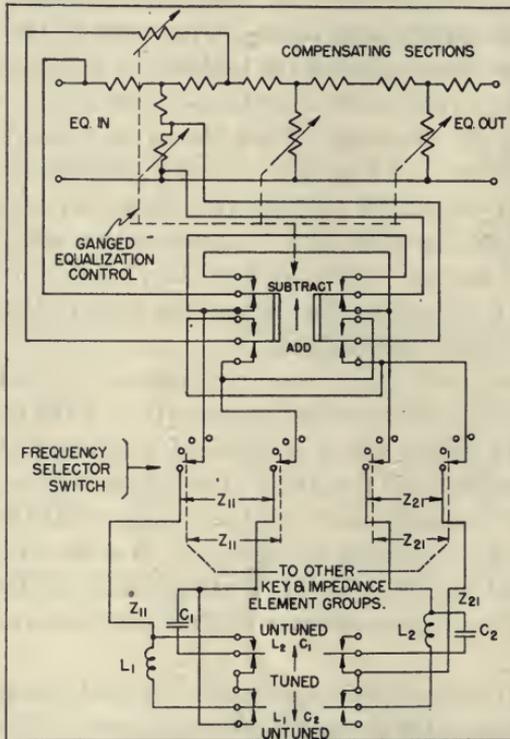


FIG. 2. Equalizer circuits.

In addition, switching should be provided to utilize single inverse elements of the series and parallel connected impedances in order to obtain the untuned or shelf-type characteristics.

- (5) It would be desirable to employ a ganged attenuator so that automatic compensation for insertion losses will occur, and that the attenuator be so constructed that both additive and subtractive equalization will result from rotation of one dial.

With such an equalizer, two methods of assembly may be provided. Considering the ganged attenuator and a switch for obtaining tuned

and untuned conditions as a basic unit, various impedance element groups tuned to selected frequencies may be individually selected by means of an additional switch and be connected to the one attenuator. This provides the choice of many equalization characteristics, only one of which may be used at any one time. If the rerecording practice requires use of several identical characteristics simultaneously, then the better method would appear to be to associate only one set of impedance elements with each attenuator, or to restrict the choice of various tuning frequencies to a smaller number. In any event, the flexibility of arrangement is great, and elements can be assembled to meet a variety of operating requirements.

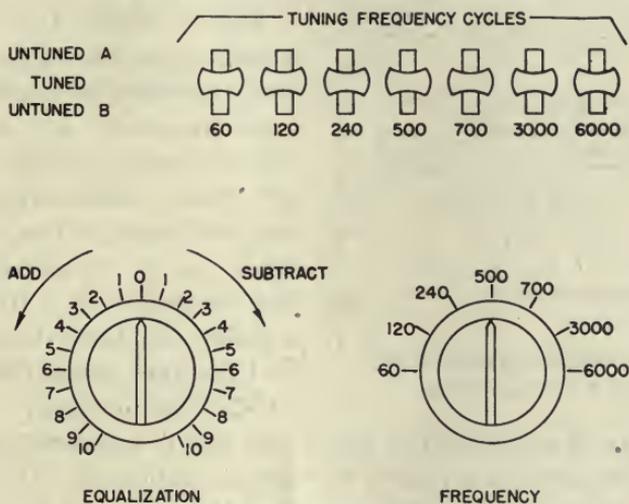


FIG. 3. Control panel.

An equalizer assembly embodying these principles is now described. A single attenuator providing the functions indicated in Fig. 1 is arranged so that rotation in either direction from a midpoint affords additive or subtractive equalization. The compensating attenuators are ganged with the equalizer portion of the attenuator so that a single knob controls the three functions. A simplified circuit schematic is shown in Fig. 2. Here the impedance elements are associated with a switching key so that the resonant circuit elements may be connected respectively as:

- (1) Tuned resonant and antiresonant circuits, L_1C_1 and L_2C_2 ;
- (2) Untuned, using complimentary impedances L_1C_2 , or impedances L_2C_1 , to obtain shelf-type characteristics.

As many keys and sets of impedance elements may be employed as desired. Normally, six to eight different tuning frequencies would appear to be adequate, and the frequencies might be chosen on an octave basis. All sets of keys and impedance elements connect to a frequency-selecting switch so that a choice of frequency may be made. The output of this switch connects to a transposing key which transposes the Z_{11} and Z_{21} , impedance elements for the additive and subtractive conditions. This key is operated by a cam attached to the ganged attenuators. Thus, in operating the single-dial equalization control, the impedance elements are transposed automatically. Connections from this key then connect the generalized impedances to the attenuator. A possible form of control panel is shown in Fig. 3.

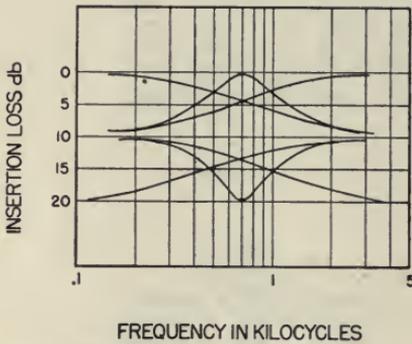


FIG. 4. Characteristics.

Fig. 4 shows the maximum equalization curves for additive and subtractive conditions for one frequency for the tuned characteristics and the two types of shelf characteristic. The nominal insertion loss of the network for no equalization, *i. e.*, flat transmission, is 10 db. All equalization takes place ± 10 db in 1-db steps about the base line (10-db insertion loss).

This type of equalizer has many uses and is sufficiently flexible in design to be used in a variety of ways, as indicated. It is compensated for varying insertion loss so that the family of curves do not overlap and equalization occurs plus or minus about a reference base. The various types of equalization provided, *i. e.*, the tuned and shelf-type characteristics, are particularly adapted to corrective work undertaken on the basis of aural monitoring.

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Appendix

Referring to Fig. 1, for the condition of maximum equalization $R_2 = \text{zero}$, and $R_4 = \text{infinity}$: The remaining resistance elements R_1R_0 , R_0 , and R_3 form a conventional bridged- T type pad. It has been shown¹ that the resistance-values for the bridged- T type pad may be computed from the equation

$$Z_{11} = R(e^\alpha - 1) \tag{1}$$

where Z_{11} corresponds to R_1 , and α is 0.23 times the insertion loss of the pad in db. The value of R_3 may be determined from the relationship

$$R_1 \times R_3 = R_0^2 \tag{2}$$

The maximum insertion loss of the complete equalizer is given by

Maximum insertion loss db =

$$\sqrt{\text{Equalization step db} \times \text{Maximum equalization db.}} \tag{3}$$

For an attenuator having a maximum loss of 10 db, the insertion losses for various steps of equalization are as follows:

Equalizer Step in db		Insertion Loss db
1	$\sqrt{1 \times 10}$	3.16
2	$\sqrt{2 \times 10}$	4.47
3		5.48
4		6.32
5		7.07
6		7.74
7		8.36
8		8.94
9		9.48
10	$\sqrt{10 \times 10}$	10.00

As an example, consider a network having a maximum insertion loss of 10 db. The equalization by (3) for this condition is also 10 db. R_1 by Eq (1) for a 600-ohm circuit is

$$R_1 = 600(e^{0.115 \times 10} - 1) = 1295 \text{ ohms}$$

$$R_3 \text{ from Eq (2) is}$$

$$1295 R_3 = 600^2$$

$$R_3 = 278 \text{ ohms}$$

For say, 5 db of equalization, the insertion loss is 7.07 db, from Eq (1)

$$R_1 = 600(e^{0.115 \times 7.07} - 1) = 753 \text{ ohms}$$

$$753 \times R_3 = 600^2$$

$$R_3 = 478$$

R_2 for the 5-db equalization condition may be computed as follows:

Let R_p be the parallel resistance of R_1 and R_2

$$R_p = R_0(e^\alpha - 1) \tag{4}$$

The loss α represents in this case the difference between the insertion loss and the equalization, or $7.07 - 5 = 2.07$ db and $R_p = 600(e^{0.115 \times 2.07} - 1) = 161$

ohms. R_1 previously computed for the 5-db equalization condition was 753 ohms; hence

$$\frac{R_2 750}{R_2 + 750} = 161 \text{ and } R_2 = 205 \text{ ohms}$$

R_2 and R_4 are complementary; hence

$$\begin{aligned} R_2 \times R_4 &= R_0^2 \text{ or } 205R_4 = 600^2 \\ R_4 &= 1755 \text{ ohms} \end{aligned}$$

The values of Z_{11} and Z_{21} may be computed in the manner outlined,¹ together with the insertion-loss characteristics for the maximum attenuator loss, 10 db, which is also equivalent to the maximum equalization.

DISCUSSION

MR. R. WILSON: All of these equalizers are designed to distort frequency characteristics, but do they add any other form of distortion because of phase shift?

MR. HOPPER: So far as I know the constant resistance network has very little phase shift. We have made extensive tests in the past in which a large amount of phase shift was introduced to see whether it had a great deal of effect on quality. I do not believe anyone was ever able to observe that it did. The constant resistance network provides a volume distortion, it is true, because it alters the distribution and amplitude of the components. But aside from that form of distortion, I do not believe there is anything else.

MR. JOHN HAWKINS: Has anyone made a survey of the various rerecording equalizers used in sound picture recording?

MR. HOPPER: I can speak only generally about these types of shelf and tuning characteristics used in Western Electric equipment. Networks of this or similar types are used by MGM, Fox, and Paramount for corrective equalization. There seems to be more discrepancy in the filter or equalizer used to simulate some particular source of sound, such as a radio or telephone.

MR. F. J. GRIGNON: I would like to say one thing here about the possibility of using the tuning frequencies spaced in octaves. Experience would seem to indicate that at the higher frequencies it is better to reduce the interval, rather than jump from 3000 to 6000 cycles, for example.

A PROJECTION REEL OF IMPROVED DESIGN*

ELLSWORTH S. MILLER**

Summary.—It is generally conceded that the present $\frac{5}{16}$ -in. diameter shaft and $\frac{1}{8}$ -in. drive key on present film reel handling equipment such as magazines, rewinds, etc., are inadequate to support and drive 2000-ft reels of 35-mm film. Much unnecessary film damage is caused by the reel wobble, backlash, and poor alignment caused by this situation. This paper describes an improved reel design featuring a 1-in. diameter splined hub shaft opening and an automatic ball and groove locking device to provide accurate lateral alignment and eliminate manually operated keys on reel shafts.

To reduce film shipping damage, a design is suggested for an exchange reel shipping case with a center shaft passing through the 1-in. openings in the hubs of the new reels.

Introduction.—The technical literature of this industry contains numerous references to the early days of motion picture projection when it was customary to run the projected film off into a barrel or sack, later to be rewound onto the shipping reels. This practice was occasioned at least partly by the fact that the early projectors were manually driven; the load imposed by a slipping take-up clutch would have been an additional burden on the operator who was already as busy as the proverbial paper hanger. With the advent of motor drives for projectors, this situation changed. It became practical to wind the projected film directly on reels as it came from the projector. It was natural to use for this purpose reels of generally the same size and construction as those used for handling and shipping the film; and as a matter of fact, larger reels were prohibited in many localities by the fire hazards resulting from poor construction of magazines and of film handling and storage containers.

As fire hazards were reduced by improved projector, magazine, and container designs, the restrictions on reel size were gradually relaxed. Reels capable of holding approximately 2000 ft of film came into use and, for a time, 3000-ft reels were used to some extent. The 3000-ft reels eventually were found to be impractical, partly because of the

* Presented Oct. 22, 1946, at the SMPE Convention in Hollywood.

** Detail Production Company, Detroit, Mich.

increased fire hazard, partly because they were excessively heavy to handle, and to a large extent, because the shafts and drive keys of existing film handling equipment were entirely inadequate in size and strength to operate such reels without very rapid wear.

It is generally conceded that the $\frac{5}{16}$ -in. diameter shaft and $\frac{1}{8}$ -in. drive key on present film reel handling equipment such as magazines, rewinds, *etc.*, are inadequate to support and drive even 2000-ft reels of 35-mm film. They are a hangover, so to speak, from the days of 1000-ft reels; and they directly and indirectly cost the industry many thousands of dollars every year in lost show time, ruined

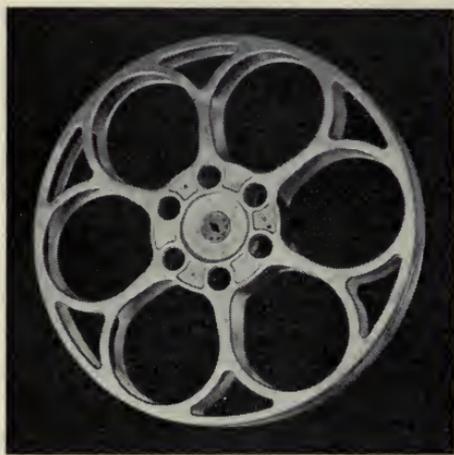


FIG. 1. Complete Millereel, showing adapter in place.

projection equipment, and heavy film damage. The overloaded shafts wear loose in their bearings and wear out the shaft holes in projection reels to cause dangerous reel wobble and serious misalignment. The undersized drive keys wear thin or break and chew out the keyways in reel hubs to cause backlash between the take-up shaft and the driven reel. This backlash may become so great that the reel goes into rotation with a heavy jerk when the machine is started, thus pulling out

film sprocket holes or actually ripping the film apart.

The turnover latches at the ends of present reel shafts are other offenders. They are relatively ineffective at anchoring the reels to the shafts in good alignment and in even the best designs, spring breakage and hinge failures are common, simply because the shaft diameter is too small to permit construction of sufficient strength to withstand heavy-duty service.

Design and Construction.—The projection reel which is the subject of this paper, and which is now being marketed under the trade name of "Millereel", was designed to overcome immediately some of these imperfections and to permit the eventual use of more adequate shaft dimensions in newly designed film handling equipment. This reel is shown in Fig. 1. Its outstanding design features are the 1-in.

diameter shaft opening in the hub having ten longitudinal splines to engage similar splines on the mounting shaft, and an internal spring-tensioned detent ball to engage a turned locking and center groove in the shaft to align the reel positively on the shaft laterally and to provide for automatically locking it in the correct position. The ten intersecting spline sections in the reel hub and on the shaft provide means for transferring the torque at the shaft to the reel with virtually no lost motion and with the loading spread over such a large area of contacting surfaces that the chance for wear on the surfaces is reduced almost to the vanishing point. The shaft and the reel hub, in effect,

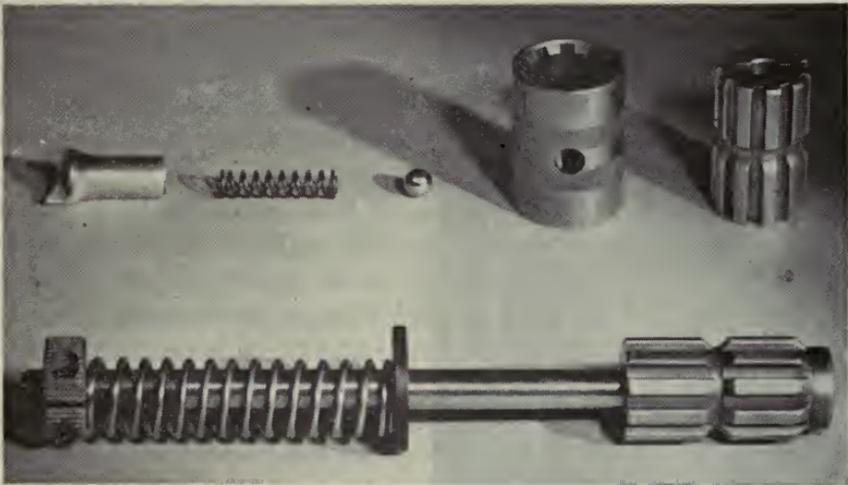


FIG. 2. Component parts of Millereel hub assembly and shaft.

become one piece of metal when the reel locks into place, for during manufacture, the hubs and shafts are held to dimensional tolerances sufficiently close to produce a maximum clearance of two-thousandths of an inch, which is entirely adequate to permit the reels to be easily put in place and removed from the shaft but allows no perceptible play in any direction after the detent ball drops into the centering and locking groove.

Details of the hub and locking device construction are shown in Fig. 2. The detent ball and spring operate in the tube which may be seen next to the reel in the figure. The rear end of this tube is pinched shut and then is milled to a semicircular contour to bear against one of the spacers between the two halves of the reel. The opposite end enters the counterbored hole visible in the splined hub for

the reel; the steel detent ball protrudes through a smaller hole between one pair of splines to engage the locking and centering groove of the shaft. The spline ends on the shaft are tapered and their corners are bevelled to guide the hub splines smoothly into engagement with the shaft splines as the reel is placed in position. It is obvious that the engagement may be made in any one of ten different angular positions of the reel with respect to the shaft, thus permitting the reel to be put into position with a film slot upward without the necessity for the usual spinning operations to align key slot and key, and to bring a film slot to the preferred threading position. This apparently minor matter is actually a considerable operating convenience.

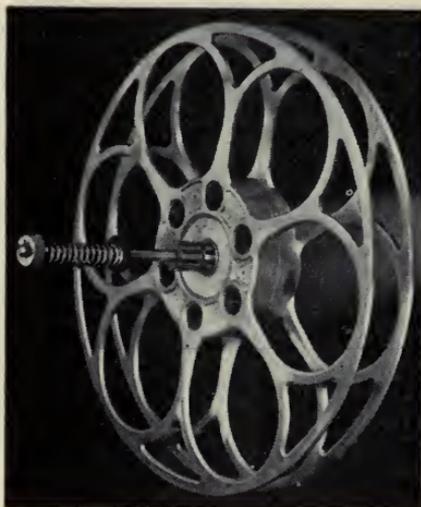


FIG. 3. Millereel (adapter removed) showing new-style shaft in place.

A still greater convenience, and one which contributes to increased safety in operation, derives from the fact that the reel is automatically locked to the shaft by the detent action as it is pushed into position. There is no manually operated reel lock to be overlooked with possible disastrous results during the running of the reel, and the hand operation of turning the reel lock is eliminated. Correct lateral positioning of the reel on the shaft is assured and the spring action of the

detent mechanism permanently eliminates lateral end play between reel and shaft. Such end play is often the cause of severe film damage, since it may disturb alignment sufficiently to pull the film off the soundhead's holdback sprocket or pull patches apart because of interference between the reel flanges and the edges of the moving film.

The new reel is constructed of two identical half sections which are aligned and are firmly locked together by compound spacer members within the film hub center section of the reel. The matching faces of the film hubs and of the three internal spacer bosses are accurately machined to a height which will give the required 1.58-in. width at the hub's film bearing surface. The bosses are bored out to take tubular, tapped inserts which are somewhat shorter than the over-all reel

thickness. Flat-head Phillips screws seating in the reel halves and entering the tubular inserts draw the two sections of the reel tightly together, with the inserts providing the necessary alignment action.

The reel half sections are fabricated from lightweight but strong cast aluminum alloy. All edges are smoothly rounded to protect both the film and the projectionist's hands. The hub sections have six $\frac{7}{8}$ -in. diameter finger holes equally spaced on a radius which permits them to be used not only for handling the reel but also as anchor points for use in disengaging the reel from the splined shaft hub. The hub splines terminate about $\frac{1}{4}$ in. from the outer end of the hub, leaving thus a plain hub extension of this length to serve as a release "button". Two fingers anchored in the holes, with the thumb pressing on the shaft hub, apply the necessary force to disengage the detent ball from the center and locking groove and thus release the reel from the shaft hub. The action is easy, straightforward, and natural, and it is much more rapidly done than the more complex one of lifting a turnover locking device and then grasping the reel for removal.

The diameter of the reel's film hub is 5 in. and the flanges are 15 in. in diameter, giving a film capacity of 2070 ft. At a film speed of 90 ft per min., the reel thus allows for a run of 23 min. The film hub is provided with three equally spaced $\frac{1}{16}$ -in. milled lateral film anchoring slots.

An obvious, though important, advantage in having the reel consist of two identical half sections lies in the fact that accidental damage to one flange does not necessitate complete replacement of the entire reel. As was mentioned in the discussion of the splined shaft and hub design, manufacturing tolerances on all matching components are being held to the small values required to permit ready field interchangeability of all reel parts without hand fitting. The over-all design and construction are of such ruggedness as to withstand easily the rough handling projection reels frequently get, but in the event of actual damage, the broken part may be replaced with little effort and at moderate cost.

Adapters.—It is almost axiomatic in this industry that improved equipment designs and new processes, to be successful, must be capable of being used with existing associated equipment items or in combination with existing processes, at least during a transition period of more or less extended duration. This is partly because of the psychological difficulty involved in getting the industry to agree about anything, and partly because of the physical impossibility of

getting the whole motion picture "plant" equipped with anything new overnight.

With this thought in mind, the new reel design has been provided with an adapter to permit the reels to be used on existing film handling equipment without the need for changing it in any manner. Other adapters consist of replacement shafts for various film handling equipment items, such as specific makes of magazines and rewinds. Such shafts are obviously limited in diameter to the dimension which will enter the bearings of the apparatus in which they are to be used, but they do carry the splined shaft hub which permits many of the advantages of the new reel design to be secured at once.

The adapter which makes the new reel directly interchangeable with older designs is shown in Fig. 2 directly to the right of the internally splined reel hub. It is a cylindrical machined piece having external splines to mate with those of the hub, a turned locking and centering groove, and a center bore with duplex keyways to fit the $\frac{5}{16}$ -in. shafts and $\frac{1}{8}$ -in. keys of existing film handling equipment. By use of these adapters, a theater may gradually replace older reels with those of the improved design until such time as a complete working set of the new reels is on hand, at which time the shafts of the existing film handling equipment may be replaced, or the equipment itself may be replaced with new units having adequate-sized shafts. A replacement shaft for Simplex upper magazines is shown in Fig. 2 next to the other items.

Fig. 3 is another view of the reel, showing it partially in place on the splined shaft end. This view also shows clearly the flange and film hub design and illustrates how corners and edges likely to touch either the film or the projectionist's hands have been rounded off to make the reel exceptionally safe to use.

Reel Shipping Containers.—Probably the roughest handling film gets takes place as it journeys between exchanges and theaters. Present practice has the reels of film squeezed side by side into closely fitting metal containers for these trips. The only support for the loaded reels comes from the container walls *via* the reel flanges and *via* their stacked hubs. It is no wonder, therefore, that both the reels and the film are frequently damaged, for the more or less rigid hubs in close contact cannot entirely prevent the necessarily somewhat flexible flanges from bending enough to transmit large forces to adjacent reels and hence to the film edges. Furthermore, the flanges cannot practically be made rugged enough always to withstand the

heavy radial stresses which occur when containers are accidentally dropped.

The one-inch diameter shaft opening in the new reel design makes possible the construction of a shipping case for loaded film reels which would almost completely eliminate the kind of reel and film damage just outlined. The case will have a central supporting shaft passing through the reel hub shaft openings to support the reels within the case with about $1/2$ -in. clearance between the walls and the reel flange edges. In this manner, the flanges would be protected against all radial strain and by the use of semiresilient spacers between adjacent hubs, they could likewise be protected against strains which would otherwise be transmitted from one flange to another. With the necessity for jamming the reels tightly into the container eliminated, the present expensive and inadequately strong split construction could be abandoned in favor of much simpler and more rugged covered metal boxes. Much handling time would be saved in addition to the savings produced by lessened film and reel damage. Nearly everyone who has had occasion to handle film at one time or another has encountered reels so tightly stuck in their containers that almost heroic measures were needed to get them out for use. All too frequently such measures ruin the container or the reel, and sometimes also damage the film.

A film reel shipping container for the new reels along the lines just discussed is now being designed and should shortly reach the equipment market. Design models are being tested thoroughly under the most adverse possible conditions, and it is felt that the ultimate production models will represent a completely satisfactory solution to the problem of how to protect loaded film reels adequately in transit.

Reels for Other Film Sizes.—While the new reel design is currently being manufactured in only the 2000-ft size for 35-mm film, its advantages become of even greater importance when the problems involved in the handling of the proposed wider films are considered. The positive drive and automatic centering and locking features of the new design would be of extreme usefulness, and the shafts in film handling equipment could be made fully adequate in diameter to support the increased weight of the wider film.

There is a need now, and it is planned to meet this need soon, for improved 16-mm film reels of large diameter to carry the longer shows. In many respects, the driving problem is even more severe than it is in the case of reels for the wider films, for the 16-mm reels cannot

have nearly the same bearing contact with the shafts even though their outside diameters may be greater than those of reels for the wider films. The splined shaft and hub construction offers an excellent solution to this problem; and, of course, the other advantages of the new design are equally beneficial.

Conclusion.—It is hoped that this outline of the principal features of the improved reel design will serve to call its merits to the attention of those responsible for the design of other equipment items involved in the handling of film. The returns to the designer and manufacturer in this instance are far overshadowed by the possible benefits to the industry resulting from improved performances and reduced damage to films.

CURRENT LITERATURE OF INTEREST TO THE MOTION PICTURE ENGINEER

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

American Cinematographer

- 27, 12 (Dec. 1946)
The M-R—A New Super High-Intensity Carbon Arc Lamp (p. 438) P. MOLE
28, 1 (Jan. 1947)
Fastax High Speed Camera (p. 7)
Staging Musical Routines for Camera (p. 8) H. A. LIGHTMAN
Development of the Cinematographic Art (p. 10) J. V. NOBLE
28, 2 (Feb. 1947)
Recent Developments in Photographic Optics (p. 44) W. B. RAYTON
Photographic Highlights of 1946 (p. 46) G. E. MATTHEWS
Mood in the Motion Picture (p. 48) H. A. LIGHTMAN
Ansco's New Film for Use in Color Motion Picture Production (p. 65)

British Kinematograph Society, Journal

- 9, 4 (Oct.—Dec. 1946)
Future of the Sub-Standard Film:
1. In Commerce (p. 122) W. G. WRIGHT
2. In Education (p. 124) H. E. DANCE
3. In Scientific Research (p. 126) R. McV. WESTON
Basic Principles of Sound for 16-Mm:
1. Acoustic Aspects (p. 130) P. G. A. VOIGHT
2. Film Recording (p. 131) N. LEEVERS
Demonstration of New Equipment:
Rapid Film Processing Tank (p. 135) S. S. WEST
Shutter Timer (p. 136) S. S. WEST
Exposure Timer (p. 138) S. S. WEST
An Almost Distortionless Amplifier (p. 139) H. J. LEAK
An Indicating Color Comparator (p. 140) D. M. NEALE

Ideal Kinema

- 13, 138 (Jan. 1947)
Technical Progress in the First Year of Peace—
Further Developments Which Lie Ahead (p. 25) R. H. CRICKS

British Contributions to Kinematograph Technique—

A Newman Memorial Lecture (p. 28)

R. H. CRICKS

An Australian-Designed Arc Lamp—Feature of the Latest Model "Tru-Trim" (p. 33)

International Photographer

18, 11 (Dec. 1946)

History of Bi-Pack Photography (p. 5)

W. T. CRESPINEL

The Art Reeves Camera (p. 6)

S. E. GREENWALD

Improvement for Process Department (p. 7)

J. ALTON

Largest Outdoor Screen (p. 18)

The Mitchell "16" (p. 20)

C. SULLIVAN

High-Speed 16-Mm Developing Introduced by Chroma-Tech Lab. (p. 22)

19, 1 (Jan. 1947)

Lumenized Lenses (p. 6)

Studio Technique in Television (p. 18)

D. C. BIRKINSHAW AND
D. R. CAMPBELL

International Projectionist

21, 12 (Dec. 1946)

Bubbles in Lenses (p. 9)

K. PESTRECOV

The New Motiograph AA Projector (p. 12)

E. WIENKE

A Six-Phase, Full-Wave Rectifier (p. 16)

M. CHAMBERLIN

22, 1 (Jan. 1947)

Magnetic Recording (p. 7)

H. E. ROYS

What Color-Correction Means (p. 10)

A. E. MURRAY

Incandescent Lamps for Film Projection (p. 14)

J. J. A. MANDERS

The Trivision Three-Dimensional Process (p. 17)

Photographic Society of America, Journal

13, 1 (Jan. 1947)

The Relative Corrosion Effect on Stainless Steels of Rapid Fixing Baths Containing Ammonium Chloride and Ammonium Sulfate (p. 30)

L. E. MUEHLER AND
J. I. CRABTREE

RCA Review

7, 4 (Dec. 1946)

Simultaneous All-Electronic Color Television (p. 459)

Frequency Modulation Distortion Caused by Common- and Adjacent-Channel Interference (p. 522)

M. S. CORRINGTON

Recording Studio (p. 634)

G. M. NIXON

Television—A Bibliography of Technical Papers by RCA Authors 1929–1946 (p. 641)

Radio News

37, 2 (Feb. 1947)

All-Electronic Color Television (p. 7)

The Reproduction of Disc Recordings (p. 13)

J. D. GOODELL

Some Possibilities in Stereophonic Broadcasting
(p. 18)

H. E. ENNES

Tele-Tech

6, 2 (Feb. 1947)

Design of Recording Studios for Speech and Music
(p. 37)

G. M. NIXON AND J.
VOLKMANN

Thomascolor for Television (p. 66)

SOCIETY ANNOUNCEMENTS

ACOUSTICS FOR RECORDED AND REPRODUCED SOUND

James Y. Dunbar, acoustic engineer for Johns-Manville Sales Corporation, New York, presented a discussion on "Space Acoustics for Recorded and Reproduced Sound" before the Atlantic Coast Section of the Society at its February 19 meeting. Mr. Dunbar discussed the basic principles of acoustics, outlining his ideas as to how acoustics developed through the ages as vocal and musical presentations were increasingly presented in enclosed spaces.

Mr. Dunbar also outlined specific applications to motion picture theaters, broadcast, recording, and television studios. He described some of the latest applications of materials now in use and various types of treatment that have proved to be most suitable.

In the discussion period which followed Mr. Dunbar's talk a great many questions were asked by Section members and guests indicating a wide interest in the subject of acoustics. About 200 attended the meeting, held at the Hotel Pennsylvania, New York.

AUTO-COLLIMATOR AND SLIDE PROJECTOR DESCRIBED

Malcolm G. Townsley, chief research engineer of Bell and Howell Company, Chicago, discussed aspects of his paper, "Auto-Collimator for Precise Measurement of Flange Focal Distance of Photographic Lenses", which was recently published in the *Journal* of the Optical Society of America, at the February 13 meeting of the Midwest Section in Chicago. Mr. Townsley explained details of the system relating to camera testing. It was pointed out that this system gives twice the accuracy of reading the focal plane position compared with any other method, such as the telescope or microscope test. An explanation was given of the method of determining the film position during running of the film. The instrument was demonstrated by Mr. Townsley following the meeting.

The second speaker was Paul C. Foote, also of Bell and Howell, who gave a discussion on "Modern Slide Projector Design". The problems of general optical design, including filament size, reflector position, heat filters, and slide temperature, were described in detail and their application to the two new Bell and Howell 2 X 2-in. slide projectors were discussed. The 300-watt projector was presented as a relatively long design of condenser system, allowing natural draft cooling.

The 750- and 1000-watt projector uses a close-coupled condensing system and down-draft cooling over the base-up lamp enabling fresh air intake over the slide. The larger projector was used for the slides during the talk, and was demonstrated after the meeting.

An inspection of the Lincolnwood plant of Bell and Howell was conducted for the Section members and guests, under the direction of C. E. Phillimore.

MIDWEST SECTION JOINS ENGINEERING COUNCIL

The Midwest Section of the Society has become affiliated with the Chicago Technical Societies Council, organized to promote general engineering activities and to publicize meetings held by technical societies in Chicago. Membership in the Council is held by 46 national and local technical groups, and their various activities are announced in Sci-En-Tech News published monthly by the Council.

PHOTOELECTRIC SPECTROPHOTOMETER

The Pacific Coast Section of the Society, at its meeting on Feb. 11, 1947, heard a paper on "Spectrophotometry" by Dr. Arnold O. Beckman and Robert Moulton of the National Technical Laboratories, South Pasadena, Calif. Mr. Moulton, who read the paper, described a quartz photoelectric spectrophotometer and explained its application to the color analysis of solids, liquids, and gases by both transmission and reflection. Although this instrument was not specifically designed for motion picture work, some ideas on its application were presented.

During the discussion period, which was led by Dr. Beckman, Allen Gundelfinger of Cinecolor explained some of the specific applications in his laboratory for an instrument of this type.

A 16-mm motion picture in color devoted to the general subject of color analysis, shown through the courtesy of General Electric Company, dealt with the use of a spectrophotometer in this field.

About 130 members and guests attended the meeting, held in the review room of Western Electric Company, Hollywood.

NEW LETTER SYMBOLS FOR CHEMICAL ENGINEERING

A new American Standard covering 163 letter symbols designed to give chemists and chemical engineers a uniform system of "shorthand" for use in their mathematical calculations has been completed and is now ready for distribution.

The new group of symbols is designed to provide the chemist and the chemical engineer with an agreed group of letter symbols which will permit a new degree of uniformity in writing and discussion of chemical problems, particularly in textbooks, scientific papers, lectures, and the like.

The symbols covered in the new work, which is part of a much larger American Standards Association project in the whole field of letter and graphical symbols already agreed on or under development, are defined as follows in the standard:

"A letter symbol is a single character, with subscript or superscript, if required, used to designate a physical magnitude in mathematical equations and expressions."

The symbols included in the present standard cover only the field thus defined and are not to be confused with those designating chemical elements or groups.

In addition to a section covering 83 such general concepts as acceleration, diffusivity, entropy, molecular weight, surface tension, thermal conductivity and others, the new standard has special sections dealing with terms relating to heat transmission, flow of fluids, evaporation, humidification, dehumidification, gas absorption and extraction, distillation, drying, sedimentation, filtration, screening and sampling, crystallization, centrifugation, and also various dimensionless numbers used by chemists.

The new standard, designated as *Z10.12*, was developed under a representative committee of which J. H. Perry, technical investigator, development department, E. I. du Pont de Nemours, was chairman, and it is available from the American Standards Association, 70 East 45th Street, New York 17, N. Y., at 50 cents per copy.

NOMINATIONS FOR ANNUAL ELECTIONS

A Committee on Nominations has been appointed by President Ryder, in accordance with By-Law VII of the Constitution and By-Laws, to recommend nominations for offices expiring December 31, 1947. General elections are held prior to the October convention; offices expiring and incumbents are given on the reverse of the contents page of this issue of the JOURNAL.

Voting members of the Society (Honorary, Fellow, and Active) are invited to submit recommendations for candidates to the Nominating Committee, sending names to the Chairman, E. A. Williford, 230 Park Ave., New York 17, N. Y., or to members of the committee as follows: Emery Huse, E. I. Sponable, H. W. Moyse, J. W. Boyle, E. W. Kellogg, K. F. Morgan, J. K. Hilliard, and M. G. Townsley, whose addresses are given in the last Membership Directory.

Only Honorary, Fellow, and Active members may hold office. A report of the Nominating Committee will be submitted to the Board of Governors at the July 1947 meeting.

EMPLOYMENT SERVICE

POSITION WANTED

Film Editor, 20 years' experience in newsreel and educational film production, and dubbing work, both 35-mm and 16-mm. Desires connection with motion picture organization. Member Film Editors' Union Local 771. Write Louis L. Hess, 174 East 96th St., New York 28, N. Y.

Terry Ramsaye, Editor of the Motion Picture Herald, says.

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	Technicolor Cinematography.....	Winton Hoch
III	Special Photographic Effects.....	Fred M. Sersen
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Indexes to the semiannual volumes of the JOURNAL are published in the June and December issues. The contents are also indexed in the *Industrial Arts Index* available in public libraries.

JOURNAL
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- *WESLEY C. MILLER, MGM, Culver City, Calif.
- **HOLLIS W. MOYSE, 6656 Santa Monica Blvd., Hollywood.
- *†A. SHAPIRO, 2835 N. Western Ave., Chicago 18, Ill.
- †°WALLACE V. WOLFE, 1016 N. Sycamore St., Hollywood.

*Term expires December 31, 1947. †Chairman, Atlantic Coast Section.
**Term expires December 31, 1948. †Chairman, Midwest Section.
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HISTORICAL DEVELOPMENT OF SOUND FILMS*

E. I. SPONABLE**

Introduction

In this introduction I should like to set down the purpose of this paper, to say something about the way in which I propose to treat the subject matter contained therein, and perhaps even to make a few personal remarks.

First, the purpose. There have been various documents published relating to the history of sound recording on film, but they have not been complete, nor have they, in most instances, attempted to rate the relative value of the contribution made by the various inventors. Since I am somewhat in the same position as the famous chemist Berthelot, who was declared to have been the last one who would know the whole of chemistry, I propose to undertake to arrange the technical contributions leading up to the commercialization of sound motion pictures in chronological order, and to attempt this evaluation. Perhaps I may be forgiven for this apparently egotistical point of view, because I was fortunate to have participated in bringing about the commercial development of sound motion pictures; and for at least a short period of time I was probably the only individual who had heard practically every sound record and knew intimately those engaged in making them. Late in 1926 I was, like Berthelot, overcome by a feeling of helpless futility; it was then that the art began such rapid expansion that I could no longer keep up with the tremendously increased number of sound records.

In dealing with this development, I shall more particularly restrict my remarks to the photographic methods of sound recording and shall list in considerable detail the steps taken in the development of the

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** Twentieth Century-Fox Film Corporation, New York.

Fox-Case system. The section of this paper which deals with the work of Theodore W. Case contains abstracts from correspondence which he kindly made available to me, and from the notes of the Case Research Laboratory, which he organized shortly after I joined him in 1916; I therefore know, of my own knowledge, that these notes were kept with a high degree of accuracy and detail, and are correct. I have quoted directly from these records in some instances, since they are available to the future historian—the original Case Laboratories having been made a museum in the city of Auburn, New York (now known as the Cayuga Museum of History and Art).

The remaining parts of the paper, dealing with the work of others, may have been treated in somewhat less detail: first, because much has already been written regarding their work and it seems unnecessary to repeat it here (except to the extent required for a clear chronological development of the subject), and, second, because I was more directly and intimately concerned with the work of Mr. Case.

To the uninitiated, this account may prove dry reading at best; it is intended to do no more than appeal to those having a substantial interest in, and present knowledge of, the art. If it enables those now devoting their time and energy to the perfection of sound pictures to see something of the stages by which we arrived at our present state, it will have served its purpose.

PART 1. EARLY STEPS IN THE HISTORY OF SOUND RECORDING

1857: Leon Scott patented in France what seems to be the first method of recording sound.¹ This disclosure shows the use of a stylus connected to a membrane through a series of levers and a method of tracing figures corresponding to speech, song, *etc.* on paper covered with lampblack. The paper was attached to a cylindrical drum, which could be rotated by hand and moved forward by a screw. He called the instrument the "phonautograph".

1862: Another example of early interest concerning the nature of sound is found in the work of one Doctor Jan N. Czermak of Vienna, who succeeded in photographing the vocal chords in action.²

1877: Thomas Edison brought out his epoch-making invention, the first phonograph. It was similar in principle to the phonautograph but differed in that he used tinfoil on the cylinder and had his stylus attached directly to the vibrating diaphragm. In his later models, wax was used as the recording medium.

1878: Professor E. W. Blake, of Brown University, published a

paper on "A Method of Recording Articulate Sounds by Means of Photography".³ This describes a mirror actuated by a microphone and the moving of a beam of light over a photographic plate.

1880: A. G. Bell patented the method of using selenium for detecting sound signals sent over a modulated light beam.⁴ The experiments in light telephony leading up to this patent were carried on in 1879.

1880: Charles E. Fritts filed a patent application in the United States entitled "Recording and Reproduction of Pulsations or Variations in Sounds and other Phenomena".⁵ This application is remarkable in its completeness, broad scope, and length of time in the patent office. As finally granted, on Oct. 31, 1916, it covered 26 pages and had 96 claims. It is doubtful if Fritts did anything practical; he confined himself to putting down a large number of ideas and variations on paper. Claim 84 of his patent reads "The method of making a sound record which consists in photographically affecting a sensitive surface in accordance with sound waves".

1886: A. G. Bell, C. A. Bell, and S. Tainter patented both a variable-area and variable-density method of recording a sound-modulated light beam through a small slit upon a photographic film.⁶ Both a physical slit and an optical slit are disclosed.

This seems to me to be an important patent that has heretofore been overlooked. It clearly anticipates Ries, as may be seen from the following quotations: "According to the record part of the invention a variable beam of light is caused to pass through a fine slit or other opening, and an image of the slit enlarged, diminished, or of the same size is then projected, by means of one or more lenses or other suitable devices upon a sensitized tablet which is moved progressively in front of the slit"; and "Sometimes it is desirable to use a second slit close to the recording tablet".

1887: The work of Hedick, a Dutch inventor, using flames that could be varied by sound waves, should be noted.⁷

1887: C. J. Hohenstein patented a more sensitive method of recording a sound modulated light beam "by reflecting light from a small pivoted mirror several times, focusing beam of last reflector, which is parabolic, upon a photographic film".⁸ This is quite similar to the optics of the recording system later developed by General Electric.

1892: Demeny's "Chronophotophone" combined a disk phonograph and a magic lantern arranged with slides.⁹

1894: Edison brought out the "Kinetoscope."¹⁰ This was a peep-show device using ear tubes to catch the sound, and rather crudely brought about synchronization of sound and picture.

1900: J. Poliakoff filed a patent application on the focusing of a light beam upon a photoelectric cell, through a positive photographic sound record moving uniformly across the beam, the photoelectric cell being connected to a telephone circuit.¹¹ This disclosure

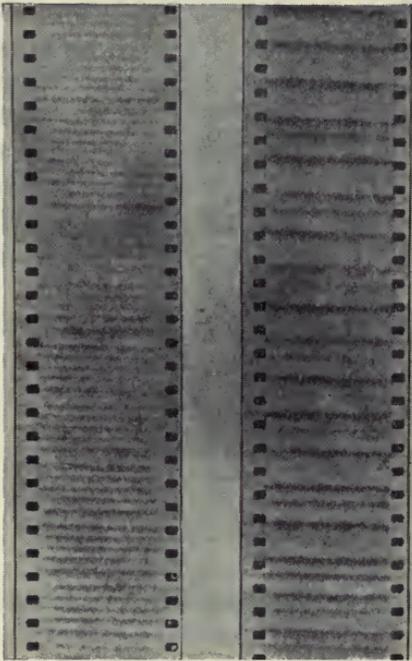


FIG. 1. Photograph of Ruhmer's sound film.

is interesting in that it mentions the first use of a *positive* record and also a photoelectric cell for reproducing.

1901: Ernst Ruhmer began publication of his work on sound recording.¹² Since he was a professor, his interest was more academic than commercial. He devised the "photographophon", an instrument something like the sound camera of today. With this he recorded and reproduced speech using arc lights and Gehrke tubes as light sources, and selenium cells in reproducing. His film speed was rather high, being of the order of three meters per second. Ruhmer's original "photographophon" and some sound records were brought to this country by the

Fox Film Corporation. The apparatus was practical and the records show clear definition of the recorded sounds (Fig. 1). Although Ruhmer never commercialized his work, he says in one article:

"For practical uses the application of the photographophon in combination with the kineomatograph whereby on one and the same film both motion and speech may be recorded should be kept in mind." Also in another article, "As far as simplicity is concerned the glow light tube surpasses all other previous means for the perception of alternating current curves."

1902: An inventor named Hulsmeyer obtained a patent on producing photographic sound records.¹³ This describes "an oscillating mirror which is varied by sound-electric impulses and which reflects a beam through a plate on a photographic strip, through a slit, said plate having a transmission varying in the direction of motion of the reflected beam in proportion to the sine of the angle".

1902: On November 8 a patent application was filed by William Duddell covering a method of variable area recording and reproducing, under the title of "An Improved Phonograph". The patent shows a comprehensive knowledge of the subject and mentions making photographic copies.

1903: Wilhelm Asam filed a patent to produce records for phonographs using a reflecting diaphragm to modulate a light beam.¹⁴

1904: F. W. LeTall patented a method for modulating electrically a vapor discharge.¹⁵

1904: A patent was granted to V. Poulsen (filed in 1901) on a method of magnetizing a moving paramagnetic wire or tape by means of sound waves.¹⁶ It also showed means of demagnetizing or obliterating the magnetic variations along the wire.

1906: Eugene A. Lauste, formerly an Edison employee, with Robert R. Haines and John S. Pletts filed a patent application on "method and means for simultaneously recording and reproducing movements and sounds".¹⁷ Although Lauste has been credited by some writers as having the master patent on talking pictures, one is impressed upon examining his patent that he really does not express himself too clearly regarding his technique.

1907: J. F. Dirzuweit patented a photographic method of recording and reproducing sound. He also shows the use of a gas discharge tube for recording. The claims of this patent are rather broad, for instance, "Claim 8—A sound recording apparatus comprising a photosensitive surface and a source of actinic rays movable relative one to the other, and means for exciting said source of actinic rays by and in accordance with sound waves".

1907: Carl Laemmle, of Universal Pictures Corporation, tried to commercialize the "Synchroscope", a system using a phonograph.¹⁸ He achieved some success, but it was found that the regular records used were too short.

1907: Dr. Lee de Forest filed his patent application on the "Audion" covering the addition of a third electrode or grid to the Fleming valve.¹⁹ This became a basic patent of great importance, as it

showed the way to make amplification of electrical impulses possible.

1908: A. Manuelli, a resident of Italy, obtained a French patent having "as its object a bicinematographic photophonic machine for public and private displays adapted to insure fixedness of projection, stereoscopic effect, photographic reproduction of sound, *etc.*" He describes a complicated machine using three films.²⁰

1908: About this time Edison again brought out another version of his talking picture device, this time called the "Camera-phone". The picture was photographed to synchronize with a phonograph record. As no close-ups were then employed, exact synchronism was not an important factor. It was accepted for a short time only, as a novelty.

1908: J. F. Child patented the making of a photographic record of a manometric gas flame and the use of selenium in reproducing the record.²¹

1910: R. O. P. Berglund, of Sweden, patented recording sound using a mirror attached to a microphone diaphragm, thus modulating a light beam and recording the variations on a sensitive disk or film.²²

1911: C. G. Timm obtained a Swedish patent similar to that of Berglund.²³

1911: F. D. Pudumjee, of India, described a method of using a mirror attached to a vibrating diaphragm to produce a photophograph.²⁴

1912: I. H. MacCarty, a resident of the United States, obtained a French patent covering "simultaneous recording by means of photography upon one and the same films of animated views and articulate or other sounds with a view to insure synchronous reproduction of such views and sounds".²⁵ (His drawing of a combined sound and picture film showed a much keener appreciation of the problem than was shown by Lauste.)

1913: Edison brought out the "Kinetophone".²⁶ This apparatus tried to create synchronism of picture and sound by using a belt connection between a phonograph on the stage and a projector in the picture booth. It had a run of about sixteen weeks in the B. F. Keith theater in New York, but attained no great commercial success.

1913: A patent application for recording sound filed by E. E. Ries was granted in 1923.²⁷ The following claim from the recording patent gives an idea of its scope: Claim 14—"The method of

producing motion pictures and photographic sound records concurrently upon the same photographic film, which consists in moving a photographic film through a camera at a speed adapted to produce a given number of pictures per second, simultaneously moving said film at the same rate per second across the back of a screen having a narrow aperture which exposes the sensitized surface to light in a continuous line or band parallel to the line of pictures and of uniform width throughout its length, limiting the area of exposure to the area of the aperture, and varying the degree of exposure of said line or band in accordance with sound waves impressed upon a sound translating device, whereby said sensitive surface when developed will present adjacent to the pictures a continuous line or band of uniform width and having alternating sections of varying degrees of density of translucency representing continuous waves corresponding to the sound waves impressed upon the sound translating device."

A similar patent covering reproducing was also filed in 1913 and granted in 1926.²⁸

In view of the decision in the de Forest-Stanley case, where the Ries reproducing patent was held infringed, it is interesting to note that Ries came to Auburn to see Case in 1923 and offered to sell his patents for one thousand dollars. Also, that opinions by Thompson and Gifford (Mr. Case's patent attorneys) in 1925 were to the effect that it was very doubtful that these patents would be upheld in Court. Ries later sold these patents and several other applications to the de Forest company.

1914: H. G. Stocks filed a patent application covering the process of recording sound photographically by modulating a mercury lamp for the purpose of making an optical phonograph.²⁹

1915: H. C. Bullis filed a patent application that was granted in 1920, describing a double system method of recording sound and picture on separate films, running synchronously through a single machine, and the use of marking lights to enable matching of sound and picture after the films were processed.³⁰

1916: T. H. Nakken obtained a patent on a means for converting sound waves into light variations; also a patent on means for transforming light impulses into electric current impulses.³¹

The various Nakken patents were purchased by the Warners, after having been offered for sale for some time by the inventor.

1918: A. C. Rutzen received a patent to engrave a sound track on a moving picture film adjacent to the picture. J. Ballance

received a similar patent in 1906. Again in 1926, E. H. Foley proposed the use of a separate film for an engraved sound record. None of these methods has been practical. F. L. Madelar cut his record on the back of the film in the nitrocellulose base with a diamond stylus. Later, similar patents were granted to A. L. Curtis and J. Kaiser.³²

1918 on: During the summer of this year, experimental work was begun by the German Tri-Ergon group consisting of Josef Engl, Joseph Massole, and Hans Vogt.³³ They worked out a system of making sound motion pictures using a glow discharge lamp in photographing the sound. The sound was recorded on special film having standard-sized pictures and a space outside of the sprocket holes for the sound band. At the time this system was brought to this country by Fox (1926) it had many novel features but the results were quite inferior to those obtained by Fox-Case methods.

Tri-Ergon obtained about eighteen patents on their system between April 1919 and July 1923. Some of these patents—such as the printing patent, the flywheel patent, and the photoelectric cell patent—were so basic that they later were the cause of extensive litigation and nearly became controlling factors in sound recording and reproduction. The Supreme Court reviewed the flywheel patent and held it invalid (Mar. 4, 1935).

1918 on: J. Tykociner, at the University of Illinois, worked out a system for producing talking pictures.³⁴ This work was quite academic and no attempt was made to commercialize it. Variable-density recording was used. Sound and picture were combined on the same film, the sound track being placed inside the sprocket holes and adjacent to the pictures. The system was called "Phonactinion". The sound was recorded by modulating luminous gas discharge devices. Tykociner's paper contains a rather extensive discussion on recording sound. He made several demonstrations before scientific societies. Later he suggested a novel means of recording that was considered quite seriously by Case at one time. This consisted of forming a glow discharge between two closely spaced semiconductors in air. The separation of the electrodes acted somewhat like a slit, in that it limited the area of exposure on a photographic film placed adjacent to the glow. So far as I know, the merit of this method of recording has never been verified.

1920: D. A. Whitson filed a patent application for producing sound records by passing a beam of light through a Kerr cell,

and modulating the latter magnetically, the resulting light being photographed on a moving film through a slit.³⁵

1921: Prof. H. O. Rankine, of England, worked out a method of recording sound photographically using a constant light source and controlling the light beam from this source by means of a mechanical "light valve". He used one fixed grid and one movable unit that was controlled by the sound impinging upon a microphone diaphragm. This work was academic and in the nature of a laboratory demonstration.

1921: Grindell Matthews devised a mechanical method of recording sound photographically by producing vibrations of a beam of light from a constant light source.

1921: A demonstration by Professors Aurbenius and Montellius was described in the London *Times*, Sept. 24, 1921. Two films were used, one for picture and one for sound. They were run in separate machines geared together. The sound record was produced in a manner similar to that employed by Matthews.

1923: The Peterson-Poulsen system was worked out in Denmark.³⁶ It used a variable-area method of sound recording on a separate film run synchronously with camera and projector. The sound record was made using an oscillograph and a small slit. The process was exploited by Tonfilm, in Germany. The reproducer used a selenium cell.

1923: A United States patent was issued to E. Peterson, showing a variety of arrangements of a magnetic wire imbedded in the marginal portion of a motion picture film.

PART 2. THE WORK OF CASE AND de FOREST—1911-1925

The results secured by the early workers were, by limitation of existing equipment, rather crude and did little more than demonstrate the principles of sound recording and reproduction. It was Theodore W. Case who, more than anyone else at this time, began to realize that, if sound pictures were to serve as a medium for entertainment, it would be necessary to perfect the system to such an extent that the illusion created in the reproduced sound and pictures be good enough to make one forget the mechanics of the system and think only of the event portrayed. Accordingly, in putting together the Case system each step was studied and developed with the idea of incorporating the best engineering practice available at the time. The way was made easier because of the developments made during

the first World War, including improved microphones, better vacuum tubes, amplifiers, loudspeakers, *etc.*

1911: Case began experimenting on sound recording while a student at Yale. In a letter to his mother, Jan. 22, 1911, he writes: "Most of my time now is taken up in experimenting with my Selenium Cell with the idea in mind of photographing sound waves and using the positives as records for a new kind of Phonograph or rather it would be called a Lithograph I suppose."

And on Feb. 12, 1911 he writes: "Yesterday I at last succeeded in transmitting sound by light. I used the principle of the manometric flame. The eye could not detect the variation of the light at all but it was registered perfectly in the varying of the resistance



FIG. 2. The original laboratory built by Case in 1916 for his research work.

of the selenium. The reproduction of the voice was perfect. Next, I have to set up an apparatus for my delicate photographing of the light variations. It is very interesting work and gives me something to do alright."

1913: Case began experiments at Auburn, New York, and devoted himself to trying to find a practical means of converting light into electricity.

1916: E. I. Sponable, upon graduating from Cornell, joined Case and with him started the Case Research Laboratory. Case's experimental work was moved from the cellar of his home at 196 West Genessee Street to a new laboratory designed by Sponable and built at 205 West Genessee Street (Fig. 2). A three-stage audion amplifier was purchased from the de Forest company. This was used to test a large number of crystals and minerals for the property of changing resistance when illuminated. About nineteen new

substances were found and studied. It was at this time that Case first met de Forest.

1917: The "Thalofide" Cell (containing a light sensitive change-of-resistance material similar to selenium but a form of thallium oxy-sulfide particularly sensitive to infrared radiation) was discovered (Fig. 3).³⁷ This was used as the receiving element in an infrared signal and communication system developed for and used by the Navy during the first World War. During this time the Case

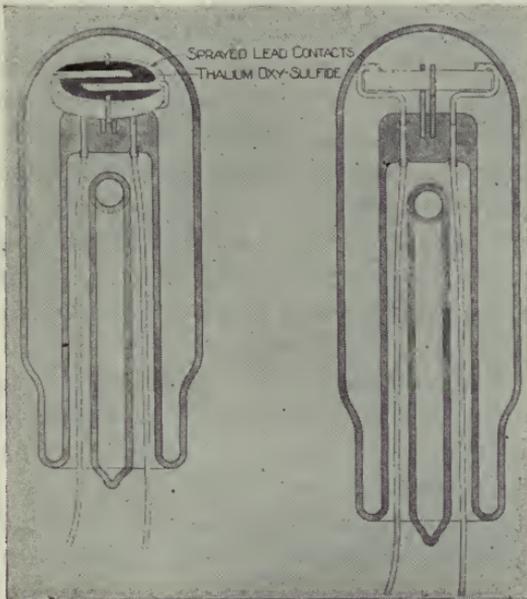


FIG. 3. Thalofide Cell, high vacuum, helium, or hydrogen filled. Case Research Laboratory, Inc., Auburn, N. Y.

Research Laboratory, working in conjunction with the Naval Experimental Station at New London, Connecticut, was entirely devoted to war work and carried on extensive research in the transmission and amplification of speech and signals in connection with its infrared system.

1918 to 1922: De Forest began work on talking motion pictures. He filed patent applications on methods of recording in 1919, and during 1922 carried on experiments in Germany trying to record sound by modulating a high-frequency gas discharge tube.³⁸

1920 to 1922: Case discovered the barium photoelectric cell and began its development.³⁹ In its final form it was used in a recorder for making permanent records of the light variations of daylight and sunlight.

1920: De Forest purchased Thalofide Cells from the Case Research Laboratory.

Oct. 1922: Case saw de Forest in New York regarding extraneous noises in Thalofide Cells that de Forest was trying to use for reproducing sound.

Oct. 1922: Case, while in London, witnessed a demonstration of Rankine's experiments in sound recording.

Nov. 1922: Upon his return from abroad, Case was invited by de Forest to visit his studio. De Forest spoke of trouble he was having in trying to record sound with high-frequency discharge tubes. He exhibited and reproduced a short piece of sound film. This was barely understandable. He apparently was about at the stage he speaks of in his SMPE article⁴⁰—"I well remember the grim satisfaction I felt when, for the first time in reproducing a photographic record of my voice, I was able clearly to determine whether or not it was being run backwards!"

Nov. 1922: A crude sound camera was made at the Case Laboratory and a sound picture made of a modulated oxy-acetylene flame. This was the same manometric flame that had previously been developed for use in infrared telephony.

De Forest at this time tried recording with tungsten filament lamps with practically no success. Case suggested to him the use of a hydrogen-filled lamp as having faster reaction. The Case Laboratory made up several hydrogen-filled flashlight lamps for de Forest, and also tried some of them for sound recording using a four-stage amplifier. The results were poor because of the large amount of unmodulated light.

Dec. 1922: De Forest's relations with Case are indicated in the following excerpt from a letter from de Forest to Case:

"As per our telephone conversation I am mailing you today six blanks, two of each capillary diameter. Kindly fill these with nitrogen and exhaust as soft as possible, *i. e.* to give them maximum brilliancy and minimum voltage. Paint with bronze the two balls at each end of the tube and wrap same carefully with tinfoil and glass. Then apply to these terminals alternating high voltage.

"I hope you can get these tubes to light up at 3000 or 4000 volts.

You might put in a needle spark gap in shunt as approximate voltage indicator.

"I suggest that you put a drop of mercury in some of these tubes to see if this does not considerably soften the discharge, at least when the tubes get hot enough to liberate the mercury. I am also requiring you to be so good as to make up two or three ballast resistances using very

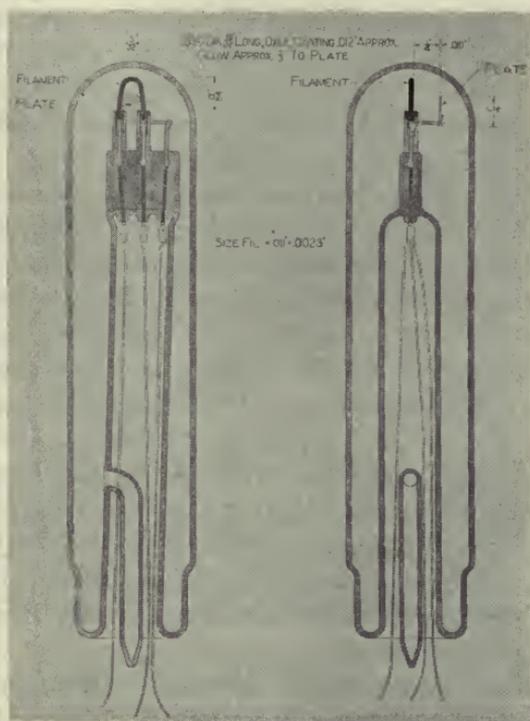


FIG. 4. Present-type Aeo light (July 1928).
Case Research Laboratory, Inc., Auburn, N. Y.

fine tungsten filament and hydrogen gas. Believe that the bulb lamps are usually filled with hydrogen at atmospheric pressure, but am not informed on this point.

"I believe if I can get a proper ballast system in series with the short filament lamp I can record the voice photographically by this means. This, of course, is an ideally simple matter compared with the high-frequency light.

"I shall await receipt of these tubes and your further suggestions with great interest."

1922: Case found that the gas discharge in an argon-filled vacuum tube whose filament was coated with alkaline earth oxides could be easily modulated at a low voltage, and it seemed to Case suitable for sound recording purposes. This tube had been previously used in his infrared signal system. This observation led to the development of the Aeo light, and was a big step in making this system of sound recording practical. Previous to this discovery by Case, de Forest had been using nitrogen-filled tubes operating on a high-frequency circuit at 3000 to 4000 v and giving a very limited photographic light output. The Aeo light operated on direct current at 200 to 400 v, and gave off radiation which was highly actinic. (Fig. 4 shows Aeo light as finally developed in 1928.)

1922: A Powers projector was converted into a sound camera at the Case Laboratory. Also the Aeo light was improved by using helium gas instead of argon, thus increasing its actinic light. Soon it was found that these recording lights could be operated without heating their cathodes.

The following abstracts from the Case Research Laboratory records indicate the stages in the development of sound recording during the period from 1923 to 1925, inclusive:

Jan. 10, 1923: A conference was held among Case, Sponable, and Thompson (patent attorney for Case) to discuss the patentability of Helio light (later named Aeo light).⁴¹

Jan. 11, 1923: It was found that nonoxide coated filaments in vacuum tubes were not good for sound recording and that a cathode discharge was more desirable.

Jan. 13, 1923: Case wrote to de Forest telling him that oxides in the recording lights effected an improvement when the filaments were operated cold. Later it was found that this oxide coating was photo-active.

Jan. 26, 1923: A letter was received by Case from de Forest about the lights containing oxides. It also mentioned trying two small ball electrodes, oxide coated. This proved impractical because the area was not great enough on small ball electrodes and an arc discharge started too easily.

Feb. 10, 1923: Case suggested to de Forest that he remove the lens from the Helio light system to get rid of "blasting" he had been getting.

Feb. 14, 1923: A new sound camera designed by Sponable and built by the Precision Machine Company of New York was

completed and first tested. Sound records were made with good results.

Feb. 23, 1923: Case and Sponable visited the de Forest studio in New York. De Forest's first combination of pictures with sound was seen and heard. These were made using Case Helio lights. The forming of a company was discussed and a contract permitting de Forest to make commercial use of Aeo lights and Thalofide Cells was negotiated but not signed.

Mar. 5, 1923: De Forest notified Case he had completed eight combination pictures.

Mar. 13, 1923: De Forest exhibited his sound motion pictures to newspaper men at his New York studio. At this exhibition, the sound system included a Case helium-nitrogen filled barium-oxide-coated recording lamp operating on direct current at low voltage and giving a moderately concentrated glow on the plate cathode. A Western Electric amplifier provided the driving power for the Helio light. The Case Thalofide Cell was used in the reproducing system. De Forest, in his discussions with the press, referred to the Case Helio light as his "Photion". The reproduced sound showed bad mechanical motion and poor quality.

Mar. 14, 1923: Case suggested, in connection with his recording lights, the use of an oxide-coated filament as a cathode. This resulted in more light and longer life.

Mar. 17, 1923: DeForest wrote to Case saying that the latter's efforts "to improve his photion light were well justified so Phonofilm could be brought out soon" and that Case was entitled to broad claims on the oxide-coated filament. De Forest said he would give Case full credit for work done in perfecting his Photion tube.

Apr. 4, 1923: De Forest gave a demonstration of his sound pictures before the New York Electrical Society. In describing his recording light he stated he was using a high-frequency gas light; he gave Case credit only on the Thalofide Cell, and for valuable suggestions and improvements to "Phonofilm."

Apr. 15, 1923: The first public exhibition of de Forest "Phonofilm" was given at the Rivoli Theater, New York.

Apr. 18, 1923: Case perfected the Thermophone for use as a microphone. This was used in making many of his early sound records.

May 7, 1923: It was found that helium purified in a calcium arc further lowered the operating voltage of Helio lights.

May 13-14, 1923: Case and Sponable visited the de Forest studio and observed weaknesses in de Forest's methods of sound recording and reproduction.

June 28, 1923: The Precision Machine Company rebuilt the Case sound camera in an effort to reduce the amount of flutter it was causing in the recording of sound tracks.

July 3, 1923: A letter received from de Forest said that the Case Helium Photion light "had gone bad". It had been in use since May 7, 1923, and the letter raised the question as to whether it should be recoated. De Forest suggested that adding a trace of mercury would avoid certain British patents.

July 11, 1923: De Forest cited a German patent which contained an admission that it is old in the art to use a discharge containing a metallic vapor. De Forest used this patent on which to base his belief that any existing patent difficulty could be avoided by introducing mercury. It was possible that the coated electrode of the Aeolight producing green barium vapor in the discharge would be equivalent to introducing a metallic vapor.

Aug. 30, 1923: The contract referred to under date of February 23, between the de Forest Phonofilm Company and the Case Research Laboratory, was consummated. This contract granted de Forest a commercial license to use Aeolights and Thalofide Cells in taking and reproducing sound pictures.

Aug. 31, 1923: The following quotation is taken from the Case Laboratory notes: "A trip was made to New York for the purpose of aiding the de Forest Phonofilm Company in setting up their 9-A amplifier and also to test out the Case air-thermo microphone under studio conditions. A comparison of the static microphone using the old set-up previously made at the studio with the same microphone using the 9-A amplifier was made. These two films were also compared with a film made using the air-thermo microphone on the 9-A amplifier system. At New York, it appeared that the voice reproduction on the air-thermo microphone was slightly better and clearer than the records made using the static microphone. The films when run at this laboratory, seemed to indicate that there was little difference in these films; if anything, the static microphone was of slightly better quality.

"De Forest was shown our method of wiring up the 8-A and 9-A amplifiers for reproducing. This system was a great improvement

over the two 7-A boxes which he was using. This improvement was in quality rather than loudness.

"A number of experiments of the talking moving pictures were witnessed at the Phonofilm studio. These indicated that the product had been greatly improved over the old films seen on previous trips. In the case of music records the film from this laboratory seemed to be of slightly better quality than those shown there." Both Case and Sponable were present during these conferences.

Oct. 8, 1923: De Forest informed the Case Laboratories that he now had twenty-five films worthy of exhibition in theaters. Did we have a supply of Aeolights?

Nov. 14, 1923: De Forest mentioned a recording he had made of a speech by Dr. F. Crane, saying "*one can understand every word first time through.*"

Dec. 7, 1923: De Forest said that the thermo-microphone supplied him by Case was "wonderful", and that the Aeolight was "working fine".

Jan. 23, 1924: For recording sound, de Forest had originally used an optical system imaging the glow discharge on a slit of the order of three mils wide; it now occurred to him that a narrower slit, say 1.5 mils, might be better. He recognized the problem of getting sufficient light with the narrower slit.

Jan. 1924: Sponable had considered the redesign problems involved in converting a Bell and Howell camera for recording sound on the same film with the picture. Bell and Howell was authorized to rebuild one of their cameras in accord with this design, which involved photographing the sound at the sprocket through a slit in contact with the film and with the Aeolight placed directly behind the slit.

Feb. 8, 1924: In the same way, a Bell and Howell standard picture printer was redesigned to provide both sound and picture printing apertures and exposure control shutters. This work was done locally.

Feb. 8, 1924: Case wrote: "I think it would be better to do away with the slit entirely in the sound reproducing chamber as a slit is liable to become dust clogged being so small and the best method of procedure will be to construct a light with a very fine short straight filament and place a lens in front of this so as to suitably produce an image of the filament which may be brought to the size desired, say one and one-half thousandths of an inch and allow

this image to pass through the sound record, spread, and then cover the Thalofide cell."

Spring 1924: De Forest had about twenty outfits giving road-shows in theaters.

Feb. 28, 1924: A letter received from de Forest explained lack of Case publicity and stated that Phonofilm was a combined invention of de Forest and Case.

Mar. 25, 1924: The Bell and Howell camera modified for sound was received at Auburn and was tested. The motion was unsatisfactory.



(Courtesy *RADIO NEWS* magazine)

FIG. 5. First Case sound newsreel outfit. Published in *RADIO NEWS*, November 1924.

May 9, 1924: Case suggested that the slit be protected by placing a glass wedge in the slit opening. Previous slits were susceptible to dirt and dust and were cleaned by opening and closing, or by an air jet.

July 9, 1924: E. B. Craft, of the Western Electric Company, advised Case and Sponable that Western Electric would probably be willing to grant a license for the Laboratory to use amplifiers commercially.

July 25, 1924: De Forest began using the Case design of camera in which the sound was photographed on the film at the sprocket

position. (This same method of recording is still in use in newsreel cameras today.)

July 25, 1924: De Forest asked Case to make recordings of Coolidge and La Follette in Washington. De Forest was to supply a professional cameraman. (These pictures, photographed on August 11, were the first news sound pictures of importance ever made—Fig. 5.)

Aug. 1924: A small sound recording studio was constructed in the basement of the Case Laboratory. This consisted of a room about 10 ft sq with a 6-ft ceiling. The walls were made of hair felt. The camera was placed outside of the studio and its lens imaged the interior through a hole in one of the studio walls.

Incandescent lighting was used to the extent of twelve 1000-w lamps. The subject could not exist in the studio for more than a few minutes at a time without coming out for air.

Dec. 8, 1924: To indicate the general character of work at the de Forest studio the following is taken from notes of Dec. 8, 1924:

“A visit was made to the de Forest studio. Reproduction was heard on the de Forest system using the slit arrangement. It was found that their slit was set at about four mils. When this was brought down to one and one-half mils the reproduction was very good, although the quality was not quite as good as with the focused filament arrangement. A focused filament set-up was made for de Forest using some lamps made in his factory. In these lamps the filament was held straight by spring tension, being the same arrangement as used in his amplifier tubes. The filament diameter of the lamps used was about one-half mil. The reproduction on this focused filament arrangement seemed to be very good. The Vitalux lens was used and improvement will probably be noticed when de Forest obtains the special Bausch & Lomb 1:1 objective which we had developed.

“Aside from a noticeable improvement in his reproducing apparatus the situation at the de Forest studio had not changed appreciably. He had made a number of Phonofilms. One, a Christmas number, included a song by Mme. Rappold in a Christmas tree setting followed by a church scene with choir boys singing and ending with a trumpet chorus in supposedly a heavenly setting. All of this number was slightly sour and it is doubtful whether or not it could be used commercially.”

Jan. 12, 1925: Case devised a slit with cover-glass protection.⁴² This was a very important step in making sound recording

practical. This slit consisted of a small piece of quartz about 0.25-in. square and 0.04-in. thick. One side was coated with chemically deposited silver and a slit about 0.001 in. \times 0.120 in. was ruled in this silver coating. A thin cover glass was then cemented on top of the silver and the cover glass was ground and polished down to a thickness of less than 0.001 in., including the cement (Fig. 6). The slit was then mounted in a steel shoe that could be placed in contact with the film at the camera sprocket. The Aeo light was set close to the quartz slit, thus eliminating the use of a lens to focus the glow discharge on

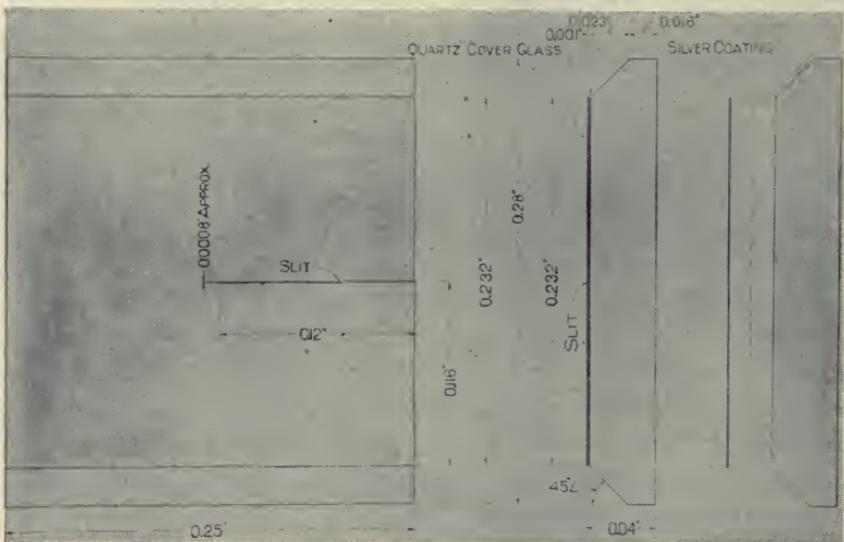


FIG. 6. Quartz camera slit. Case Research Laboratory, Inc., Auburn, N. Y.

the film and ensuring the maximum amount of light reaching the film (Fig. 7).

May 13, 1925: De Forest borrowed the rebuilt Bell and Howell camera from Case in order to make sound pictures of Dr. Elliott in Boston.

Sept. 1925: Business complications terminated the working arrangement between de Forest and Case. Case, having gone this far in the talking picture field, decided to continue the work and finish up some of the technical problems that were still not solved.

During the fall of 1925, the Case Laboratory started building their first sound reproducing attachment. After considerable deliberation it was decided to design this to operate below the projection head

rather than above, as had been de Forest's previous practice. This was decided upon for three reasons: First, it was desired to incorporate a large flywheel that would give sufficient inertia to iron out all inequalities that might be transmitted from the projection head. Second, in the Bell and Howell camera the sound came after the picture and a better printer design was possible if the sound was not transposed to a position ahead of the picture. And, last, which seemed important at that time, an attachment was wanted that would not run sound films previously made, which in some instances

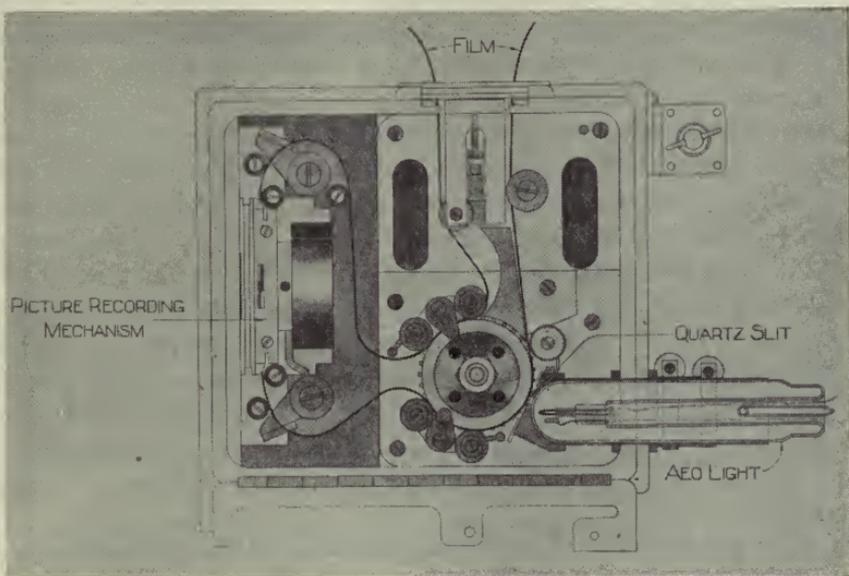


FIG. 7. Remodeled Bell and Howell camera for sound recording. Case Research Laboratory, Inc., Auburn, N. Y.

were quite bad. Sponable laid out this design and supervised local mechanics in executing it. It was here that the industry received its $14\frac{1}{2}$ -in. hangover—the sound and corresponding picture were displaced by $14\frac{1}{2}$ in. or 20 frames. This early attachment was very similar in principle and design to the present ERPI type 206.

Sept. 14, 1925: It became apparent that great mechanical accuracy was required in making the recording camera; this is emphasized by the following quotations from the Case Laboratory records: "The camera was received back from Bell & Howell Company on September 12. Tests were begun on this camera September 14. The first test taken was made of voice and piano. When this was

reproduced it was found that the camera still had a bad sprocket pulse. The eccentricity of the sprocket was determined with an indicator. It was found that it was running off about .5 of a mil on one end and .7 of a mil on the other. This, together with a noticeable high spot in the gears, was sufficient to account for the pulse observed."

"We tried the shaft alone in its bearing and found that it was running fairly true. The sprocket, when tried alone on an arbor running true, was found to be $2\frac{1}{2}$ mils off and also slightly out of round. We made inquiry as to the best machinists around here and after trying a number of shops found that Doyle & Wall, 322 Pearl Street, Syracuse, seemed to be the best to do further work on the camera. They are used to working with a tolerance of .1 mil and seemed to fully appreciate our problem."

Nov. 23, 1925: "After returning to Auburn Case went over the patents on sound recording and after calling Mr. Thompson into conference it was decided that the field was much more open than we had previously supposed. De Forest gas discharge patent seemed to be limited to the use of alternating current. Also it seemed questionable whether a court would uphold such patents as the Ries and the Fritts. Mr. Thompson was sent to New York to get the opinion of Mr. Gifford, supposedly one of the best attorneys in the matter of patents. Mr. Gifford's opinion in this matter seemed to confirm Thompson's, that is, that the field was open and that no one seemed to have any fundamental patents on the system of talking moving pictures."

Dec. 8-10, 1925: "About a year ago we approached the Western Electric Company regarding the use of their amplifiers or commercial showing of the talking pictures. At that time Mr. Craft advised us to go ahead and use them for this purpose and stated within a few weeks the Western Electric Company would submit a contract to us covering some form of a license agreement. Nothing further happened regarding this agreement at that time. Now that we are interested in using these amplifiers for possibly road show work and having severed connections with the de Forest outfit E. I. Sponable went to New York for the purpose of seeing Mr. Craft and if possible, obtain his O.K. to go ahead with their amplifiers for any commercial work we should want to do."

"On seeing Mr. Craft we explained to him the situation and recalled to his mind our conversation of last year. He stated that since that time *considerable water had gone over the dam* and that they were

now interested in talking moving pictures themselves. Further, that they were negotiating or had completed negotiations with Warner Bros. to furnish the latter company with apparatus and technical aid to enable this moving picture firm to produce and market talking moving pictures. Considerable discussion of the subject resulted in Mr. Craft's saying that he believed we were further along in the art than they were and that he saw no reason why both the Case Research Laboratory and the Western Electric Company should not get together and compare their accomplishments and possibly enter into some agreement with a moving picture company whereby both the Western Electric Company and the Case Research Laboratory would benefit. He further stated that he would like to send two of his technical men up to Auburn to hear our films and look over our developments. After they had returned and reported to him he would then try to arrange a meeting between representatives of this laboratory and the commercial men of the Western Electric Company."

"Before the call on Mr. Craft the Keith-Albee people were visited for the purpose of determining whether or not they would be interested in obtaining our talking moving pictures for an act of vaudeville. Mr. Oakford of the booking department of the Keith people was given information regarding our system. He was very much interested in what we told him and stated that he would take it up with men higher up in the company and advise us regarding their interests. He reported the following day that he had talked with the vice president of the Keith company and that the latter was very much disturbed to think that he would dare to bring up the subject of talking moving pictures to them again. They admitted that they had been stung on the thing twice, once about fifteen years ago where they invested considerable money in stock of a talking picture outfit, and later in certain connections with the de Forest company. The vice president of the Keith company stated positively that they were not interested in talking moving pictures."

Dec. 15, 1925: "In our conference with Mr. Craft last week, he intimated that the use of amplifiers in talking moving pictures would come under their public address work and that at least for two or three years we would be unable to use amplifiers for this purpose without the permission of the Western Electric Company."

"In order to check up this point it was thought best to talk it over with Dr. W. R. Whitney of the General Electric Company. This was done by E. I. Sponable on December 15. Dr. Whitney stated that

the situation was really something that Mr. A. G. Davis (vice president of the General Electric Company) was more fitted to give an opinion on than he. After describing the situation to Mr. Davis he stated that he believed that the talking moving pictures did not come under the public address work and that at present the amplifier situation was quite muddled, there being almost an endless number of patents in this connection. Sometime within the next year they hope to clear this situation by placing all these patents in the hands of the Radio Corporation. Mr. Davis stated that he believed we should see Mr. David Sarnoff, president of the Radio Corporation, and get his opinion regarding our requirements. He very kindly suggested that he would arrange such a meeting for us and is doing so at the present time."

"Dr. Whitney as usual was very nice in this connection and took the attitude that he was particularly anxious to aid anyone who was doing good research like the work carried on at the Case Research Laboratory."

Dec. 17, 1925: "Dr. Crandall and Dr. MacKenzie of the Bell Telephone Laboratories were sent here by Mr. Craft. They were shown our talking films and all parts of the taking and reproducing system were explained to them in detail."

"We gathered from them that our films were very good. They stated that they believed that in their own recording that their ground noise might be slightly less but discounting the fact that we were not using as good loud speakers or telephone equipment as they have they thought our stuff to be remarkably good. They noted the simplicity of design of the camera and projector and commented on the fact that such a design could be readily commercialized."

"We gave them data concerning our photoelectric cells and recording lights. They stated that they would like to order these various devices so that they could determine their constants using their own apparatus at the Bell Laboratories."

Jan. 4, 1926: An opinion was received from Mr. Adams, head of the patent department of RCA:

"He stated that due to de Forest's original patent having expired that de Forest now had no more right to use amplifiers or to make vacuum tubes than anyone else and that the field now seemed to be completely controlled by the Radio Corporation as the result of patents held by the General Electric Company and relating to the manufacture of vacuum tubes and their use in various circuits."

"With reference to whom has the right to supply amplifiers for use with talking moving pictures he stated that this right rested with the Radio Corporation or at least would rest with them when certain patents now under negotiation are finally turned over to them. Further, that he believed from the agreement with the Bell Telephone Company that the Radio Corporation reserved the right to use amplifiers in the connection with talking moving pictures for themselves."

Jan. 7, 1926: A meeting was arranged with Adams and his associate, Capt. Ranger.

"The only new thing which developed was at this meeting Adams reversed a statement which he had made at a previous conference with E. I. Sponable, that is, that both the Radio Corporation and Western Electric Company would have rights to use amplifiers for talking moving picture work. He stated that he would talk the matter over with Mr. Sarnoff and advise us shortly regarding some arrangement for starting a company to handle the talking picture situation."

"Previous to this meeting of Adams and Ranger, Mr. Case and Mr. Sponable were at the Bell Telephone Laboratories to see Mr. Craft. We told Mr. Craft that we had checked up the amplifier situation with reference to talking moving pictures and had found that the General Electric Company seemed to believe that they controlled the rights for the use of amplifiers in this connection. Craft then stated that it was really something that both companies had a joint right in and that in case the General Electric Company should use amplifiers for this purpose they would possibly have to obtain permission to do so from the Western Electric Company. Mr. Craft further stated that he was anxious to get a report from his men regarding our Aeo lights and photoelectric cells which they wished to examine."

"We went down to Dr. Crandall's office where we saw the Western Electric system of film recording. Inasmuch as our visit was rather unexpected they seemed to have considerable difficulty in getting their apparatus to work properly. The showing which they made during this exhibition was not impressive to us. They were, however, using fairly high quality amplifiers and a laboratory model of a loudspeaker which gave excellent and true quality of reproduction. They showed a number of records taken of the Capitol Theater music including pipe organ, orchestra and singing. They also showed one talking record made in their own laboratories. The talking record was not good and when reproduced on a cone such as we use, it was

extremely bad. Their recording of music reproduced seemingly well although possibly part of this was due to the high quality of the music recorded, that is, the Capitol Theater orchestra. After hearing these records we attended a luncheon with Messrs. Adams and Ranger noted above and then returned again to the Bell Telephone Laboratories. During this time the apparatus had apparently been given an overhauling and the showing or reproduction was much better than that heard during the morning. It is interesting to note here that with the Western Electric reproducing amplifier which they were using they found it necessary to add an equalizer to correct for a discrepancy in their photoelectric cell. Without the equalizer the low frequencies came through in great predominance. Adding the equalizer decreased the volume to about $\frac{1}{30}$ and brought the quality to approximately normal. Their photoelectric cell was connected to the first tube using 20 megohm resistances. In our work we use about two megohms across the cell and about 50,000 ohms across the first bulb. It is possible that we compensate for the equalization in this manner."

Jan. 29, 1926: Case and Sponable visited the Warner Theater to see a demonstration of Maxfield's Vitaphone.

"We all agreed that the showing was very good and of commercial quality. However, we believe that our own reproduction was better with regard to illusion and naturalness. In the Western Electric system they were using the large public address system thus accounting for the large range without distortion. Their loudspeaker was apparently of the horn type placed above the screen."

"After lunching with MacKenzie we returned to the Bell Telephone Laboratories where we met Dr. Crandall and proceeded to Mr. Craft's office. Mr. Craft advised us that his men had only made a preliminary report to him but it seemed that we had nothing in our system which would be of particular use or addition to the Western Electric system."

"Mr. Craft, however, was reluctant to give up our system entirely and said he would like to know more about it. Inasmuch as the reproduction of the film was the real test, we suggested that the Western Electric Company send us some of their film, both voice and music. We could then reproduce it at Auburn and at least satisfy ourselves regarding the merits of the two systems. They did not care to submit some of their film already taken and stated that they would take two numbers and send them up to us the following week."

"We then left the Western Electric Company and proceeded to Captain Ranger's office in the Radio Corporation building. We advised Captain Ranger that we were now ready to go ahead with the talking pictures with them or arrange for licensing the use of their amplifier system. We asked him to bring these things to Mr. Adams' attention and arrange for a get-together to talk the situation over. After leaving Captain Ranger we stopped at the office of Mr. Gifford where we talked over the patent situation. He had already prepared an opinion regarding the de Forest and Ries patents, this opinion being that these patents were of questionable value. Our talk with him seemed to further his conviction regarding their questionable value and he stated that he would send us the written opinion in the near future."

Feb. 13, 1926: Case devised a way to avoid film splice clicks by using graded opaque at the join.

Feb. 15 to Mar. 1, 1926: Case and Sponable discussed with Whitney and Stone (a vice president of General Electric Company) the possibility of combining the Case system with the work of their inventor, C. A. Hoxie. General Electric engineers, Robinson and Marvin, came to Auburn and went over the Case system. They were very pleased with it. Stone, however, would not admit the Case system added materially to that of General Electric and no agreement was reached.

Mar. 19, 1926: John Joy, who knew Sponable at Cornell, paid a friendly visit to the Case laboratory. Technically, he represented Courtland Smith who had just joined the Fox Film Corporation. Joy reported concerning the Case talking picture system to Smith and the latter requested Case to bring his equipment to New York to demonstrate to the Fox people.

Apr. 8, 1926: Max Mayer (a dealer in theatrical equipment) came to Auburn to witness the Case talking pictures. He pronounced the demonstration to be perfect, but advised Case that a feature picture would be necessary to sell the system to a producer. Case considered making this.

May, 1926: Case organized the Zoephone Company to take over and handle the Case system of talking pictures.

Responding to Courtland Smith's suggestion, reproducing apparatus was taken to New York and successful demonstrations given before representatives of the Fox company at Parlor B on 10th Avenue, at the Nemo Theater, and at William Fox's home in Woodmere.

Mr. Fox was at first suspicious of the process; however, a close-up of a canary bird singing while perched on the top of its cage seemed to convince him that the sound was not a matter of trickery.

June 8-24, 1926: The reproducing equipment was installed in the Fox Film building, 850 Tenth Avenue. Recording equipment was brought from Auburn and about 300,000 feet of test records were made in a temporary hair felt studio room partitioned off on the large stage of the Fox building. The purpose of these tests was to convince Fox of the practicability of making sound pictures under studio conditions. The results were entirely successful.

July 23, 1926: An agreement was reached between Case and Fox resulting in the formation of the Fox-Case Corporation. In general, Case turned over all patents and rights in his system of talking pictures to the new company (exclusive of amplification, in which he had no rights to give). Case agreed to continue his laboratory for the purpose of making recording lights, photoelectric cells, and for general development purposes.

[*Ed. Note.*—Parts 3-7 of Mr. Sponable's paper will be published in the next issue of the JOURNAL.]

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- ¹ French patent No. 19,457 (1857).
- ² *Royal Soc. Cat. of Sci. papers*, II, p. 123.
- ³ *Amer. Jour. Sci.*, 16 (1878), p. 54.
- ⁴ U. S. patent No. 235,199.
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- ⁷ *J. Soc. Mot. Pict. Eng.*, XVI, 4, p. 405.
- ⁸ U. S. patent No. 356,877.
- ⁹ HAYS: "See and Hear," p. 38.
- ¹⁰ HAYS: "See and Hear," p. 39.
- ¹¹ U. S. patent No. 680,614.
- ¹² *Anal. der Phys.* (1901), p. 803; *Phys. Zeit.*, 34 (1901), p. 498; RUHMER: "Wireless Telephony," p. 36.
- ¹³ British patent No. 19,901 (1903).
- ¹⁴ British patent No. 4,661 (1903).
- ¹⁵ British patent No. 1,364 (1904).
- ¹⁶ U. S. patent No. 788,728.
- ¹⁷ British patent No. 18,057 (1906).

* In connection with the early history of sound this work has purposely omitted patents relating to sound-on-disk. Anyone interested can find these described in the *Film Daily* beginning February 24, 1929.

- ¹⁸ HAYS: "See and Hear," p. 40.
- ¹⁹ U. S. patent No. 841,387.
- ²⁰ French patent No. 386,737 (1908).
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- ²⁶ FRANKLIN: "Sound Motion Pictures," p. 5.
- ²⁷ U. S. patent No. 1,473,976.
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- ³³ VIEWEG AND LOHN: "Der Toewende Film," *Jour. Engl. Pub.* (1927).
- ³⁴ *Trans. SMPE*, 16 (1923), p. 90.
- ³⁵ U. S. patent No. 1,474,695.
- ³⁶ Der Sprechende Film Mihaly (1928).
- ³⁷ U. S. patent Nos. 1,301,227; 1,316,354.
- ³⁸ U. S. patent No. 1,466,750.
- ³⁹ Case, *Jour. Opt. Soc.* (1918).
- ⁴⁰ *Trans. SMPE*, 16 (1922), p. 62.
- ⁴¹ U. S. patent No. 1,816,825.
- ⁴² U. S. patent No. 1,605,531.

REPORT OF THE SMPE COMMITTEE ON PROGRESS*

W. V. WOLFE**

Summary.—During the war it was not possible to obtain annual progress reports as has been the custom, and up to the present time it has not been possible to obtain progress reports in all fields covering the war period. However, some reports have been prepared and are presented here, with the hope that publication of annual reports of the Progress Committee may be resumed in 1948.

CINEMATOGRAPHY

Professional 35 Mm (*Emulsions*).—The war years saw intensive research and development on three-color films and papers, particularly of the multilayer type. Concurrently, there was an increasing demand for color on the screen.

In 1945, Technicolor Monopack went into extensive production use, "Thunderhead", a Twentieth Century-Fox production, being the first feature filmed entirely with the three-layer camera film. C. G. Clarke described the application of Monopack on this production in a paper¹ published in the JOURNAL.

Also, in 1945, Ansco announced a complement of 35-mm reversible color films, Type 735 soft gradation camera film, Type 132 duplicating film, and Type 732 printing film. These were described by Duerr and Harsh in a paper² presented at the October 1945 Technical Conference. The processing of these films may be done by the studio or commercial laboratories on continuous processing machines.

- (a) Development of the negative silver image
- (b) Shortstopping
- (c) Hardening
- (d) Second exposure, with white light
- (e) Color development, with the dyes formed simultaneously in the three layers by coupling action between nondiffusing dye-formers in the layers and the oxidation products of developing the positive silver image

* Received Feb. 25, 1947.

** Chairman, 1946.

- (f) Shortstopping
- (g) Hardening
- (h) Bleaching by reconverting both silver images to halides
- (i) Fixing
- (j) Washing and drying.

In Europe several features and shorts were produced in Agfacolor, a negative-positive three-color process using multilayer films. Reports on this process and its application were presented at the October 1945 and May 1946 Technical Conferences of the Society.

16-Mm Film.—In 1943, Technicolor began production of 16-mm three-color imbibition prints with dye soundtracks. Early in 1945, Ansco introduced two 16-mm reversible color films, Type 234, balanced for tungsten illumination, and Type 235 balanced for daylight. The processing of these films is described³ by Forrest in the November 1945 issue of the JOURNAL.

Nondiffusing color-formers in the emulsion layers couple with oxidation products of the action of a single developing agent in the second developer to form the three dyes in their respective layers.

In August 1946, Eastman introduced Type 5268 Kodachrome Commercial Film 16-mm, designed to provide a low-contrast color original from which a color release print of normal contrast can be made on Kodachrome Duplicating Film. Type 5268 is balanced for a color temperature of 3200 K.

SOUND RECORDING

Films.—The trend toward fine-grain recording stocks resulted in their universal usage by 1945, following the introduction of Types 1372 and 1373 by Eastman, and Types 232 and 236 by duPont. Types 1372 and 1373 are described⁴ by Corbin, Simmons and Hyndman in the October 1945 issue of the JOURNAL. The 1372 emulsion, designed for variable-area recording, is characterized by high contrast and minimum image spread. The latter characteristic permits its use for recording direct positive VA tracks. It has sufficient speed to record with either unfiltered or UV filtered tungsten. Comparable image quality is obtainable with either type of illumination. Type 1373 is a variable density negative material designed for development in a normal picture developer, and has sufficient speed for white-light recording. DuPont Type 236 variable-density negative stock was designed to fit release negative requirements for white-light printing

to release positive. It has an inherent low gamma infinity to reduce 96-cycle flutter and to permit development in picture negative developer, and is sufficiently fast to record either low or high gamma variable density with white-light exposure. Type 232 is a fine-grain sound positive developed to meet the need for a printing material which, white-light printed from high gamma *VD* negatives and processed with normal release positive techniques, would yield the desired over-all contrast.

TELEVISION

Films.—Increased activity in television has resulted in requirements for special film stocks. Early in 1946, duPont announced two such films, Type 323 Kinescope Recording and Type 136 Gamma Pan 2. The former was described by White and Boyer in a paper entitled "A New Film for Photographing Television Monitor Tubes", presented at the May 1946 Technical Conference. Type 136 is a panchromatic negative, similar in speed and contrast to duPont 126 Type Superior 2, but differs from the latter in that the upper portion of its sensitometric curve has a rising characteristic rather than the conventional shoulder. Meschter discussed the considerations leading to the design of this product in a paper presented before the May 1946 Technical Conference, "Television Reproduction from Negatives".

STUDIO LIGHTING EQUIPMENT

Set Lighting.—To meet a demand for a super-powered lighting unit to be used where the cinematographer desires to create an effect as though all of the light on the set were coming from a single source, the Mole-Richardson Company has designed and manufactured a super-high-intensity carbon-arc lamp known as *MR* Type 450.

This unit is a rotating high-intensity type which uses a carbon trim consisting of a 16-mm \times 22-in. super-high-intensity positive and a $17/32 \times 9$ in. *HD* Cored Orotip negative operating at 225 amp and 75 arc v.

It is equipped with a 24-in. diameter Fresnel-type condenser lens, and the drum is of sufficient size for proper ventilation. The feed motor is mounted on the back of the lamp where it is away from the heat of the arc.

In addition to use as a "one-source" lighting unit, this lamp is valuable for shadow effects, for penetrating into deep sets, and for boosting daylight on exteriors.

Another unit in the advanced stages of design is a super-high-intensity spot projector, which will be similar to the Type 450. This lamp will be equipped with an integral optical system for throwing a well-defined and close-controlled spot for use in follow shots such as would be made in a skating picture.

Process Projection.—Mole-Richardson Company has resumed production on a special carbon arc process projection lamp house, a number of which were manufactured before the war to meet specifications set up by the Research Council of the Academy of Motion Picture Arts and Sciences. As a result of information gained during the production of specialized searchlight equipment during the war, and from experience in operating the process lamps previously manufactured, the current input contacts for the positive carbon and the photronic cell control mechanism have been simplified.

THE BRITISH DOCUMENTARY MOVEMENT

The end of the war found Britain supporting an efficiently organized movement whose sole function was the production of documentary films sponsored by the Ministry of Information. The movement, which in 1939 was an enthusiastic but scarcely fully developed industry, had advanced from almost an amateur to a professional organization of considerable value to the government in its work of information and propaganda. In technical polish, too, the advance was made from bare adequacy to frequent brilliance. This last, despite the appalling shortage of equipment, floor space, and raw stock, and the uncertainties of processing and projection conditions.

With the end of the war and the sweeping change of administration from a Coalition to a Socialist government, considerable doubts were felt by documentary technicians as to what their future would be. Although finance for this type of film could always be relied upon for a number of films for major commercial undertakings, this number would be nothing like enough to keep all the units fully occupied. And, in any case, many documentary workers feel that the advertising, no matter how well made, is scarcely the ideal vehicle for their particular styles and technique.

However, these doubts now seem to have been unnecessary. The present government, after over a year in office, has shown no signs of abating its thirst for cinema material. Films on health information, social services, and all forms of education are still being commis-

soned, and even if the tendency of the cinema exhibiting trade to close its screens to the official-sponsored film becomes a reality, the Central Office of Information, which is the peacetime counterpart of the Ministry of Information, has a vast organization for nontheatrical screenings. In any case, documentary workers in general feel that the public taste has been so whetted by this type of film, and the ability to blend entertainment with information is now so skillful, that commercial distribution in the theaters will still be secured for the best of them.

In Britain, the gap between the production methods of the documentary and the feature units, so wide in 1939, has closed appreciably. The feature units have made pictures on documentary lines of realism—using natural artistes and actual settings—while the documentary movement has frequently moved into the studio's sound stage with the professional actor. Perhaps in this country more than in any other have the two paths drawn together. Not only that, but our ideas have been broadened by seeing many of the magnificent documentary films from the American Office of War Information. We have learned a great deal from films like "Fighting Lady" and the "Why We Fight" series. And we like to think that perhaps we have contributed some ideas to America with films like "London Can Take It", "Target for Tonight", and "Desert Victory", while neither of us will forget the wonderful Anglo-American collaboration that gave us "True Glory".

The great difficulty, now as always, is technical equipment, particularly in the field of sound recording. The majority of the units producing documentary films do not carry recording equipment, and rely for their sound tracks upon the very few organizations that do. With the exception of one or two of the nonroyalty recording studios, there are two units which are doing the bulk of all recording necessary for Central Office of Information films. They are the COI's own production unit, the Crown Film Unit, which will be headquartered at Beaconsfield Studios operating with RCA equipment, and Merton Park Studios using Western Electric. During the war, it was frequently possible to make use of recording facilities at the larger feature studios, but these are now more or less fully occupied making the films for which they were intended, and little time is left for other work.

The units which were maintained during the war by the fighting services have now largely been disbanded. Their personnel on

demobilization have been reabsorbed into the industry in civilian capacity, both in documentary and in feature work, and some of their equipment has come the way of the documentary movement. In particular the RCA channel, used during the latter years of the war by the Royal Naval Film Unit, has been transferred to the Crown Film Unit where it is helping enormously to keep up the flow of production. New equipment from the United States is coming in slowly, but the Board of Trade is naturally more ready to grant import licenses to organizations capable, or at least potentially capable, of exporting films in exchange for foreign currency. Further, we in this needy country do not always realize that the Hollywood industry is presumably making big claims on American production after the supply difficulties of wartime. There are indications that a considerable amount of motion picture equipment will be manufactured in this country eventually, but in Britain as everywhere else, it takes a long time to recover from six years of war, and to develop and produce a regular flow of highly specialized machinery.

While comparatively few changes have taken place during these years in the type of sound and camera equipment at our disposal, nevertheless we have progressed in our methods. The RCA *PM 45* portable recording channel made its British debut with the Crown Film Unit, and its compactness has made it possible for us to record direct sound on the type of location loved by documentary directors, obtaining the benefits of automatic volume compression not available in the earlier model, so invaluable when trying to cope with "natural" untrained voices. The few Mitchell cameras possessed by the makers of short films are above reproach, although tremendous use is still made of the light-weight "wild" camera manufactured over here by Newman and Sinclair. We are also learning, or rather our sound engineers are beginning to teach our directors, that the post-synchronized sound track, when properly done, can be cheap, very easy and most convincing. Some of our technicians have paid brief visits to Hollywood where they learned many things, and our films are beginning to profit by their lessons.

Class "A" push-pull recording is beginning to trickle into documentary studio work, and the laboratories seem to have overcome most of their initial troubles with fine-grain positive stock. Fine-grain emulsions for recording negatives are now being manufactured over here, but at the moment of writing are being avoided until full research with the laboratories has been finished. The 200-mil push-pull track

for variable-density work is still only a projected feature of the major studio.

An interesting development during the past month or so has been the formation of the British Broadcasting Corporation's Television Film Unit. It is beginning modestly, but has already made its mark by producing and broadcasting its own film of the Victory Day celebrations in a very few hours. Indeed, the film was transmitted from the Alexandra Palace transmitting station on the evening of Victory Day, June 8. There would appear to be room in the future for a lively and profitable collaboration between the Television unit and the other documentary groups.

As might be expected with a movement which depends for so many of its screenings upon the purely nontheatrical show, we have suffered, and are still suffering, from acute 16-mm troubles. The enormous demand for this type of film tended completely to swamp the laboratories, and inevitably processing suffered. This factor, coupled with the relatively inefficient projectors in use throughout the war, and all the other problems of acoustics and so on, gave the substandard film show a richly deserved bad name. And, unfortunately, this country's efforts to overcome these problems have not had the enthusiasm behind them, and certainly not the successful results, that have attended similar situations in the U. S. A.

The country is just now going through a form of 16-mm revival. Commercial distributors have indicated their intention of releasing substandard copies of their feature films; miniature movie houses have appeared in many towns, and in many other ways the 16-mm cinema is being brought before the public in so determined a fashion that it is becoming regarded even more rapidly than during the war as something other than a toy. All this is bound to help the efforts of those who have tried, so far in vain, to point out that a casually performed optical reduction print from a doubtful release copy is scarcely the most efficient way of providing material for the education and instruction of those whose only approach to the cinema is by way of the miniature projector and the village hall.

The Crown Film Unit, with which the writer is actively connected, has before it a period of intense interest and development. Throughout the past four years, it has worked in the Government-requisitioned studios at Pinewood. These are the most modern studios in operation in the country. They are blessed with all the elaborate refinements necessary for the production of major feature films, and,

for England at any rate, are very large. In these respects, Pinewood is completely unlike anything that the documentary movement has ever been accustomed to, or is ever likely to enjoy in the future.

The studios have now generally been de-requisitioned, and with the exception of one stage and the bare minimum of other space left to the Unit pending the transfer to its new home, they are back on the job of normal production. The documentary movement is thus in the unenviable position of being the unwanted guest, and this position will continue until the beginning of 1947.

The Unit then moves to Beaconsfield studios, which at the time of writing are being transformed from their wartime status as a munitions factory back to a studio—a complicated and laborious operation. There will be one medium-sized stage, plenty of cutting rooms and vaults, and two theaters. Of the latter, one will be devoted entirely to the processes involved in sound recording, and will be large enough for small orchestral work. Its interior will be fitted with the latest ideas in policylindrical surfaces, reverberation chamber, and rerecording from seven tracks, and should be admirably suited for the work it has to perform. The Unit will be provided with three RCA recording channels mounted on trucks, two of which are the standard studio model and may be patched through to the theater for rerecording work or to the stage for normal shooting. The third is the *PM 45* portable channel already referred to. All three will be capable of producing the standard or the Class "A" push-pull track. It is hoped in time to reopen the laboratory attached to the studio, but the fact has been accepted that this must remain a long-term project. The Unit is not falling into the mistake of thinking that a laboratory can perform first-class work without many months of experiment and "settling down".

A rear projection process plant is to be installed in the new studio. The equipment we intend to use was constructed during the war for the Royal Air Force Film Production Unit, and extensive use of it will reduce many of the problems of actual "on-the-spot" shooting, characteristic of this type of film. We hope that it will not reduce the reputation for authenticity gained by the Unit's productions in the past.

Finally, at Beaconsfield will be housed the Central Film Library, the organization responsible for ordering and dispatching copies of COI films to where they are to be screened. There is room for expansion at Beaconsfield, and while at first it will accommodate purely

the production nucleus of the Crown Film Unit, in time it may well prove to be one of the main centers of the European documentary film movement.

FEATURE FILM PRODUCTION IN BRITAIN

British feature film production as we know it today has had to face up to many trials and difficulties, including two world wars. But whereas during World War I production practically ceased, World War II saw the plans laid and even developed for it to become a major British industry.

In 1938, the number of feature films made in Britain and registered with the Board of Trade was well over two hundred. However, judged by American standards, a large number of these were of poor quality—a fact which discerning British cinema audiences were quick to detect when viewed alongside the American product. This state of affairs could not long continue, and as a result of the new Quota Act coupled with the financial crisis greatly influenced by the turn of European events, about 100 feature films (or less than half those registered in the previous year) were made in 1939. During this year, British feature production was at the crossroads and with the threat of war, the freezing of capital and the general low standard, everything pointed to a very rapid decline and possible extinction.

With the outbreak of war and the probability of large-scale air raids, it was obvious that war industries would have to be expanded and dispersed. Studios, mostly situated on the outskirts of London, were ideal places for requisitioning by the Government, particularly as the industry had slumped and some studios were not in production. For instance, Amalgamated Studios (now owned by MGM) at Boreham Wood, with a floor space of over 150,000 sq ft, although completed long before the outbreak of war, had never been opened. So this studio with four stages, Pinewood (five stages, 70,000 sq ft), Sound City (six stages, 50,000 sq ft), ABPC (four stages, 60,000 sq ft), Beaconsfield (one stage, 7000 sq ft), MP (two stages, 15,000 sq ft), Wembley (two stages, 10,000 sq ft), Worton Hall (three stages, 20,000 sq ft), and Nettlefold (two stages, 15,000 sq ft) were among those to be requisitioned, while Denham had one of its large stages used for food storage. Pinewood and Wembley were given to the Service and Crown Film Units which, of course, were built up and expanded rapidly throughout the war years. This left eight studios or about thirty stages free where feature films might be made.

During the first uneasy lull of the first eight months of war—the “phoney war”, as it was called—it was realized that entertainment had to be provided for the people and Armed Services. Encouraged by official statements and steadily growing box-office receipts, finance became available and over sixty feature films were produced in 1941. However, this output was not maintained in 1942—with only 45 features produced. Shortage of material, declining manpower, damage to Studios, and loss of production time because of air raids, all had their effect. When the air raids were intense it was not unusual for production crews to have to take cover half a dozen times a day, particularly at those studios nearest to Central London. Each period of “alert” lasted any time up to an hour, and during the winter months personnel were anxious to get home as soon as possible after black-out to avoid the dangers of traveling across London during a raid. In the mornings, lateness on the set was often unavoidable because of railroad dislocation from the previous night’s raid. It is to be wondered how such a “luxury” industry could survive under such conditions. But survive it did and what is more, it flourished increasingly.

Several British features—some on war subjects—appeared which had a sincerity and authenticity far superior to the American product arriving in Britain. British cinema audiences were quick to recognize this, as they had first-hand knowledge of such situations presented on the screen. Instead of the isolated British feature being praised by critics and audiences alike, a new standard was gradually but surely being set up throughout the whole industry and more and more features received approbation. Naturally, the cry was for more and better British features; but, although the standard increased each year, the number remained around seventy for 1943 to '45. With its lack of organization compared with the American industry, gradual deterioration of equipment through little or no replacements, together with the difficulties already mentioned, British feature production had reached its wartime peak with the amount of manpower and number of studios available. Over a third of the prewar technicians in the industry were in the Armed Services and nearly a quarter of those who entered the industry after the outbreak of war had been drafted also.

The British industry had gradually broadened the canvas of its production—notably with “Henry V” and “Caesar and Cleopatra”, both made, like many other features, under extreme difficulties.

So the war came to an end with British features comparing favor-

ably and in many cases out-grossing their American counterparts. During the war, new British stars had been built up and these, with those already established, had a drawing power equal to many in the Hollywood constellation.

The immediate need was for the speedy de-requisitioning of those studios occupied for war purposes and the repair of those damaged by air raids and V-bombs. Practically all studios had received damage chiefly from blast and a few cases from incendiary, but many had been temporarily repaired. Teddington (Warner Bros.) had unfortunately received a direct hit by a fly-bomb and was completely out of action. Denham had scores of offices and the dubbing and scoring stage destroyed by incendiary bombs, but permission was given to rebuild the latter and so it was kept in production throughout the war. Shepherds Bush likewise was extensively damaged by incendiary but kept in production.

By the middle of 1946 most of the requisitioned studios had been released. Naturally, many months were needed before production could start on its former scale. Structural alterations were needed in some cases and equipment required a complete overhaul. The position today is that most of the studios released are already in restricted production and by the end of 1946 all the necessary repairs and reconstruction will have been completed. The rehabilitation of studios has been relatively slow despite the Government's interest in and support of the industry. Shortage of materials and manpower are the principal reasons for this slowness, efforts being concentrated on the repair and construction of houses which receive first priority.

Although the future looks bright, the expansion of the industry depends upon construction of new stages, the delivery of new equipment, and the training of additional personnel. Work has already started on the reconstruction of ABPC, MGM, and Teddington Studios. Production should start there during 1947. Both Paramount and Twentieth Century-Fox have announced building programs, but it will be some considerable time before these projects are started. Most of the existing studios are planning or have already planned extensions to their lots and are now awaiting Government licenses to build.

The industry is desperately short of all kinds of equipment. Much of the existing equipment is obsolete and modern replacements are being delivered very slowly—too slowly to meet the demands. New cameras, sound booms, and light equipment are being manufactured, but the supply of recording and rerecording equipment—particularly

that of American manufacture—is very inadequate. British manufacturers are doing their best to meet the situation but are faced with shortage of materials and labor.

Although the majority of the technicians in the Armed Services have been demobilized, shortage of skilled personnel is still acute. The position is improving slowly and fortunately the industry can call upon many ex-Service people who learned technical jobs in the various film units during the war and who may wish to enter the film industry upon their return to civilian life.

About seventy sound stages should be available for feature production when all the existing plans are completed. The immediate objective is to produce 200 features per year. To attain this, the industry must become much more efficiently organized, and more and better equipment must be given to the technicians. If the industry is to prosper, schedules and costs must be drastically reduced.

A golden opportunity presents itself for the future of feature production in Britian today and, given the necessary facilities, nothing should prevent it reaching a peak undreamed of only a few years ago.

FILM PRODUCTION IN MEXICO

In 1941 there were in Mexico two principal motion picture studios, Clasa and Azteca. These studios provided 17 stages. There were three licensed production recording channels, one combination scoring and rerecording channel, and also about six locally made recording channels. Both Clasa and Azteca had laboratories, but the Azteca laboratory was operated on a "rack and tank" basis. There were no facilities for handling color pictures and in general the feature pictures being made were of the low-budget variety.

About 35 such features were made during 1941. By the fall of 1946 there were five major studios in operation: Clasa, Azteca, General Cinematographico, Churubusco, and Tepeyac. These studios provided 61 stages with eight additional stages under construction. There were also two studios under construction but not yet in operation—Stahl and Quotemoc—each of these studios will consist of four stages. There were 32 licensed production recording channels and five rerecording and scoring channels.

Each of the studios now in operation includes a machine laboratory. A limited amount of color work is being done on the bipack principle. During 1945 about 100 features were made but during 1946 only about 50 features will be made. Although the number of features has

increased very little compared to the increase in production facilities, features now being produced are of a much higher caliber than those produced prior to the war.

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SOME SPECIAL PROBLEMS OF POST-SYNCHRONIZATION MIXING*

THEODORE LAWRENCE**

Summary.—The history of post-synchronization as a technique is briefly described, with special reference to its use in the process of language conversion. The means by which the illusion of acoustic perspective is obtained within the confines of a limited stage are described.

Post-synchronization is a term which originally described a form of salvage operation in sound motion pictures. The technique has been developed and its uses expanded to such an extent that today the post-synchronization process often becomes an integrated and almost independent phase of motion picture production.

The process is essentially one of making a dialogue and effects record to synchronize precisely with the lip movements and action of an already existing picture.

The technique grew very understandably out of a desire to salvage the dominant value of a scene or sequence in a picture for which the original synchronously recorded sound was defective. In a majority of such instances the original sound was defective because of pictorial requirements which demanded locations in which even adequate sound recording could not be accomplished. In recent years the density of air traffic over Southern California has tentatively put almost any exterior location into this category.

As the post-synchronization technique developed to the point where its intervention was undetectable in the final product, an undeniable further liberty became available in the choice of pictorial situation. Although a sound record is usually made in even the most extreme of these locations, it is recorded to serve simply as a transcript of what was said—as a helpful tool in the later post-synchronization process.

* Presented Oct. 22, 1946, at the SMPE Convention in Hollywood.

** MGM International Films Corporation, New York.

Most producers of entertainment films derive from thirty to forty per cent of their gross revenues from the exhibition of their product in territory outside of the United States. The continuance of this foreign revenue plays a dominant part in the profitable operation of any American film company. This pattern of income in the main held true even before the introduction of sound motion pictures. The initial adverse influence of this development in the medium on receipts from abroad was largely lost sight of in the light of the enormous success it enjoyed in the domestic market.

After a lag of about two years behind domestic theater sound installation, important numbers of theaters abroad were prepared to play sound motion pictures. American producers were now confronted with the problem of competing with foreign-made pictures on an entirely new basis. That same attraction of novelty which so beguiled American audiences into a profitable attendance at almost any "all-talking" picture in the early years of sound operated now to the profit of foreign producers, who delightedly discovered that their own nationals actually preferred to *hear* and to see a mediocre picture in the language of their own country to a good film which, in the large, they could not understand.

The first American reaction to this problem was the introduction of superimposed titles. By this device foreign audiences were provided with a truncated printed translation of the English dialogue, and thereby were enabled to follow the story. Although this method bridged the competitive gap between the average foreign picture playing to its native audience and the basically more attractive American film, it demanded a concentration on reading matter by those of the audience who did not understand the original English and introduced an inevitable distraction to those who did.

This state of affairs had not gone on for very long before it occurred to a good many people technically involved with motion pictures that the post-synchronization technique already existing might satisfactorily be extended to include language *conversion*.

The extension of the post-synchronization technique to the vast new field of language conversion of course involved, first of all, the basic necessity of providing a complete new script of dialogue in a foreign language which would not only match its English prototype in general syllabic conformation and special labial movement, but in its very spirit and character as well. Certain mechanical devices were developed to make graphic to the translator the type and duration of

salient sounds in the original dialogue and, by extension, to provide the ultimate re-enacting actors with an indication of the beginning, duration, and end of each word they were to speak. These devices, though they undoubtedly accomplished the specific things they were designed to do, were also inclined to produce a stultifying effect on both the translator's imagination and the actor's interpretation. MGM International Films and certain other American companies have found it advantageous to the over-all quality of their product to dispense completely with these mechanical aids and to substitute for them more time and greater effort in script preparation and rehearsal. We believe that this latter approach more than justifies its greater cost. The detailed problems of translation and casting have been previously described in considerable detail and I shall speak no more of them here.

By whichever means arrived at, the actors and their script eventually come together on a synchronization stage. This is where the ultimate illusion must be created and there are two people working together to do it: the director and the sound mixer.

The mixer in this situation, in contrast to his predecessor on the set of the original production, is in a position to suffer from an almost complete lack of imposed conditions. He is in the unhappy position of having, himself, continuously to set up bigger and better hurdles for himself to jump over. There would be nothing easier than for him to set up a microphone in an ideal position, with all the actors grouped obligingly in front of it, and then, after the director had achieved a satisfactory excellence of performance and synchronization from the cast, make a flawless recording. It would seem, offhand, that everything is in his favor. He is alone on a nice quiet stage with the director and a few actors; no cameraman to complain about the mike being in the picture or casting shadows; no annoying sound reflections from the walls of peculiarly shaped sets. The actors have an amiable tendency to stay approximately where they are put. It would seem to be a perfect setup, except that the result, when later seen with the picture, would be bad. All of the tangibles would seem to be there; proper casting, performance, synchronization. Everything except the illusion of reality that the original conveyed.

The missing elements, whose lack has robbed the synchronized version of the illusion of the original, are perspective (or rather, changes in perspective), with the variations in voice effort which should accompany such changes.

It is to supply these missing factors in the illusion that drives the synchronization mixer to a constant exercise of his imagination. To do this, he has at hand a small collection of basic tools. These consist of a studio of moderate size and low reverberation time, a few hard-surfaced panels with which he may modify that reverberation time, two or three small straight-backed chairs to serve as barriers for actor movement, and three or fewer microphones. It is not a particularly impressive array with which to re-create the enormous acoustic ambiance of the original. As a matter of fact, it *can not* be done, it can only be made to *seem* to have been done! And dramatically speaking and for the purpose of the ultimate illusion, no more need be required.

In effect, the mixer is required to provide the impression of an almost unlimited range of reverberation characteristics while operating, actually, within relatively circumscribed limits. To achieve this impression successfully requires a careful deployment of forces. Before the first post-synchronized scene is recorded, the mixer must have clearly in his mind the exact range of acoustic conditions in that particular picture which he is going to have to simulate. Even more important, for his purposes, is the sequence in which such changing conditions occur. It is difficult to explain this without examples, but hypothetical ones will do.

Let us, for example, assume that a sequence of settings occurs in the following order: (*A*) a large entrance hall, (*B*) a drawing room, (*C*) a dining room, (*D*) a long corridor, (*E*) a bedroom, and (*F*) a bathroom.

It is proper to assume that settings (*A*)(the hall), (*D*)(the corridor), and (*F*)(the bathroom), should be more reverberant in character than the other three. There is no obvious reason why the remaining three locations—the drawing room, the dining room, and the bedroom—should differ acoustically among themselves and it is quite possible that there is no detectable difference among them in the original recording. Since, however, it is an important thing in the illusion to supply an acoustic change to accompany each visual one, settings (*B*) and (*C*), which adjoin, should be treated differently acoustically. The absolute value of reverberation present is of much less importance in general than its contrast with what immediately precedes and succeeds it.

The present example, if there were no other reason to dictate length, would be broken down into a minimum of three scenes. The first

two settings could be shot together with the studio set up in its more reverberant condition. The necessary differentiation between the entrance hall and the drawing room would be accomplished in the first instance by exaggerating microphone distance relative to the apparent visual placement of the speaking characters, and in the second case by compressing it.

The second group of three settings could be shot together with the studio set up in an intermediate reverberant condition. The dining room set might be shot with microphone distances in a "normal" relationship with apparent visual placement; in the corridor, microphone distances would again become exaggerated; and in the bedroom, compressed.

The bathroom would need a treatment all its own—a tight boxing-in with reflecting panels.

Should these same sets occur in a different sequence, say in the order (*D*), (*A*), (*B*), (*C*), (*E*), they would undoubtedly be shot in two groups: (*D*)(the corridor) and (*A*)(the entrance hall) in a reverberant studio condition, and (*B*)(the drawing room), (*C*)(the dining room), and (*E*)(the bedroom) in a moderately reverberant condition. Thus in all cases the set requiring the most reverberant condition is shot on a "bright" stage, and the one requiring the least reverberation is shot on a relatively "dead" stage, all those falling between can be satisfactorily controlled by microphone placement.

Except in extreme cases where a really dramatic effect is required to be made by acoustic means, the usual set need have no absolute reverberation characteristic. It is sufficient, in its post-synchronized re-creation, that it conform with the actual only in very general and relative terms. It is much more important, for example, in the case of two such generally comparable acoustic structures as a living room and bedroom in immediate sequence, that they should be made to differ from each other at the cut between them rather than that any very serious effort be made to maintain an absolute acoustic quality associated with an individual set whenever it may occur throughout a picture. There are, however, the inevitable exceptions. There occasionally occur sets which have associated with them extreme and therefore memorable acoustic characteristics. Since such occurrences are deliberate and serve a definite dramatic purpose, a definite and recognizable acoustic characteristic must be established for such a set and carefully maintained.

It has already been pointed out that the post-synchronization

mixer is singularly free from externally imposed conditions on his microphone placement. This gives him one important advantage in the enhancement of the apparent acoustic range through which he can operate. He is in a position to shoot an extreme close-up with a much closer microphone placement than would be physically possible on the original set. This sounds like something very minor, but it *is* one additional position added to a technique which is greatly concerned with the acoustic illusion of position.

There is a further extremely valuable tool to employ in the simulation of an acoustic ambiance. Unfortunately, for its more active employment, it demands a remarkable degree of co-operation among the mixer, the director, and the actors. This is the matter of using to the greatest possible advantage the voice effort energy distribution characteristic. To inflict yet another hypothetical example, let us assume just one more arbitrary situation. A fully modulated recording of an actor speaking in a moderate volume of voice, at, say, six feet from a microphone in an average studio, will, when reproduced at normal volume, suggest a very definite combination of position and room characteristic. That same actor speaking loudly, all other conditions being held constant and no attempt being made to increase the reproduced volume, will appear to have receded considerably in position and to be speaking in a "deader" enclosure. It is only by the employment of this device that it is possible to obtain an acceptable illusion of voices in exteriors, even though recorded in the "deadest" commercially practicable studio.

Since vocal performances of any musical importance are almost invariably prerecorded in current production practice, there can be little, if any, attempt made to match sound pickup to picture. Although a great deal of dramatic license is permissible in this respect, there is no denying that in the post-synchronization of such material in a new language the mixer enjoys an invaluable assistance: he at least is certain of what the picture looks like—and it helps enormously.

The rerecording of a post-synchronized film is, in all essentials, the same process as was gone through for the original version. Some companies, and in particular MGM, operate several synchronization studios, each synchronizing in the language of the country in which it is located. In the interest of simplification of both the rerecording process and the transshipment of film, a certain consolidation of the original rerecording material is effected. The original music tracks, of which there may have been several per reel, are premixed with

effects to provide a basic museffex track for foreign rerecording. Sustained crowd noises are supplied separately since they will ultimately be bolstered by similar tracks of foreign origin and the proper balance for the premix, therefore, cannot properly be predetermined.

The ultimate result—the release print—of a post-synchronized film is an integrated whole, betraying little, if anything, of the conversion process through which it has passed. The only thing it will not do is to serve in its old incidental role: a teacher of “English Without Tears”.

DISCUSSION

MR. J. I. CRABTREE: How closely does a post-synchronized language film compare with one originally acted with, say, natural actors just speaking the native tongue?

MR. LAWRENCE: It is quite possible to watch the picture for a considerable period of time and never realize anything has been done to it. The illusion is virtually complete.

MR. CRABTREE: I am very surprised at this. Many years ago, at one of our conventions, a picture was shown in which the synchronization was remarkable. Then for some reason all the companies dropped this synchronization, and now I am very surprised that it has reached the stage that it has. Apparently there is quite a lot of it going on. Could you give us some idea as to how much of this is being done now?

MR. LAWRENCE: Before the war most of the principal American companies were synchronizing in foreign languages, and owing to restrictive regulations abroad most of the synchronization had to be done abroad. The war, of course, was the reason why it was stopped. At the present time, Metro is synchronizing every picture which is released in South America. They are beginning again to apply the same practice to those pictures which are released in France, and it will undoubtedly extend considerably to other parts of the world.

MR. WOLFE: Has any work been done for China?

MR. LAWRENCE: About five months ago Metro-Goldwyn-Mayer started what might be called an interim method of providing language versions other than the principal ones. That is being called the narrated film, in which the English dialogue is retained and a narrator in the foreign language explains what the action is all about at appropriate intervals. It is, we think, superior to superimposed titles, inasmuch as the distractive effect of the titles on the picture is not there. This is being done at present in Chinese, Arabic, Hindustani, and Portuguese with some Siamese.

THE CONCENTRATED-ARC LAMP AS A SOURCE OF MODULATED RADIATION*

W. D. BUCKINGHAM AND C. R. DEIBERT**

Summary.—The concentrated arc is a new type of lamp whose radiation emitting source is a thin film of molten zirconium and a cloud of excited and ionized zirconium vapor and argon gas which forms on and very close to the end of the specially prepared negative electrode. By modulating the lamp current, the radiation may be modulated at audio frequencies.

The continuous radiation from the molten zirconium can be only partly modulated, the per cent modulation decreasing with increase in modulating frequency and in spectral wavelength. The line radiation from the cathode-glow region close to the electrode modulates almost completely at all audio frequencies. It is particularly strong in the near-ultraviolet and infrared.

By using suitable modulator circuits, which are adapted to the rather unusual impedance characteristics of these lamps, and by using optical filters to select the spectral region used, the light output may be made to follow the lamp current modulation with good fidelity.

During the war, information about concentrated-arc lamps was restricted for security reasons. After the war, security restrictions were at first only partly removed so that the original public announcement of the lamps^{1,2} could refer only to their static characteristics and the lamps were discussed as simple light sources. Now, all restrictions have been removed, so the dynamic or modulation characteristics of the lamps may be disclosed.

Western Union's concentrated-arc lamps are made in sizes ranging from 2 to 100 w. The smallest, or 2-w lamp, is the most satisfactory for modulation purposes because of its very small source diameter, only 0.003 in., its high brightness, about 100 candles per sq mm, and its superior modulation characteristics. The larger wattage lamps can be modulated, and they will give many more lumens of modulated radiation than the 2-w size, but their light can be less completely modulated; their modulated light output is less constant with frequency,

* Presented, Oct. 23, 1946, at the SMPE Convention in Hollywood.

** The Western Union Telegraph Company, Electronics Division, Water Mill, N. Y.

and their modulated intensity or brightness is less than that of the 2-w lamp. For applications where a high intensity rather than a large quantity of modulated radiation is required, the 2-w lamp is superior. Large lamps are finding their major application in photographic enlarging, photomicrography, spot lighting, and projection.

The lamps are made* with the two arc electrodes permanently sealed into a glass bulb which is filled with argon gas. The cathode or negative electrode is made by packing zirconium oxide into a tantalum or molybdenum tube. The positive electrode or anode is a simple plate of molybdenum with a hole in the center, through which the light coming from the end of the cathode can pass. After the lamps have been evacuated, the bulbs are filled with argon to almost atmospheric pressure, and the lamps are processed or "formed". In this process the exposed oxide surface at the end of the cathode tube is converted to metallic zirconium. When the lamp is operating, this extremely thin layer of zirconium metal is melted and maintained as an incandescent pool by the intense argon ion bombardment of the arc. Most of the visible radiation of the lamp comes from this white-hot surface. It has a continuous spectral distribution of the black body type peaking near 10,000 A.

Directly above this zirconium film is a layer of excited and ionized zirconium vapor and argon gas in the cathode-glow region of the arc. This layer extends for only a few thousandths of an inch from the cathode. The radiation from this region is very intense and shows three principle spectra, a continuum reaching from the ultraviolet to about 5000 A, and the line spectra of zirconium and argon. The majority of these zirconium lines occur at wavelengths shorter than 4500 A, peaking around 3500 A. Strong argon lines are scattered throughout the spectrum, the strongest occurring in the near-infrared around 8115 A. The continuous radiation from the cathode surface and the continuum and line radiation from the cathode-glow region combine to produce the complete spectral distribution characteristic of concentrated-arc lamps.

When the current through the lamps is changed or varied slowly, the candlepower of all of the various sizes of lamps changes in almost exact proportion and the modulation ratio is nearly 100 per cent. Modulation ratio is defined as the ratio of the per cent candle-power change to the per cent current change which produced it. The linear

* [Ed. Note.—See references for more detailed description of lamp construction.]

relationship and high modulation ratio are not maintained exactly as the frequency of the current variation is increased into the audio frequency range.

That part of the radiation which comes from the incandescent cathode surface shows a rapid decrease in modulation ratio with increase in frequency and with increase in spectral wavelength. Thus, measurements made in the continuum of a 100-w lamp at 3500 A in the ultraviolet show per cent modulation ratios of 78 at

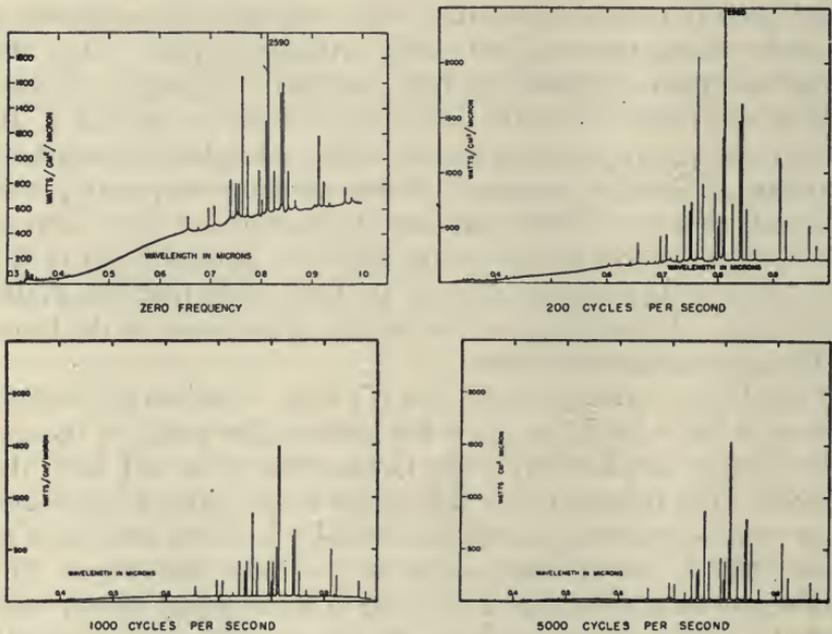


FIG. 1. Spectral distribution of the modulated radiation of a 100-w argon-filled concentrated-arc lamp:

200 cycles, 44 at 1000 cycles, and 18 at 5000 cycles. In the infrared part of the spectrum at 9000 A, modulation ratios drop to 33 at 200 cycles, 8 at 1000 cycles, and practically zero at 5000 cycles.

The radiation from the gas and vapor cloud, of the cathode-glow region of the arc, can be almost completely modulated. It shows a modulation ratio of 85 per cent or better, a factor which holds for all audio frequencies and for line radiation in all parts of the spectral range. The spectral distribution of the modulated portion of the total radiant energy of a 100-w concentrated-arc lamp when modulated at 0, 200, 1000, and 5000 cps is shown by the curves of Fig. 1.

These curves show that, as the modulating frequency is increased, the amplitude of the continuum, in any spectral region, decreases by a much larger factor than the amplitude of the lines. Also, the modulation ratio appears to be more favorable in the ultraviolet and blue end of the spectrum.

That such is actually the case, for a 2-w lamp, is shown by Fig. 2 which plots the average per cent modulation ratio, in spectral bands 0.1 micron or 1000 Å wide, at a 1000-cycle modulating frequency. This shows that, in the ultraviolet, ratios of better than 80 per cent may

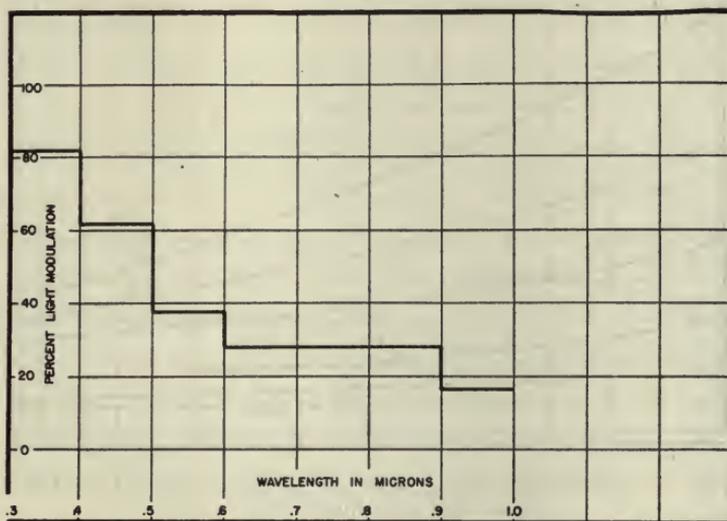


FIG. 2. Average per cent modulation ratios in spectral bands for a 2-w concentrated-arc lamp modulated 100 per cent at 1 kc.

be obtained while, in the infrared, values drop to less than 20 per cent. The flat portion of the characteristic at around 0.8 micron results from the strong argon gas lines, with their high modulation ratios, which occur in this region. The strong downward trend is caused by the modulation characteristic of the continuum.

The radiant output of the lamps is so much greater in the infrared that there is actually more modulated radiation given off in the longer wavelengths than in the ultraviolet, but its degree of modulation is less complete. The choice of which spectral region is to be used will depend upon which factor, quantity or quality, is the most important for the particular application.

In many cases the part of the spectrum employed will be determined by the spectral sensitivity of the receiving device. Thus, if a red-sensitive caesium-silver-oxide type of photoelectric cell is used to measure the modulated light coming from a concentrated-arc lamp, the system will exhibit an entirely different over-all frequency-light characteristic than it would if a blue-sensitive antimony type of photocell or an ultraviolet-sensitive photographic film is employed. Optical filters can be used to further select or restrict the spectral region covered.

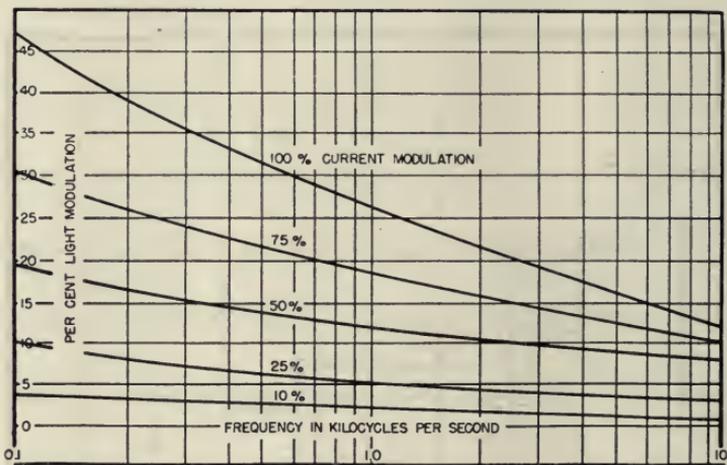


FIG. 3. Frequency characteristic for 2-w concentrated-arc lamp taken with a caesium phototube.

The effect on the over-all modulation ratios of systems using these two different types of photoelectric cells is shown by the figures of Table 1. This shows, for example, that a 2-w argon-filled lamp,

TABLE 1
MODULATION RATIOS

Per Cent Modulation Ratios at 75 Per Cent Current Modulation

Lamp Rating Watts	Gas Filling	Antimony Cell (Freq.)			Caesium Cell (Freq.)		
		200	1000	5000	200	1000	5000
2	Argon	76	63	49	35	25	17
10	Argon	63	57	31	28	23	14
25	Argon	52	35	15	27	18	8
100	Argon	39	22	12	19	12	7
100	Krypton	50	40	24	21	16	9

75 per cent current modulated, if measured with an antimony-type photocell, will show a modulation ratio of 76 per cent at 200 cycles, 63 per cent at 1000 cycles, and 49 per cent at 5000 cycles. If a caesium cell is used, the ratios will be 35 per cent at 200 cycles, 25 per cent at 1000 cycles, and 17 per cent at 5000 cycles.

Among the various sizes of lamps, the per cent modulation ratios show a decrease as the lamp size increases. The tabulation shows that a 100-w concentrated-arc lamp has less than one-half the per cent modulation ratio of a 2-w lamp. The 100-w lamp has about

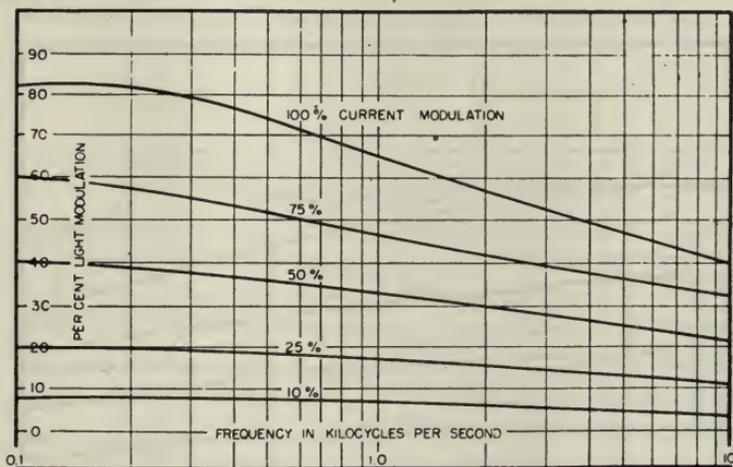


FIG. 4. Frequency characteristic for 2-w concentrated-arc lamp taken with an antimony phototube.

250 times the light output of a 2-w lamp; thus, even with its lower modulation ratio, the modulated light output of the 100-w lamp will be many times that of the 2-w.

Table 1 also shows the effect of a change in the gas used to fill the lamp. The first four lamps listed are argon-filled, while the last is filled with krypton gas. By comparing it to the 100-w argon-filled lamp, it can be seen that there is a considerable advantage in the krypton filling; the average gain in modulation ratio being 56 per cent for the antimony cell, and 21 per cent for the caesium cell. Other gases have been tried in the lamps, but these two are the most satisfactory.

The complete frequency characteristic for a system consisting of a 2-w argon-filled lamp and a caesium-type photoelectric cell is given in Fig 3. This shows the effect on the per cent light modulation of

different modulating frequencies and different percent current modulation. For this particular combination, the maximum per cent light modulation shown is slightly less than 50 per cent. A linear relationship between modulated light output and modulating current is indicated by the uniformity of the spacing of the curves for the various percentages of current modulation.

Fig. 4 shows the same characteristic for a 2-w lamp when combined with an RCA 931 A antimony-type photocell. These curves also show a linear light-current relationship with an increase in the per cent light modulation, whose maximum now exceeds 80 per cent.

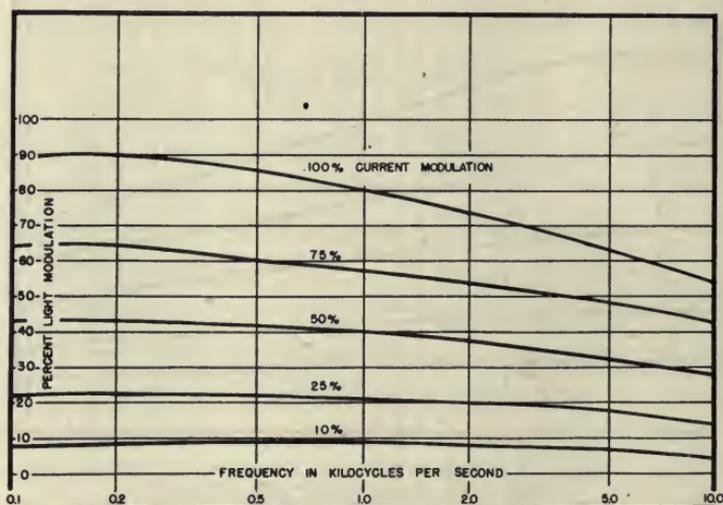


FIG. 5. Frequency characteristic of 2-w concentrated-arc lamps as seen by an antimony phototube through a CG587 filter.

If the spectral region used is restricted further by the addition of a Corning No. 587 ultraviolet-passing glass filter so as to employ radiation which peaks around 3750 Å, which might be suitable for photographic film, a characteristic such as shown in Fig. 5, will be obtained. The use of this filter raises the modulation ratio by amounts ranging from 10 per cent at low audio frequencies to 35 per cent at 10 kc. As a result, the 100 per cent current modulation curve of this combination shows a modulated light output which is flat to within less than 5 db from 100 cycles to 10 kc.

Some gain in the depth of modulation and flatness of the light-frequency characteristic shown in Fig. 4 can be obtained by using a krypton-filled 2-w concentrated-arc lamp with the RCA type 931 A

photocell as is shown in Fig. 6. Further gains result from the addition of the ultraviolet glass filter to produce the curves of Fig. 7. These curves show a maximum light modulation of 93 per cent and a drop with frequency of only 2.3 db between 100 cycles and 10 kc.

The total amount of modulated radiation emitted by concentrated-arc lamps can be more than doubled by increasing the gas pressure of argon or krypton from one to ten atmospheres as is shown by the curve of Fig. 8. Because of the possible danger of explosion, such lamps have not been made commercially.

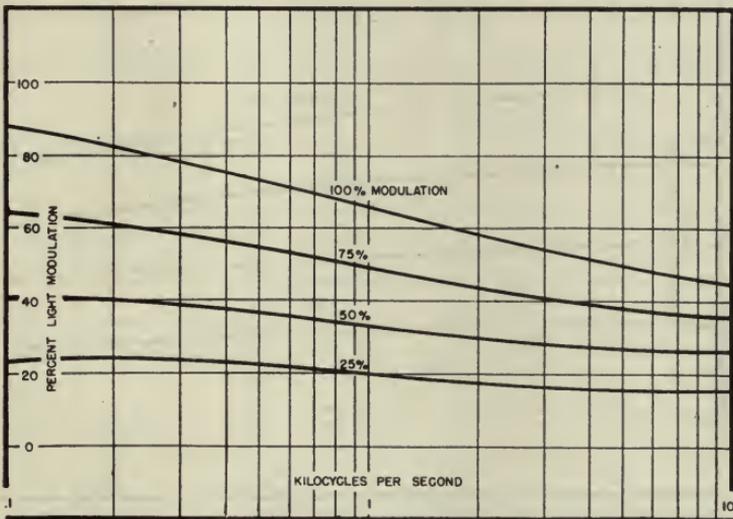


FIG. 6. Frequency characteristic for 2-w krypton-filled concentrated-arc lamp as seen by an antimony phototube.

The dynamic relationship between lamp current and lamp light is not absolutely linear. At the peak of a cycle of modulation, the lamp may be driven to give high light output with good fidelity. On the opposite half of the cycle, as the light output approaches zero, the response becomes nonlinear. This results in a flattening of the negative peaks, which analysis shows to consist largely of second-harmonic distortion. For this reason the percentage of second-harmonic frequency in the modulated light wave is used as a measure of the distortion of the lamps.

A typical distortion characteristic for a 2-w argon-filled concentrated-arc lamp taken with an antimony type of phototube is given in Fig. 9.

Table 2 gives the percentage of second-harmonic distortion of the modulated light output of the several sizes of lamps taken at 75 per cent current modulation and at various frequencies. Percentage of distortion tends to rise with an increase in the percentage of current modulation, the lamp wattage, and the frequency.

The random fluctuations in the light output of the lamps result in background noise in the systems in which they are used. When the 2-w argon-filled lamp is used with an RCA 931 A photocell and Corning No. 587 ultraviolet filter, the noise level is more than 50 db below

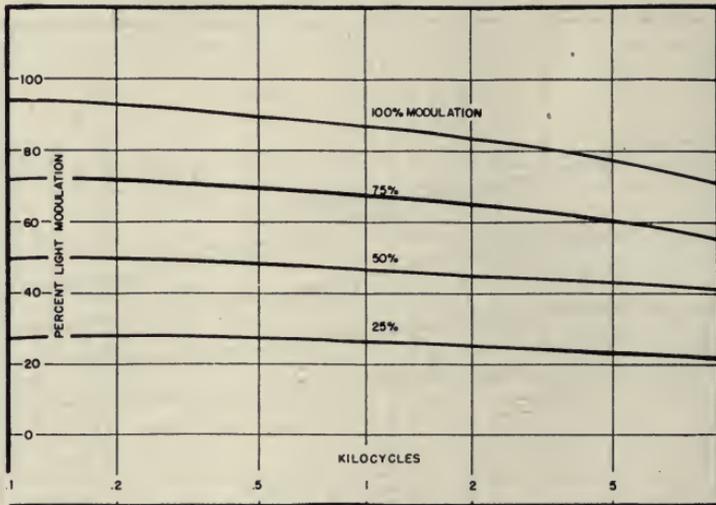


FIG. 7. Frequency characteristic for 2-w krypton-filled concentrated-arc lamp taken with an antimony phototube through a CG587 filter.

the maximum output of the lamp when it is 100 per cent current modulated. The majority of this noise seems to occur in the very low audio and subaudio frequency range and, in radio frequencies, between 100 kc and one megacycle.

TABLE 2
DISTORTION

Per Cent Second-Harmonic Distortion at 75 Per Cent Current Modulation

Lamp Rating Watts	Gas Filling	Antimony Cell (Freq.)			Caesium Cell (Freq.)		
		200	1000	5000	200	1000	5000
2	Argon	1.8	2.2	4.1	10.0	7.7	9.0
10	Argon	4.2	10.5	11.5	4.3	6.8	6.4
25	Argon	5.2	10.5	12.5	4.1	6.1	7.4
100	Argon	7.5	14	22.5	6.2	12.8	15.0
100	Krypton	10.0	17.5	18.8	7.8	12.3	13.0

Over a period of time, the lamps show small changes in modulated light output, as shown by the trace of Fig. 10. The amplitude of these changes in a good lamp is usually of the order of 2 db or less. The relative amplitude of these changes can be reduced if the lamps are operated at slightly higher than normal currents. This will tend to reduce the average life expectancy of the lamps, which for the 2-w lamp, operating on unmodulated direct current, is 175 hrs. When the lamp current is modulated, the life of the lamp may also be reduced. This is probably because of loss of zirconium vapor from the cathode-glow region of the arc during the extreme excursions of the modulation cycle, particularly if the polarity actually reverses.

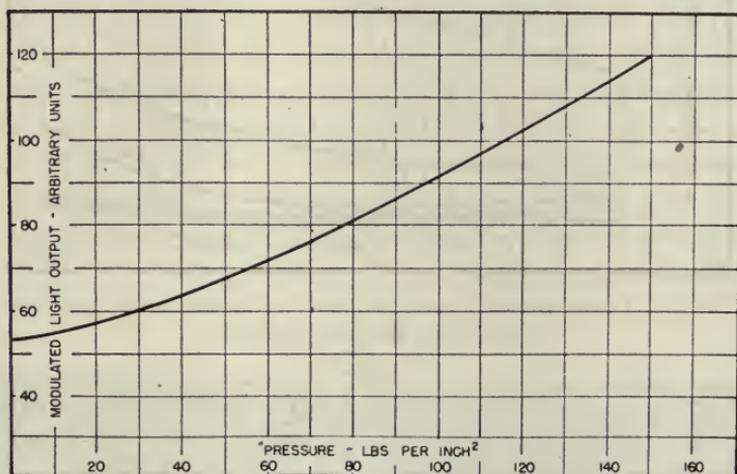


FIG. 8. Relative modulated-light output of concentrated-arc lamps at various gas-filling pressures.

The intensity of the modulated component of the radiation is not constant over the face of the cathode spot. Fig. 11 shows the relative values of modulated light intensity at different frequencies and at different positions in the cathode spot of a 100-w argon-filled lamp as measured with a caesium-type photocell. This diagram shows that the highest modulation intensities are found at the center of the spot.

If the current through a lamp is increased slowly, the diameter of the cathode spot will also increase, with some slight time lag, so that the unit brightness of the surface tends to remain almost constant. If the current is varied at a frequency of a few cycles per second or higher, the spot diameter remains constant, and the variations in current produce an almost linear change in the unit brightness of the

cathode spot. The fact that the dynamic relationship between the modulating current and the light output is linear, at various audio frequencies, is shown by the oscillograms of Fig. 12. These traces also show that there is a phase lag between the current and light,

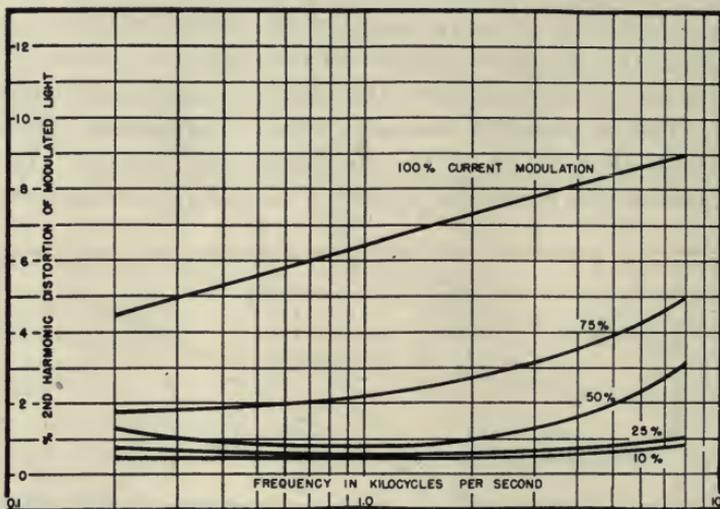


FIG. 9. Distortion characteristics of a 2-w concentrated-arc lamp taken with antimony phototube.

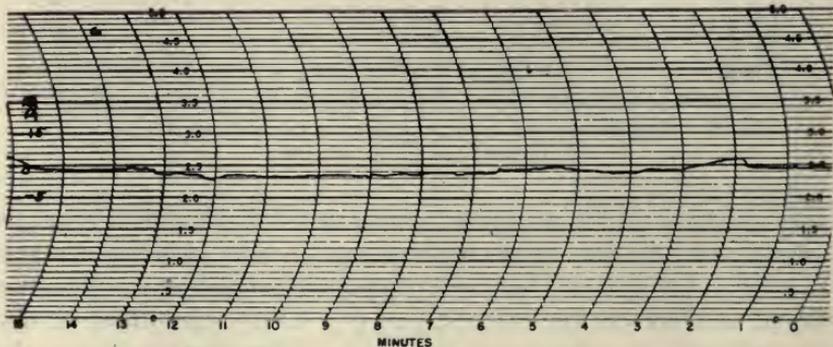


FIG. 10. Slow changes in modulated light output of a 2-w concentrated-arc lamp.

which increases with frequency. In the 2-w lamp, this lag rises to about 35 deg at 10 kc.

In their static characteristic, concentrated-arc lamps, like most arcs, show a negative volt-ampere curve. Thus, as the current is increased, the voltage across the lamp drops, giving the electrical

effect of a negative resistance. For stable operation, positive resistance must be added to the circuit in an amount sufficient to match the negative resistance of the arc and leave a positive surplus.

Fig. 13 shows oscillograms of the volt-ampere characteristic of a 2-w lamp at various audio frequencies. At 10 cycles, the negative slope is quite similar to that of the static characteristic; but, as the frequency increases, the pattern opens up, showing a negative characteristic over only a part of the cycle.

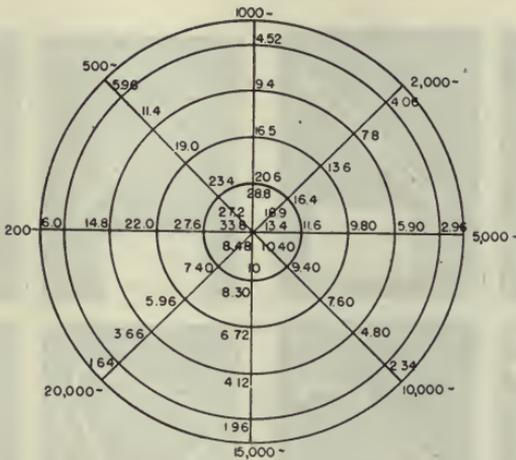


FIG. 11. Relative modulated brightness at various frequencies and at different parts of the light-source spot of a 100-w concentrated-arc lamp.

Impedance and phase characteristics of 2-w lamps are shown by the curves of Fig. 14. When operated at rated current and 50 per cent current modulation, the lamp acts as an inductive load with an average impedance, over the audio-frequency range, of about 200 ohms. As the frequency increases, this impedance Z at first decreases, reaches a minimum of 150 ohms at 1200 cycles, and then increases to 270 ohms at 10 kc. The resistive component R of this impedance has a value of minus 260 ohms at 100 cycles, reaches zero at 2600 cycles, and rises to 200 ohms at 10 kc. The voltage-current phase-angle curve θ_{EI} shows that the current lags the voltage, the lag decreasing as the frequency increases. The light always lags the current, the amount increasing with frequency, as shown by the current-light phase-angle curve θ_{IL} .

The impedance and phase characteristics of the larger wattage lamps show similar trends. Fig. 15 shows that the impedance of the 10-w lamp is 7 ohms at 1000 cycles, and that its resistive component becomes positive at 900 cycles.

The 25-w lamp of Fig. 16 shows an impedance of 5 ohms at 1000 cycles, and its resistance is positive at frequencies above 200 cycles.

Fig. 17 shows the same trends for the 100-w lamp. Here the 1000-cycle impedance is 1.5 ohms and its resistance becomes positive at a frequency less than 100 cycles.

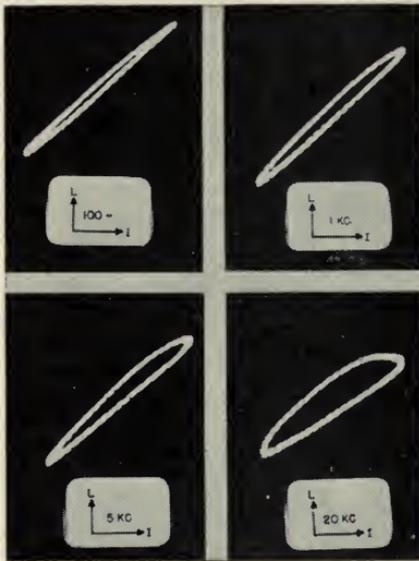


FIG. 12. Oscillograms of the dynamic light-current characteristic of a 2-w concentrated-arc lamp at various frequencies.

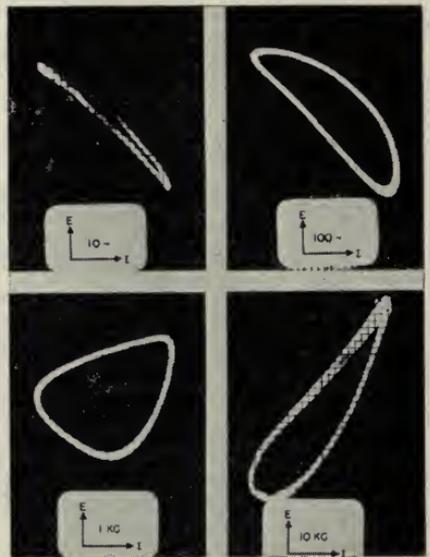


FIG. 13. Oscillograms of the dynamic volt-ampere characteristics of a 2-w concentrated-arc lamp at various frequencies.

Modulating circuits for concentrated-arc lamps are of two general types. The first, shown in Fig. 18, is applicable to 2-w lamps only. The impedance of this lamp is high enough so that it can be connected directly into the plate circuit of a vacuum tube, such as a 6L6, the modulating voltage being applied to the grid. Only 0.055 amp of direct current is required to maintain the arc, and this can be supplied by the normal plate current of the modulator vacuum tube.

In this circuit, the lamp is started automatically by a small spark coil, which is controlled by a relay in series with the lamp. In

practice, a pentode connection for the modulator tube would be preferred because of the stabilizing effect of the higher plate impedance

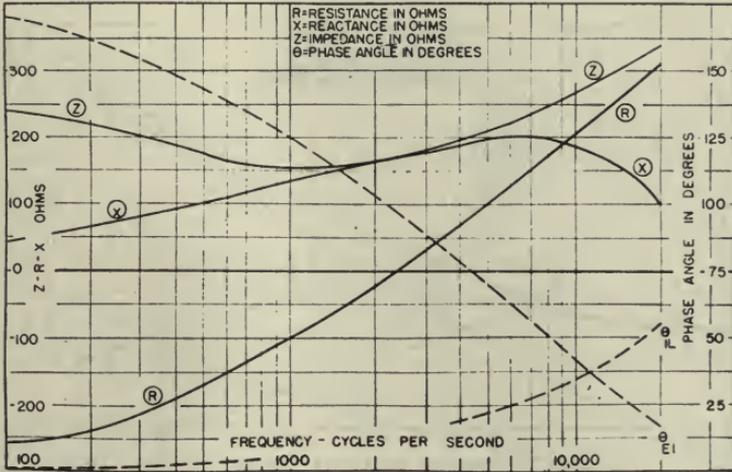


Fig. 14. Impedance and phase characteristics of 2-w concentrated-arc lamps.

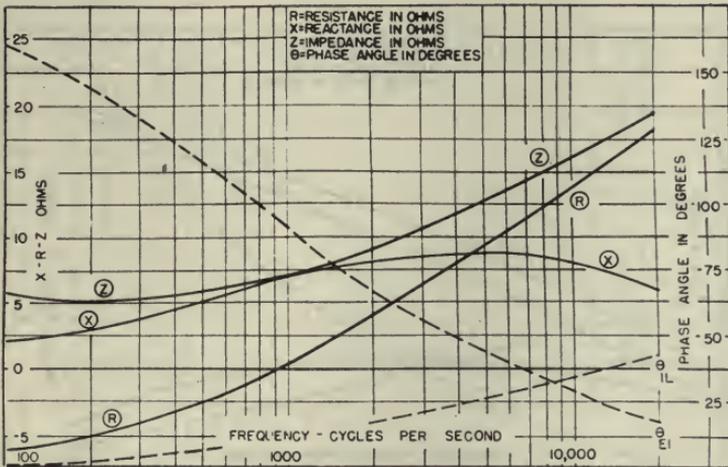


Fig. 15. Impedance and phase characteristics of 10-w concentrated-arc lamps.

and its more nearly constant current characteristic. There are also advantages in the use of negative current feedback.

Fig. 19 shows a type of modulator circuit which can be employed with all sizes of concentrated-arc lamps. Here, the lamp is coupled

to the modulator tube through a suitable impedance matching transformer, and the direct current for the arc is drawn from a separate supply. Manual starting is used in this circuit. The high voltage

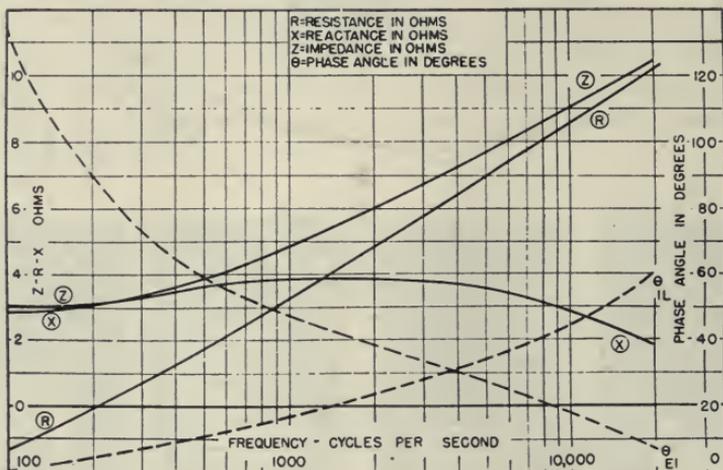


FIG. 16. Impedance and phase characteristics of 25-w concentrated-arc lamps.

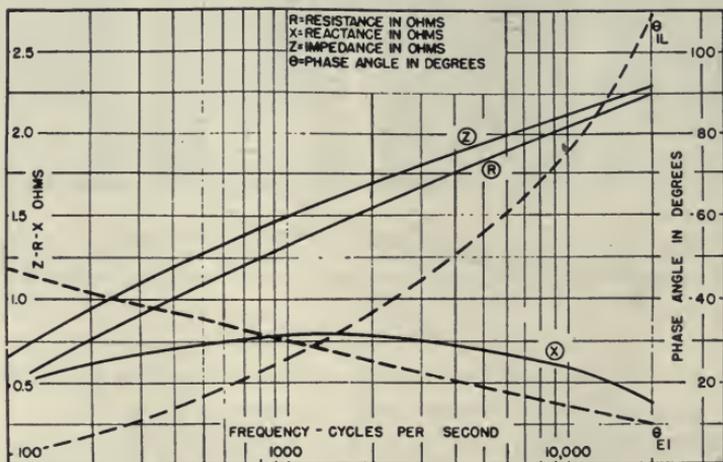


FIG. 17. Impedance and phase characteristics of 100-w concentrated-arc lamps.

necessary to start the arc is obtained from an inductive surge produced when a vacuum-type shorting switch is opened in the highly inductive direct-current supply circuit.

In the design of such modulators, consideration must be given to the unusual impedance characteristics of the lamps. For example, the 2-w lamp has a negative resistance at frequencies lower than 2600

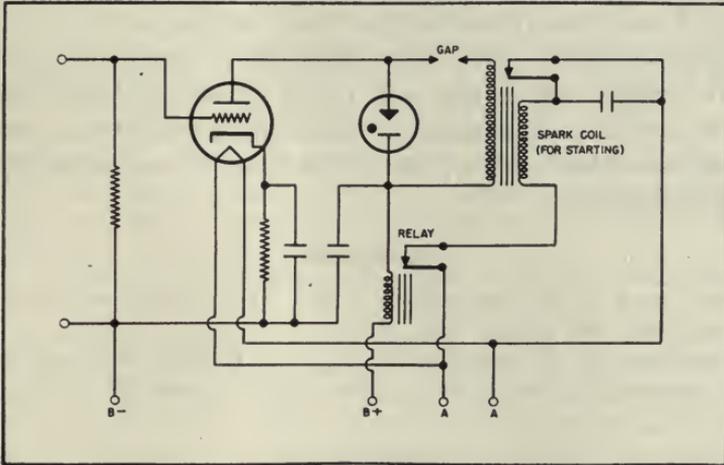


FIG. 18. Direct-coupled modulator circuit for 2-w concentrated-arc lamps.

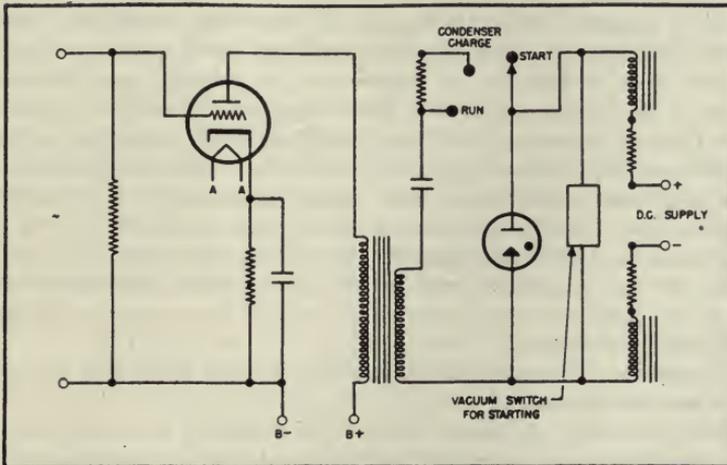


FIG. 19. Transformer-coupled modulator circuit for concentrated-arc lamps.

cycles. If this lamp is put into a circuit whose natural resonance is less than 2600 cycles, and if the positive resistance of the circuit is less than the negative resistance of the lamp, the circuit will oscillate. Thus, resistance must be added to some circuits to secure stability.

The actual power required to modulate the lamps, with the necessary circuit and stabilizing resistance, varies from about 2 w for a 2-w lamp to 50 w for a 100-w lamp. Modulating power requirements, for a given percentage of current modulation, rise with the increase of modulating frequency for all sizes of lamps.

A concentrated-arc lamp thus furnishes a source of modulated radiation which has unique and useful characteristics. The 2-w lamp, in particular, is adapted to applications requiring a source of high brightness, high percentage of light modulation, low background noise, and high fidelity.

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DISCUSSION

MR. R. S. LEONARD: What is the output of the 100-w lamp in lumens?

MR. BUCKINGHAM: On a candlepower basis, the 100-w lamp is quite similar to the 100-w tungsten filament lamp, giving about one candlepower per watt. Since the lamps have a cosine spatial distribution rather than spherical, when you convert from candlepower to lumens, you can multiply only by pi instead of four pi, so the lumen output of a 100-w lamp is pi times 100, or about 300 lumens. That is the reason we do not recommend these lamps for applications where total quantity or lumen output is important. Their use is indicated where the high brightness of the source is of major importance. The brightness is several times that of a tungsten filament and in many places that is very useful. Also, the source is so extremely small that in optical systems it has the advantage of forming the stop of the system in many applications to give unusual results. But the lumen output is only one-fourth of that of the corresponding tungsten lamp with equal efficiency.

MR. LEONARD: What would be the expected life at 3000-cycle operation of the 100-w size—continuous?

MR. BUCKINGHAM: We do not know. We have had some experience that indicates that the life is less under conditions of modulation than it is when operated with direct current, but now and then we have a lamp that comes along and lasts and lasts and lasts, under conditions of modulation, which I guess only proves that our lamps are not all exactly alike. For example, we have a 10-w lamp operating in New York City now which has been going steadily for over six months. I do not know the number of hours that would figure out, but since we expect a life of about 800 hr for the 10-w lamp, something is wrong there. So I do not know what length of life you would get in a 100-w lamp.

MR. LEONARD: Would you estimate in terms of hours just roughly?

MR. BUCKINGHAM: I would guess you would get somewhere near the normal length of life, which is 1000 hr. We think if you over-modulate the lamp so as to reverse the polarity, you may carry away enough of the active material to shorten the life very greatly.

DR. J. G. FRAYNE: What is the signal-to-noise ratio, approximately?

MR. BUCKINGHAM: It was not on the curve, but I gave it as being better than 50 db below the maximum output of the lamps. We do not know the exact figure because when we got 50 db below, we ran into 60-cycle hum which we were picking up because of an inadequate filter in the power supply.

DR. FRAYNE: Have you made any recordings on film?

MR. BUCKINGHAM: We have not. Being a communication company we do not have those facilities. That was one of the reasons for coming out here. We are hoping that somebody with those facilities will make the test and see what actually turns up.

MR. L. G. DUNN: Can you tell us the progress being made with high-wattage lamps?

MR. BUCKINGHAM: There has been a great deal of interest in the higher wattage lamps, and we have had them up to about 1500 watts in operation in the laboratory. The 1500-w lamp, for example, has a source spot about $\frac{3}{8}$ in. or a little less in diameter, giving about 4000 cp. This means that it has a unit brightness which figures out about 70 candles per sq mm. That is a large enough spot size so that it could be used in a 35-mm projector with an ordinary condensing system. We have been working hard on this particular phase of the lamp development, because there is so much interest in it, and expect shortly after the first of the year to have something that we can show people. The lamps so far have been of a highly experimental nature, but very, very promising in their performance.

MR. DUNN: What specific applications have been made?

MR. BUCKINGHAM: The applications that have been made so far have been, of course, with the smaller lamps, which are now available, the 2- to 100-w sizes. The major applications have been perhaps in the field of photography and microscopy. In a photographic enlarger the use of the point source lamp in a condenser system acts as a stop of the lens system so that the pictures you get are extremely sharp in comparison to those you would get on the same system using a larger source lamp.

MR. P. A. WILLIAMS: Mention was made of the appreciable radiation of these lamps in the ultraviolet and infrared regions and it would seem that the latter would be a rather important factor in the heat radiation and necessary cooling equipment. It would be interesting to learn whether or not it has been found necessary to provide forced air or other means of cooling when these lamps are used in enclosures.

It is also suggested that some information be provided regarding the effects of operating temperature on the light output. Several attempts have been made in the past to use gaseous discharge tubes for photographic printing but the variability of light output with temperature has made the practical use of such sources rather difficult.

MR. BUCKINGHAM: The spectrum of the concentrated-arc lamp differs from that of the tungsten-filament lamp only in that it shows a few sharp peaks of

line radiation which originate in the gas discharge and also in that the concentrated-arc lamp is several times as bright as the tungsten-filament lamp.

There is no greater proportion of ultraviolet or infrared in the output of a concentrated-arc lamp considering its increased brightness in the visible. It has the same advantages in these spectral regions as it has in the visible, those of high brightness or concentration of energy and small-source size.

From a practical standpoint, 100 w of electrical energy put into a concentrated-arc lamp will produce no more heat than 100 w put into a tungsten-filament lamp. However, because of the high brightness of concentrated-arc lamps, it is possible in some applications to substitute a 100-w concentrated-arc lamp for a 500-w tungsten-filament lamp without decreasing the useful light output of the equipment. In this case, there will be only one-fifth as much heat given off by the concentrated-arc lamp as by the tungsten lamp.

The second question has to do with the effect on lamp operation of the room or operating temperature. We have been unable to detect any difference in the lamp operation or light output as the external temperature is varied over a range of several hundred degrees. The lamps are not critical in this respect.

A NEW BLOPING DEVICE*

GEORGE LEWIN**

Summary.—This paper describes a method of automatically silencing the splices on work prints used for rerecording. Holes are punched in the picture area of the sound track by means of a convenient foot-operated punch, at a fixed distance from each splice. These holes then serve to operate a switch in the rerecording head so that the sound output is momentarily cut off while the splice is passing the scanning beam.

The need for a satisfactory method of silencing or "blopping out" the noise caused by splices in sound track has been recognized since the inception of sound pictures. This need is especially felt when preparing the sound tracks for final rerecording, at which time original dialogue, narration, music, and sound effects tracks are blended together to make a single continuous negative, free from any noises caused by splices on the original tracks. Various methods are in use, some operating on the print, and others on the negative.

Common methods for treating the positive consist of painting over the splice with various types of ink, spraying the splice with an air gun containing the ink, while covering the area of the splice with a triangular shaped mask, or covering the splice with a special adhesive tape cut in triangular form.

When operating on the negative, the principal method is to punch a triangular hole over the splice which prints through opaque on the positive. The second method is to produce a flash exposure in the printing machine at each negative splice.

All of the above methods are very effective when properly accomplished, but all require extreme care in handling the film so as not to introduce extraneous noise caused by dirt, and all are time-consuming.

* Presented Oct. 24, 1946, at the SMPE Convention in Hollywood.

** Chief, Sound Branch, Studio Division, Signal Corps Photographic Center, Long Island City, N. Y.

In most of the pictures produced at SCPC, the negative is not cut, and all cutting and rerecording operations are carried out on the work print. In the case of "lip-sync" type of picture, where foreign dialogue is recorded to match the lip movements of a picture which was originally photographed with English dialogue, it is not uncommon to have as many as 250 splices in a single reel. It can readily be appreciated, therefore, that the blooming operation assumes major importance when preparing a print for the rerecording process.

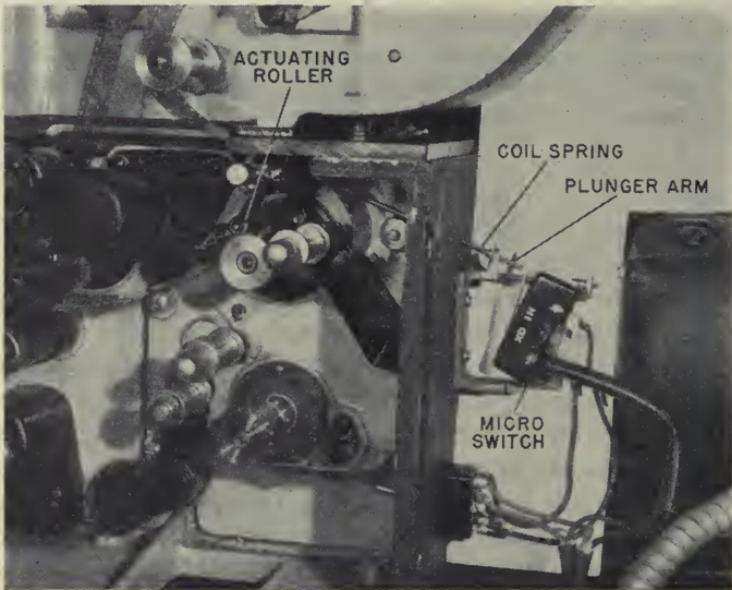


FIG. 1. Switch and actuating mechanism installed on rerecording head.

The machine about to be described was developed for the purpose of eliminating, as far as possible, the tedious and time-consuming operations of blooming sound film, and at the same time resulting in sound tracks which are quieter as a result of avoiding the handling necessary with hand blooming. The operating principle adopted is to shut off the sound automatically whenever a splice passes the scanning beam. Three methods of accomplishing this effect were tried before the third method was finally adopted.

The first method consisted of introducing a variable-gain amplifier into the output of the rerecorder. This permitted accurate control

of the rate of decay and restoration of the signal. It proved very effective in silencing an oscillator tone with complete absence of clicks, but peculiarly it developed that this method caused a noticeable thump in the background noise of the film.

The second method attempted automatically to block the exciter light with a properly shaped mask to produce the same wave form as is obtained with a good ink or tape bloop. This method showed great promise but involved mechanical difficulties, and was abandoned when it was found that the third method proved to be the simplest as well as the most effective.

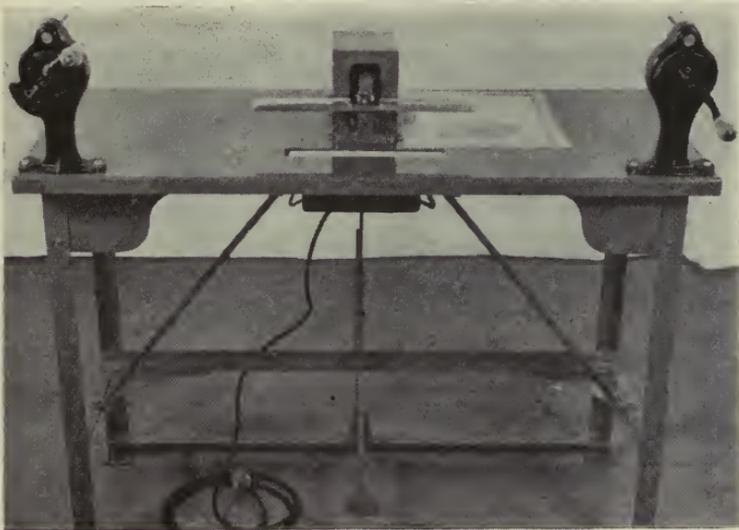


FIG. 2. Film-punching table.

This third method consisted simply of switching off the sound from the rerecorder momentarily with an automatically operated switch, whenever a splice went through. The switch is located in the rerecording head itself and is operated as described below. Electrically, the switch is connected in the output of the preamplifier, just ahead of the input to the mixer. This ensures maximum signal-to-noise ratio as regards any electrical noise the switch might introduce.

The principal problem remaining was the method of operating the switch. Consideration was first given to the possibility of having the thickness of the splice itself operate the switch, but it was feared that this might prove too delicate for practical use. It would also

require the use of time-delay circuits, or else undergo the possibility of introducing flutter in the film motion through the use of contacting mechanisms close to the scanning beam.

It was, therefore, decided to punch a hole in the film at a fixed distance from each splice and use this hole to provide positive operation of a sensitive switch. This method also provided the advantage of permitting adjustment of the duration of cut-off simply by varying the length of the hole. Where two or more splices occur within the space of a few inches, with no intervening modulation, which is often necessary to improve synchronization, it is possible to blank the entire duration simply by overlapping two or three punch holes.



FIG. 3. Film in position for punching.

Fig. 1 shows the installation of the actuating mechanism in a recorder. A light coil spring is placed over the plunger arm to provide positive return pressure, rather than rely on the relatively feeble spring return in the switch itself. The actuating roller is swung up out of the way when threading the machine. It can be left in the "up" position whenever it is desired to run prints which do not require machine blooming, or have been bloomed by conventional methods.

Fig. 2 shows the film punch table used by the operator in preparing the sound track. The punch itself is foot operated, leaving both hands free to handle the film.

Fig. 3 shows a close-up of the film guide-plate. The register pins serve to positively determine the position of the splice so that the

distance from splice to hole is accurately fixed. This distance and the length of the hole were set so that the switch operates approximately 0.025 sec before the splice enters the scanning beam, and remains closed for a total duration of approximately 0.050 sec. These dimensions have proved adequate for the most closely cut splices, while at the same time allowing a tolerance of at least one sprocket hole either way in threading the rerecorder.

The film punching machine has been laid out so that the sound track remains outside the punch with the emulsion side up, thus minimizing the possibility of scratching the film.

It is estimated that this machine reduces the time necessary for blooping a reel to a negligible fraction of the time normally required to do a good hand-blooming job. Where formerly it was necessary to spend a day or more in preparing and then making corrections in a reel, it is now done in anywhere from ten minutes to one hour. Furthermore, it can be successfully operated by semiskilled personnel with practically no special training. The most important saving of all is, of course, the avoidance of long delays during rerecording sessions while noisy bloopers are located and painted out.

The machine has also proved useful in blooming out noises resulting from causes other than splices—such as accidental scratches and dirt marks on the film, and pin holes in the emulsion.

Should a hole be accidentally punched in the wrong location, it can be corrected simply by applying a piece of scotch tape over the hole.

Credit for the design and construction of the punch and switch actuating mechanism is due the personnel of Sound and Machine Shop Branches of Studio Division.

[*Ed. Note.*—A sound film was projected demonstrating the effectiveness of the blooming device. The film consisted of a typical narration track, rerecorded first without and then with the antiblooper in operation. In order to accentuate the operation, numerous extra splices, closely spaced, were made in the original track. Each splice was scraped of emulsion to make it unusually loud. The complete silencing of the splices in the second rerecording was evident.]

IMPROVED ENGINEERING DESIGNS FOR STAGE DOORS, TRANSPARENCY SCREENS, AND WATER TANK BULKHEADS*

A. C. ZOULIS**

Summary.—This paper describes three innovations in studio stage construction: (1) *Vertical-Lift Stage Separation Doors.* These doors eliminate the hinged type formerly used, which required so much valuable stage space. Ease of operation and good sound insulation have been obtained between adjacent stages. (2) *A Movable 50-Foot Transparency Screen.* A screen has been suspended from a monorail system for storage outside the stage. It can be readily rolled into position in the space normally occupied by the vertical lift doors to permit large screen transparency shots to be made between two connecting stages. (3) *A Vertical-Lift Disappearing Bulkhead for a Stage Water Tank.* A hydraulically lifted bulkhead has been designed which permits a large sound stage to be quickly converted into a 7-ft deep tank.

Vertical Lift Stage Separation Doors.—With the ever-increasing demand for larger and improved motion picture stages, the architectural, engineering, and allied professions have made great strides and improvements in keeping abreast of the constantly changing techniques and new demands for improved facilities.

Ingress and egress to motion picture stages has, from the beginning of stage operation, presented an important problem. The conventional hinged, sliding, and vertical raising doors have filled the needs where this type installation served the purpose best. However, in many instances sacrifices were made either in size of opening or other restrictions imposed by utilities or building limitations.

The ever-increasing scope to accommodate extensive motion picture sets and provide for unusual effects has created a demand for larger stages, which in themselves may prove an extravagance economically where an entire stage may be required to accommodate a comparatively small motion picture set.

With this in mind, the Engineering Department of Paramount Pictures, Inc. undertook the problem of devising a means of dividing

* Presented Oct. 22, 1946, at the SMPE Convention in Hollywood.

** Chief Engineer, Paramount Pictures, Inc., Hollywood.

a large stage area under one roof into smaller areas. Obviously, such an arrangement provides a greater flexibility in the use of the area as the occasion demands. Accordingly, plans were prepared and an installation made between Stages 12-14 and Stage 15, the former containing 17,630 sq ft, the latter 17,668. The opening separating the two stages is 60 ft wide and 38 ft high. The vertical raising sections consist of a pair of leaves on each side, divided in the center. The sections are raised into an overhead well so that when the maximum height is reached, the plane of the bottom chord line of the stage trusses is unobstructed. The total weight of the vertical sections is approximately 40,000 lb. The leaves are constructed of structural steel frames into which is incorporated the insulation and finishing materials for the desired attenuation. The opening is provided with sealing features at the top, at the center horizontal joint of the leaves, and at the floor, and has an automatic self-sealing device in the jambs. A structural separation is provided between the doors with necessary isolation at jambs, head, and floor for greater attenuation.

The structure supporting the overhead well consists of an independent superstructure housing, supported by two frame towers at the jamb sides. The towers are designed to accommodate the counter-balance space and arbors. The overhead truss structure, in addition to supporting the weight of the vertical sections, also accommodates the hoisting mechanism.

Each vertical raising section is electrically operated with a 5-hp, 2-speed, constant torque, 22-v, 3-phase, 60-cycle motor in conjunction with the mechanical brake, upper and lower limit switches, slow-down switches and a reversing controller providing automatic acceleration, antiplugging on de-acceleration to final lowered position and locked with limit switches.

After the installation was completed, a sound test was made by placing a loud speaker and microphone at selected positions within the large area closed by the door. Warble tone at selected frequencies was applied to a loudspeaker (Lansing Iconic used by the studio for playback monitoring) which was shifted to selected positions within the opening closed by the door and with the face of the loudspeaker approximately two feet from the surface of the door. A 618A microphone on the other side of the door and opposite the corresponding loudspeaker position picked up the sound level from the loudspeaker for measurement on an RA-142 Sound Level Meter. The difference in levels between the open door and that obtained

with the door closed represents the attenuation caused by the door. This method of direct comparison eliminates differences resulting from response of loudspeaker, microphone, *etc.*

In comparison with the attenuation of the wall construction used in the stage where the installation was made, the measurement indicates that the door, when fully closed, provides a relatively good insulation against the transmission of sound for the frequency range checked. This was indicated from the measurements taken which were from frequencies of 150 to 500 cps. Under these conditions, the measurements tend to concentrate between the levels of 38 to 45 db and 57 to 60 db, respectively. The measurements of the frequencies above 500 cps tend to concentrate within the levels of 63 to 66 db.

Movable 50-ft Transparency Screen.—The advantage of using large transparency screens for background projection purposes has increased the scope of this activity to an important function within the motion picture industry. Transparency screen techniques have made possible the incorporation of animated interiors and exteriors within the confines of a motion picture sound stage, resulting in drastically reduced production costs. These improvements, to a large extent, have replaced former procedures required by locations for the backgrounds desired.

The problem of handling and storing large screens is in direct proportion to their size. Since it is not practical to remove acetate screens from their rigid frames and roll them into a compact unit for storage, numerous methods have been employed.

A practical method for the storage of a large 50-ft screen is employed at Paramount Pictures, Inc. The installation consists of a large storage enclosure approximately 8 × 62 ft on the exterior and adjoining the stage equipped with monorail for handling the screen. In designing the screen storage housing, particular attention was given to the construction details to exclude dust particles and to provide for eventual screen size expansion. Within the storage area the screen, attached to carriers, is suspended from a monorail which connects to the system within the adjoining stage. When occasion demands use of the screen on the stage, the screen is moved through a door especially constructed to accommodate full height of the screen and then transferred to a crane beam suspended from the monorail system attached to the overhead trusses within the stage proper. The screen is then ready to be moved longitudinally within the stage to the required foreground position. Chain hoists at each end of the

crane beam which support the screen permit vertical adjustment as required for the height above stage floor.

In conjunction with the crane beam for screen movement, a light bridge to accommodate lighting equipment is suspended from an independent monorail system above the top of the screen proper. This permits the light bridge to be placed at the most advantageous location for properly lighting the screen foreground and for shadow elimination. Chain hoists at each end of the light bridge permit vertical adjustment to coincide with the transparency screen crane beam. Canvas roller curtains for each side of screen frame are provided to cover and protect screen while not in use or when being moved about the stage or into the storage area.

Vertical Lift Disappearing Bulkhead for a Stage Water Tank.—

The use of concrete tanks within a motion picture stage for water effects when required for production has long been established as a decided advantage over exterior locations without benefit of sound-proofing, acoustical control, or other standard facilities.

The problem of providing a vertical lift bulkhead to permit direct access to the stage floor from the exterior without grade interruptions and also to make possible the use of a continuous floor level with adjoining stage without temporary bulkheads, was recently studied by the Engineering Department of Paramount Pictures, Inc. The walls of an existing concrete tank within the stage are 8 ft high. Opposite the opening to an adjoining stage, a vertical lift steel bulkhead 60 ft long and 7 ft high has been installed. The installation consists of a subsurface elongated well to permit vertical movement of the bulkhead. When lowered, the top cover plate is flush with the surrounding tank floor and adjacent stage area.

The operation of the bulkhead, which weighs approximately 20,000 pounds, is through a sheave system and counterbalance with sufficient weight differential between counterbalance and weight of bulkhead for sufficient ease of handling. The counterbalance is located at the center of the bulkhead compartment and is raised or lowered with a 5-ton chain block. The bulkhead is adjustable in vertical height from zero at floor level to 7 ft above floor. Within these limits the bulkhead may be locked into position with a manually operated 50 : 1 reduction worm and bevel pinion gear on a continuous shaft, to which are attached eccentric cams, the rotation of which actuates toggles secured to the sealing mechanism to make the bulk head water-tight at sides and bottom.

Provisions have been made in the bulkhead cover plate to permit additional construction to accommodate transparent spillway or to raise the over-all height to coincide with the 8-ft concrete tank side walls.

ELECTRONIC FIRE AND GAS LIGHT EFFECT*

HAROLD NYE**

Summary.—A method is described for electronically modulating small incandescent light sources to simulate the effect of gas flame flicker and light emanating from a fireplace. The effect produced is more natural than can be obtained with dimmer and flasher methods and is entirely automatic.

When photographing motion picture sets using gas light brackets, it has been common practice to conceal a 50- or 100-w projection lamp back of each shade to reinforce the light from the gas flame, as the flame itself does not produce enough light for satisfactory photographic results. These lamps are usually controlled by means of a flasher and dimmer combination to simulate the flicker of the gas flame on the wall, as shown in Fig. 1. The results obtained are more or less mechanical and require the constant attention of an operator.

Some time ago we received a request from the Decorative Lighting Department to develop an automatic control for these lights that would make them synchronize exactly with the flicker of the gas flame. If the gas light is turned up, or turned down or out, the reinforcing light must follow the action faithfully as well as producing the flicker, and it must do this without any manual operations.

This was accomplished with a simple electronic control in the following manner: The light from the gas flame in the bracket was picked up with a photocell attached to the back of the bracket shade and concealed from the camera (Fig. 2). The photocell was connected in a phase-shift circuit which controlled the grid of a thyratron tube. The lamps that produce the reinforcing light were connected in the anode circuit of the tube and the light produced could be made directly proportional to the amount of light picked up by the photocell. The cell was enclosed in a metal shield with a tubular window so arranged that it could pick up the light from the tip of the gas flame and not be affected by the normal set lighting.

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

** Warner Bros. Pictures Inc., Burbank, Calif.

The thyatron unit controls the current through the lamp. The light reproduced on the wall was a very faithful reproduction of the gas flame flicker and the lag in response could not be detected. The circuit, with the omission of protective devices, is shown in Fig. 3.

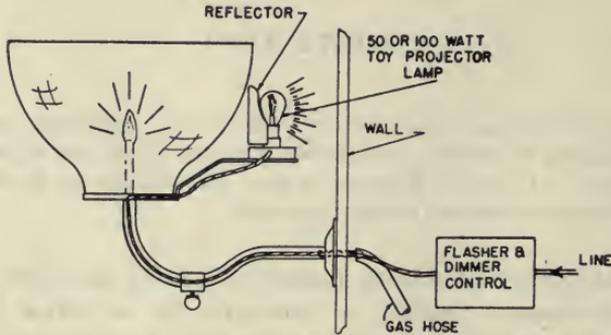


FIG. 1. Method ordinarily used for concealing a small projection lamp back of a gas bracket to reinforce the light produced by the gas flame.

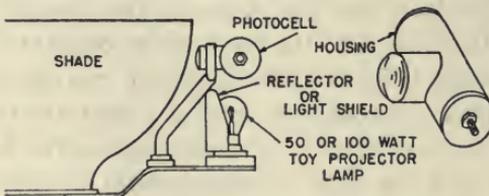
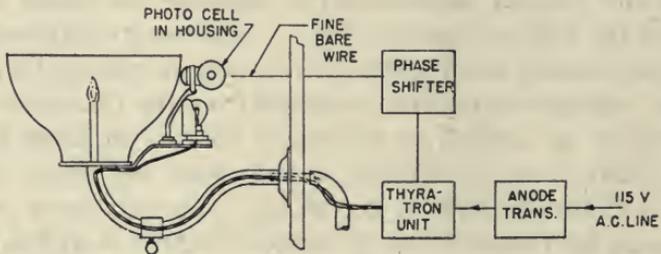


FIG. 2. An electronic circuit is added to modulate the projection lamp to simulate gas flame flicker.

The thyatron employed was an *FG-105*, which is a shield grid type and is rated at 6.4 average amp, and it will take care of the requirements of the average set to be photographed in black and white. T_2 is the anode transformer which must be capable of carrying the

entire lamp load. T_1 is the grid transformer which handles very little power. P_1 is a potentiometer connected across the secondary of the grid transformer and serves as the sensitivity control.

The section AB of this potentiometer, the secondary of the anode transformer, the capacitor C , and the photocell, form a resistance-capacitance phase shift bridge in which the photocell serves as the resistive element. This bridge controls the phase angle of the grid voltage relative to the anode voltage. The phase angle of the grid voltage determines the amount of current that flows through the thyatron and the load.

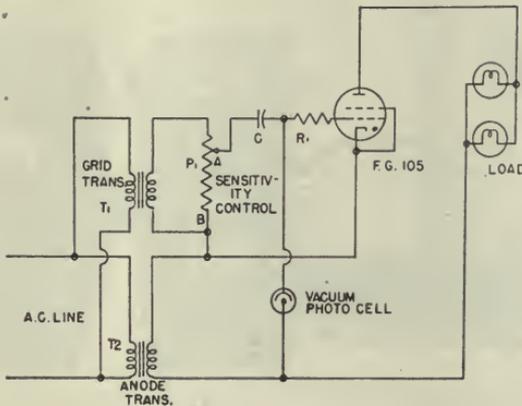


FIG. 3. Half-wave electronic circuit for modulating incandescent lights.

The sensitivity control is adjusted so that when no light strikes the cell the grid voltage is about 180 deg out of phase with the anode voltage and the tube does not conduct. Small increments of light on the photocell decrease the angle by which the grid voltage is displaced from the anode voltage, and the tube starts to conduct. When there is sufficient light on the cell, the grid and anode voltage are practically in phase and the thyatron conducts maximum.

The photocell used was a 922, which is a vacuum cartridge type. This particular cell was selected because it could be mounted in a small housing.

The capacitor C is in the neighborhood of $0.0003\mu\text{f}$. The grid circuit is a high impedance circuit and should be properly shielded. R_1 is the grid resistor used for the protection of the thyatron grid.

The sensitivity control is the only adjustment in the circuit. With this control the lights can be phased full on, off, or the photocell can be given any desired amount of control, *i. e.*, the flicker can be made violent or barely perceptible. The rate of flicker, of course, depends on the flicker of the gas flame. All the operator has to do is to adjust the sensitivity control until the flicker looks natural to the eye. Any operator can run the equipment with a few minutes instruction.

The characteristics of mercury thyratrons vary slightly until they reach their operating temperature and some adjustment of the sensitivity control may be necessary for the first half hour, but after the

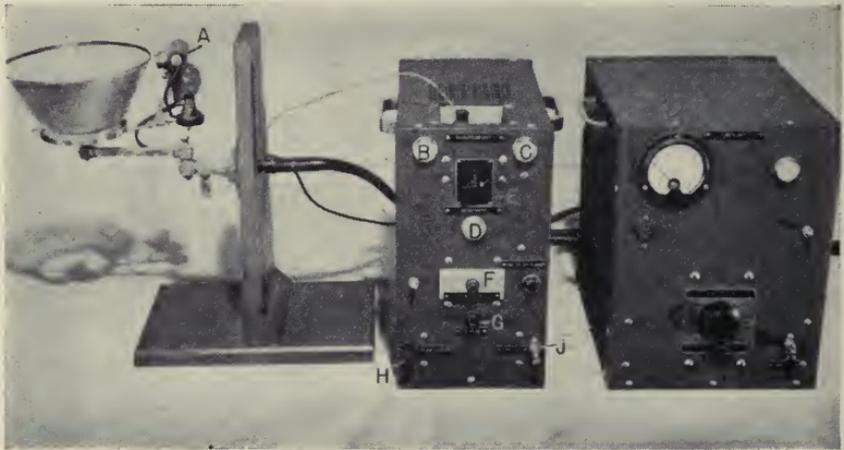


FIG. 4. Equipment used for electronic flicker effect.

tube has heated sufficiently, no further attention is required from the operator.

A five-minute time delay relay is required to delay the application of the anode voltage until the cathode has reached its operating temperature. This relay, switches, fuses, and pilot lights are omitted from Fig. 3.

A photograph of the original equipment as used is shown in Fig. 4.

A is the photocell in a metal housing set so it will pick up the flickering light from the gas flame. No optical system is used. Since one photocell terminal is common with one of the power lines to the lamp, it is necessary only to run one lead from the photocell to the thyratron grid circuit. Trouble was encountered when we tried to cable this lead along with the power leads, even though it was shielded,

but bare wire can be used if it is kept away from the power leads. A piece of No. 38 bare copper wire run from the sensitive side of the photocell to a pin driven through the wall serves as this lead and it is so fine that it will not photograph. A lead fastened to the other end of the pin on the back of the set connects to the grid post on top of the thyatron unit which is in the center of the picture.

The pilot light *B* indicates that the filament is turned on. The pilot *C* lights when the time delay relay has applied the anode voltage. The pilot *D* is connected across the load and permits the operator to observe the flicker being produced even though he is not in a position to see the lights on the set. *E* is the sensitivity control, *F* is the anode

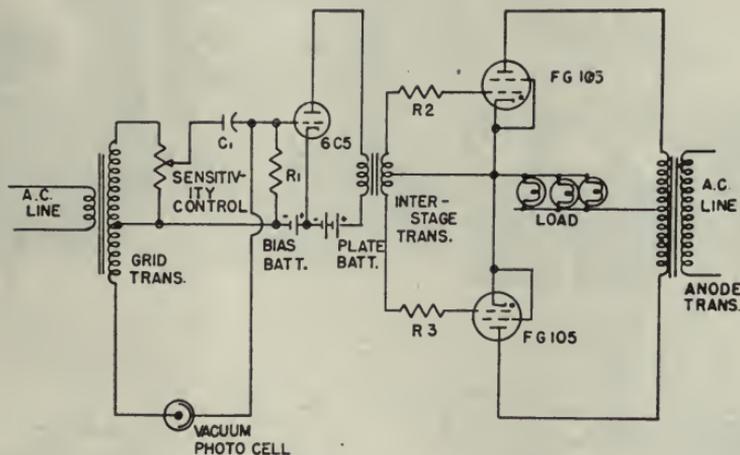


FIG. 5. Full-wave flicker and fire effect.

fuse compartment, *G* is the filament fuse, *H* is an external cathode connection which is not used in this setup, and *J* is a ground connection. It is not necessary that the equipment be grounded as no interference is created with the sound recording equipment.

The unit on the right of Fig. 4 contains the anode transformer. The unit shown has a varitran and voltmeter built into it, and while not absolutely essential, it is convenient to be able to raise the anode voltage somewhat above normal when the maximum light picked up by the photocell is insufficient to produce a 180-deg phase shift of grid voltage.

In some long shots we connect as many as ten bracket lights to one of these electronic units. The fact that all of the lights are controlled from one flame is not obvious in a long shot.

Small lighting units such as Dinky Inkies or Baby Juniors are also controlled by these units when it is desired to have the light flicker over some local area.

Light sources of 250 w or less respond to the flicker modulation better than the larger units because the thermal inertia of large lamp filaments filter out much of the higher frequency component of the flicker. Photoflood lamps of the same wattage produce better results than the regular projection lamps.

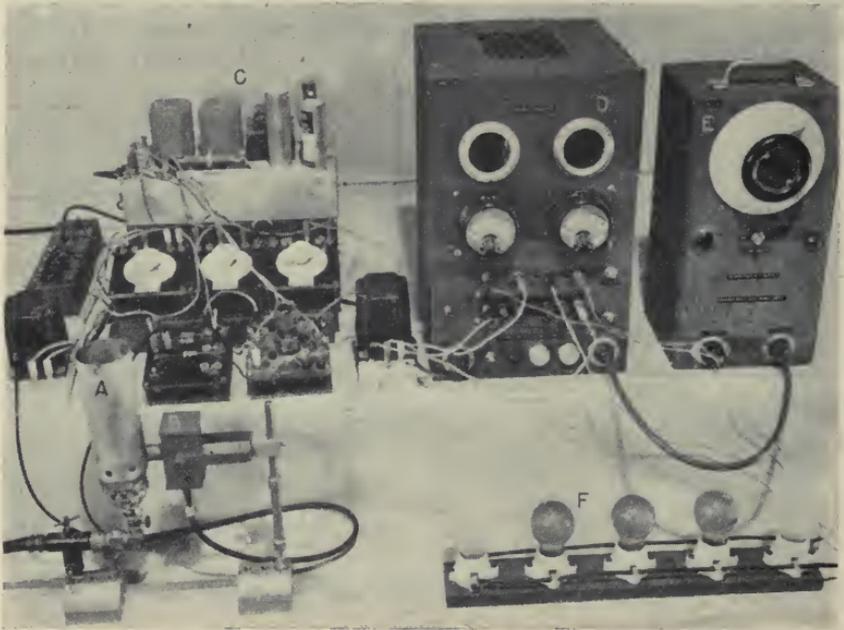


FIG. 6. Laboratory setup of full-wave flicker and fire effect.

Gas flames are usually used in fireplaces on motion picture sets, and here again it is necessary that the light produced be augmented with a flickering incandescent light source in order to produce sufficient light to photograph satisfactorily. The unit just described is ideal for controlling these lights when not more than 750 w are required. This wattage is ample for the ordinary fireplace to be photographed in black and white. When used for a fireplace effect, the photoelectric pickup is made from a gas pilot flame located off stage.

When more than 750 w are required, two setups like the one just described may be used or a full-wave unit consisting of two thyratrons may be used. A full-wave circuit is shown in Fig. 5.

This circuit operates on the same principle as the one shown in Fig. 3. A vacuum tube and an interstage transformer have been added to the circuit so that the voltages applied to the grids of the two thyratrons are 180 deg out of phase with each other. The anode transformer must have a center tapped secondary, and although batteries are shown in Fig. 5, a power supply was actually used. Fig. 6 shows a laboratory setup of this circuit. The gas burner *A* and the photocell housing *B* are similar to the pickup system used for a fireplace effect. The equipment shown at *C* is a bread-board setup of the control circuit. *D* is a full wave thyatron unit, *E* is the anode transformer and variac, and *F* is a lamp bank of photofloods which serves as a load. This setup has been tested for some time in the

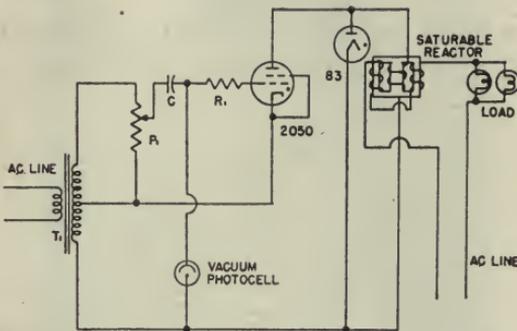


FIG. 7. Electronic fire effect utilizing a saturable reactor.

laboratory and appears to operate very satisfactorily but it has not been built up for use on production.

The gas burner should be in a chimney so that it can create its own draft and be independent of drafts that exist on the stage. The air holes for the burner should be properly located and be made adjustable so that any amount of flicker can be produced.

If, for any reason, it is not possible to place the photocell close to the gas flame, the cell may be located several feet away and the image of the flame can be focused on the cell with a simple optical system.

Electronically controlled saturable reactors can be used for fireplace effects, but they are not so satisfactory as the circuits already described. The circuit for such a unit is shown in Fig. 7. The grid circuit of the 2050 thyatron is the same as that shown in Fig. 3. The saturable reactor has a capacity of 500 va and the direct-current winding can saturate the core with about 100 mils flowing through it.

The tube load is highly reactive and the 83 tube forms a path for the current because of the collapse of the direct-current field. With this "free-wheeling" circuit it is necessary that only one tube be grid controlled.

The only advantage of this circuit is that small tubes are used and it is cheaper to build. The disadvantage is its slow response caused by the lag in the reactor. With a well-designed saturable reactor, not larger than 500 va capacity, it is possible to produce a fair fire-place effect.

Some experiments have been conducted using ignitrons to control heavy loads such as might be used for large fires, but these experiments have not progressed far enough to reach any definite conclusions.

We have been using some of these electronic fire and flicker effects for about a year and the results have been very satisfactory.

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C. W. HANDLEY
A. C. HARDY

P. J. LARSEN
G. E. MATTHEWS

CINEMATOGRAPHY.—To make recommendations and prepare specifications for the operation, maintenance, and servicing of motion picture cameras, accessory equipment, studio and outdoor set lighting arrangements, camera technique, and the varied uses of motion picture negative films for general photography.

J. W. BOYLE, *Chairman*
1207 N. Mansfield Ave.
Hollywood, Calif.

C. G. CLARKE
KARL FREUND

*ARTHUR MILLER

ARTHUR REEVES
JOSEPH RUTENBERG

COLOR.—To make recommendations and prepare specifications for the operation, maintenance, and servicing of color motion picture processes, accessory equipment, studio lighting selection of studio set colors, color cameras, color motion picture films, and general color photography.

J. A. BALL, *Chairman*
12720 Highwood St.
Los Angeles 24, Calif.

M. R. BOYER
O. O. CECCARINI
L. E. CLARK
R. O. DREW

R. M. EVANS
J. L. FORREST
J. G. FRAYNE
L. T. GOLDSMITH

A. M. GUNDELFINGER
A. C. HARDY
L. L. RYDER
J. G. WHITE

* Advisory Member.

CONVENTION.—To assist the Convention Vice-President in the responsibilities pertaining to arrangements and details of the Society's technical conventions.

W. C. KUNZMANN, *Chairman*
Box 6087
Cleveland 1, Ohio

JAMES FRANK, JR.
E. R. GEIB

H. F. HEIDEGGER
O. F. NEU

A. SHAPIRO
L. H. WALTERS

EXCHANGE PRACTICE.—To make recommendations and prepare specifications on the engineering or technical methods and equipment that contribute to efficiency in handling and storage of motion picture prints, so far as can be obtained by proper design, construction, and operation of film handling equipment, air-conditioning systems, and exchange office buildings.

(Under Organization)

FELLOW AWARD.—To consider qualifications of Active members as candidates for elevation to Fellow, and to submit such nominations to the Board of Governors.

D. E. HYNDMAN, *Chairman*
342 Madison Ave.
New York 17, N. Y.

E. A. BERTRAM
M. R. BOYER
JAMES FRANK, JR.
C. R. KEITH

W. C. KUNZMANN
G. T. LORANCE
J. A. MAURER

L. L. RYDER
A. SHAPIRO
E. I. SPONABLE
W. V. WOLFE

FILM PROJECTION PRACTICE.—To make recommendations and prepare specifications for the operation, maintenance and servicing of motion picture projection equipment, projection rooms, film storage facilities, stage arrangement, screen dimensions and placement, and maintenance of loudspeakers to improve the quality of reproduced sound and the quality of the projected picture in the theater.

G. T. LORANCE, *Chairman*
63 Bedford Road
Pleasantville, N. Y.

HENRY ANDERSON
*C. J. BACHMAN
T. C. BARROWS
H. D. BEHR
H. J. BENHAM
M. F. BENNETT
KARL BRENKERT
F. E. CAHILL, JR.
D. W. COLLINS
C. C. DASH

L. W. DAVEE
A. S. DICKINSON
J. K. ELDERKIN
JAMES FRANK, JR.
R. R. FRENCH
G. GAGLIARDI
E. R. GEIB
ADOLPH GOODMAN
HERBERT GRIFFIN
SYLVAN HARRIS
J. J. HOPKINS

C. F. HORSTMAN
L. B. ISAAC
E. R. MORIN
M. D. O'BRIEN
HARRY RUBIN
J. J. SEFING
R. O. WALKER
V. A. WELMAN
H. E. WHITE
A. T. WILLIAMS

HISTORICAL AND MUSEUM.—To collect facts and assemble data relating to the historical development of the motion picture industry, to encourage pioneers to place their work on record in the form of papers for publication in the *JOURNAL*, and to place in suitable depositories equipment pertaining to the industry.

(Under Organization)

HONORARY MEMBERSHIP.—To diligently search for candidates who through their basic inventions or outstanding accomplishments have contributed to the advancement of the motion picture industry and are thus worthy of becoming Honorary members of the Society.

H. W. REMERSCHIED, *Chairman*
716 N. LaBrea St.
Hollywood, Calif.

F. E. CAHILL, JR.
WALTER CLARK

A. S. DICKINSON
C. W. HANDLEY

* Advisory Member.

JOURNAL AWARD.—To recommend to the Board of Governors the author or authors of the most outstanding paper originally published in the JOURNAL during the preceding calendar year to receive the Society's Journal Award.

J. I. CRABTREE, *Chairman*
Research Laboratories
Eastman Kodak Company
Rochester 4, N. Y.

C. R. DAILY
A. C. DOWNES

L. T. GOLDSMITH
D. R. WHITE

LABORATORY PRACTICE.—To make recommendations and prepare specifications for the operation, maintenance, and servicing of motion picture printers, processing machines, inspection projectors, splicing machines, film cleaning and treating equipment, rewinding equipment, any type of film handling accessories, methods, and processes which offer increased efficiency and improvement in the photographic quality of the final print.

H. E. WHITE, *Temporary Chairman*
342 Madison Ave.
New York 17, N. Y.

J. R. ALBURGER
A. C. BLANEY
L. A. BONN
A. W. COOK
O. B. DEPUE
R. O. DREW

F. L. EICH
G. H. GIBSON
EMERY HUSE
T. M. INGMAN
C. L. LOOTENS
A. J. MILLER

J. M. NICKOLAUS
N. F. OAKLEY
W. H. OFFENHAUSER, JR.
W. L. PRAGER
V. C. SHANER
J. H. SPRAY

MEMBERSHIP AND SUBSCRIPTION.—To solicit new members, obtain nonmember subscriptions for the JOURNAL, and to arouse general interest in the activities of the Society and its publications.

(*East*)

L. E. JONES, *Chairman*
427 West 42d St.
New York 18, N. Y.

Atlantic

A. R. GALLO
T. J. GASKI
N. D. GOLDEN
C. F. HORSTMAN

W. C. KUNZMANN
O. F. NEU
P. D. RIES
W. H. RIVERS
EDWARD SCHMIDT

C. W. SEAGER
A. G. SMITH
C. M. WEBER
C. R. WOOD, SR.

Midwest

D. M. ALEXANDER
G. W. COLBURN
E. W. D'ARCY
E. R. GEIB

I. F. JACOBSEN
P. L. KARR
R. E. LEWIS
C. E. PHILLIMORE

T. I. RESS
A. M. SMITH
L. H. WALTERS
J. G. ZUBER

16 Mm

E. L. BERMAN
G. A. CHAMBERS
A. W. COOK
R. C. HOLSLAG

W. F. KRUSE
C. L. LOOTENS
L. R. MARTIN
W. F. OFFENHAUSER, JR.

A. G. PETRASEK
F. B. ROGERS, JR.
R. J. SHERRY
LLOYD THOMPSON

Foreign

R. J. ENGLER

B. J. KROGER
R. O. STROCK

H. S. WALKER

(*West*)

G. C. MISENER, *Chairman*
6424 Santa Monica Blvd.
Hollywood 38, Calif.

L. W. CHASE, JR.
J. P. CORCORAN
C. R. DAILY
J. G. FRAYNE

L. T. GOLDSMITH
HERBERT GRIFFIN
EMERY HUSE
K. F. MORGAN
H. W. MOYSE

W. A. MUELLER
G. E. SAWYER
W. L. THAYER
W. V. WOLFE

NOMINATIONS.—To recommend nominations to the Board of Governors for annual election of officers and governors.

E. A. WILLIFORD, *Chairman*
230 Park Ave.
New York 17, N. Y.

J. W. BOYLE
J. K. HILLIARD
EMERY HUSE

E. W. KELLOGG
K. F. MORGAN

H. W. MOYSE
E. I. SPONABLE
M. G. TOWNSLEY

PAPERS.—To solicit papers, and provide the program for semi-annual conventions, and make available to local sections for their meetings papers presented at national conventions.

G. A. CHAMBERS, *Chairman*
343 State St.
Rochester 4, N. Y.

HERBERT BARNETT, *Vice-Chairman*
92 Gold St.
New York 7, N. Y.

R. T. VAN NIMAN, *Vice-Chairman*
4431 W. Lake St.
Chicago 24, Ill.

N. L. SIMMONS, *Vice-Chairman*
6706 Santa Monica Blvd.
Hollywood 38, Calif.

H. S. WALKER, *Vice-Chairman*
1620 Notre Dame St., W.
Montreal, Canada

G. M. BEST
P. E. BRIGANDI
J. P. CORCORAN

G. R. CRANE
C. R. DAILY
A. R. DAVIS
G. E. MATTHEWS

J. H. MAYNARD
P. A. MCGUIRE
EDWARD SCHMIDT

PRESERVATION OF FILM.—To make recommendations and prepare specifications on methods of treating and storage of motion picture film for active, archival, and permanent record purposes, so far as can be prepared within both the economic and historical value of the films.

J. G. BRADLEY, *Chairman*
The Library of Congress
Washington 25, D. C.

J. E. ABBOTT
H. T. COWLING
J. I. CRABTREE
A. S. DICKINSON

J. L. FORREST
*J. E. GIBSON
ORVILLE GOLDNER
C. L. GREGORY

*C. A. LINDSTROM
G. S. MITCHELL
TERRY RAMSAYE
V. B. SEASE

PROCESS PHOTOGRAPHY.—To make recommendations and prepare specifications on motion picture optical printers, process projectors (background process), matte processes, special process lighting technique, special processing machines, miniature set requirements, special effects devices, and the like, that will lead to improvement in this phase of the production art.

(Under Organization)

PROGRESS.—To prepare an annual report on progress in the motion picture industry.

(Under Organization)

PROGRESS MEDAL AWARD.—To recommend to the Board of Governors a candidate who by his inventions, research, or development has contributed in a significant manner to the advancement of motion picture technology, and is deemed worthy of receiving the Progress Medal Award of the Society.

F. E. CARLSON, *Chairman*
Nela Park
Cleveland 12, Ohio

HARRY BRAUN
R. M. CORBIN

T. K. GLENNAN
W. C. MILLER

PUBLICITY.—To assist the Convention Vice-President in the release of publicity material concerning the Society's semi-annual technical conventions.

*HAROLD DESFOR, *Chairman*
RCA Victor Division
Radio Corp. of America
Camden, N. J.

*LEONARD BIDWELL
J. H. BOOTH

*D. C. GILLETTE
S. A. LUKES

P. A. MCGUIRE
HARRY SHERMAN

* Advisory Member.

SCREEN BRIGHTNESS.—To make recommendations, prepare specifications, and test methods for determining and standardizing the brightness of the motion picture screen image at various parts of the screen, and for special means or devices in the projection room adapted to the control or improvement of screen brightness.

E. R. GEIB, *Chairman*
National Carbon Company, Inc.
Fostoria Works
Fostoria, Ohio

HERBERT BARNETT
F. E. CARLSON
SYLVAN HARRIS
W. F. LITTLE

*V. A. SILARD
*M. H. STEVENS
C. M. TUTTLE

C. R. UNDERHILL
H. E. WHITE
A. T. WILLIAMS
R. J. ZAVESKY

16-MM AND 8-MM MOTION PICTURES (Formerly Nontheatrical Equipment).—To make recommendations and prepare specifications for 16-mm and 8-mm cameras, 16-mm sound recorders and sound recording practices, 16-mm and 8-mm printers and other film laboratory equipment and practices, 16-mm and 8-mm projectors, splicing machines, screen dimensions and placement, loudspeaker output and placement, preview or theater arrangements, test films, and the like, which will improve the quality of 16-mm and 8-mm motion pictures.

D. F. LYMAN, *Chairman*
333 State St.
Rochester 4, N. Y.

E. W. D'ARCY
WILLIAM BALCH
W. C. BOWEN
F. L. BRETHAUER
*F. E. BROOKER
F. E. CARLSON
G. A. CHAMBERS
S. L. CHERTOK
JOHN CHRISTIE
G. W. COLBURN
R. O. DREW
*J. WALTER EVANS

E. R. GEIB
R. C. HOLSLAG
H. J. HOOD
R. KINGSLAKE
L. R. MARTIN
W. C. MILLER
G. S. MITCHELL
V. J. NOLAN
W. H. OFFENHAUSER, JR.
M. W. PALMER
A. G. PETRASEK
S. READ, JR.
L. T. SACHTLEBEN

A. SHAPIRO
D. G. SMITH
RAYMOND SPOTTISWOODE
*J. B. STREIFFERT
HARRY STRONG
*A. L. TERLOUW
LLOYD THOMPSON
M. G. TOWNSLEY
L. E. VARDEN
J. E. VOLKMANN
R. J. ZAVESKY
A. G. ZIMMERMAN

SOUND.—To make recommendations and prepare specifications for the operation, maintenance, and servicing of motion picture film, sound recorders, rerecorders, and reproducing equipment, methods of recording sound, sound film processing, and the like, to obtain means of standardizing procedures that will result in the production of better uniform quality sound in the theater.

J. G. FRAYNE, *Chairman*
6601 Romaine St.
Hollywood 38, Calif.

D. J. BLOOMBERG
B. B. BROWN
F. E. CAHILL, JR.
C. R. DAILY
R. J. ENGLER
L. D. GRIGNON

L. B. ISAAC
J. P. LIVADARY
G. T. LORANCE
W. C. MILLER
W. A. MUELLER
SERGE PAKSWER
OTTO SANDVIK

G. E. SAWYER
R. R. SCOVILLE
S. P. SOLOW
E. I. SPONABLE
R. T. VAN NIMAN
J. E. VOLKMANN

STANDARDS.—To constantly survey all engineering phases of motion picture production, distribution, and exhibition, to make recommendations and prepare specifications that may become proposals for SMPE Recommended Practices and/or American Standards. This Committee should carefully follow the work of all other committees on engineering and may request any committee to investigate and prepare a report on the phase of motion picture engineering to which it is assigned.

F. T. BOWDITCH, *Chairman*
Box 6087
Cleveland 1, Ohio

J. M. ANDREAS
M. F. BENNETT
E. A. BERTRAM
M. R. BOYER
F. L. BRETHAUER

F. E. CARLSON
E. K. CARVER
*J. S. CHANDLER
A. W. COOK
E. D. COOK

L. W. DAVEE
A. A. DURVEA
A. F. EDOUART
P. C. GOLDMARK
A. N. GOLDSMITH
(See next page.)

* Advisory Member.

L. T. GOLDSMITH
 IRL GOSHAW
 HERBERT GRIFFIN
 A. C. HARDY
 R. C. HOLSLAG
 J. K. HILLIARD
 D. B. JOY
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G. T. LORANCE
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 R. R. SCOVILLE
 J. H. SPRAY
 MONROE SWEET
 LLOYD THOMPSON
 M. G. TOWNSLEY
 D. R. WHITE
 H. E. WHITE

STUDIO LIGHTING.—To make recommendations and prepare specifications for the operation, maintenance, and servicing of all types of studio and outdoor auxiliary lighting equipment, tungsten light and carbon arc sources, lighting effect devices, diffusers, special light screens, etc., to increase the general engineering knowledge of the art.

C. W. HANDLEY, *Chairman*
 1960 West 84th St.
 Los Angeles 44, Calif.

J. W. BOYLE
 R. E. FARNHAM

KARL FREUND

W. W. LOZIER
 D. W. PRIDEAUX

TELEVISION.—To study the television art with special reference to the technical inter-relationships of the television and motion picture industries, and to make recommendations and prepare specifications for equipment, methods, and nomenclature designed to meet the special problems encountered at the junction of the two industries.

D. R. WHITE, *Chairman*
 Redpath Laboratories
 E. I. du Pont de Nemours & Co.
 Parlin, N. J.

R. B. AUSTRIAN
 *G. L. BEERS
 F. T. BOWDITCH
 A. W. COOK
 E. D. COOK
 C. E. DEAN
 BERNARD ERDE
 P. C. GOLDMARK
 A. N. GOLDSMITH

T. T. GOLDSMITH
 HERBERT GRIFFIN
 C. F. HORSTMAN
 L. B. ISAAC
 A. G. JENSEN
 P. J. LARSEN
 C. C. LARSON
 NATHAN LEVINSON
 J. P. LIVADARY

H. B. LUBCKE
 PIERRE MERTZ
 W. C. MILLER
 *PAUL RAIBOURN
 OTTO SANDVIK
 G. E. SAWYER
 R. E. SHELBY
 E. I. SPONABLE
 H. E. WHITE

TELEVISION PROJECTION PRACTICE.—To make recommendations and prepare specifications for the construction, installation, operation, maintenance, and servicing of equipment for projecting television pictures in the motion picture theater, as well as projection room arrangements necessary for such equipment, and such picture-dimensional and screen-characteristic matters as may be involved in high-quality theater television presentation.

P. J. LARSEN, *Chairman*
 1401 Sheridan St., N. W.
 Washington 11, D. C.

F. E. CAHILL, JR., *Vice-Chairman*
 321 West 44th St.
 New York 18, N. Y.

R. B. AUSTRIAN
 M. C. BATSEL
 *G. L. BEERS
 *THOMAS BILLS
 HARRY BRAUN
 F. E. CAHILL, JR.
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E. P. GENOCK
 T. T. GOLDSMITH
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 A. G. JENSEN
 H. E. KALLMANN
 J. J. KOHLER
 W. W. LOZIER
 PIERRE MERTZ
 E. R. MORIN

JAMES FRANK, JR., *Secretary*
 356 West 44th St.
 New York 18, N. Y.

A. H. ROSENTHAL
 HARRY RUBIN
 BEN SCHLANGER
 R. E. SHELBY
 E. I. SPONABLE
 C. S. SZEGHO
 V. A. WELMAN
 H. E. WHITE
 *R. S. YEANDLE
 *N. H. YOUNG

* Advisory Member.

TEST FILM QUALITY.—To supervise, inspect, and approve all print quality control of sound and picture test films prepared by any committee on engineering before the prints are released by the Society for general practical use.

F. S. BERMAN, *Chairman*
111-14 76th Ave.
Forest Hills, N. Y.

C. F. HORSTMAN

F. R. WILSON

THEATER ENGINEERING, CONSTRUCTION AND OPERATION.—To make recommendations and prepare specifications on engineering methods and equipment of motion picture theaters in relation to their contribution to the physical comfort and safety of patrons, so far as can be enhanced by correct theater design, construction, and operation of equipment.

HENRY ANDERSON, *Chairman*
1501 Broadway
New York 18, N. Y.

H. J. BENHAM
WILLIAM BORBERG
F. E. CARLSON
*W. B. CUTTER
*W. L. FLEISHER

JAMES FRANK, JR.
T. T. GOLDSMITH
ADOLPH GOODMAN

J. J. HOPKINS
C. F. HORSTMAN
E. R. MORIN
BEN SCHLANGER
J. J. SEFING

SMPE REPRESENTATIVES TO OTHER ORGANIZATIONS

American Documentation Institute..... J. E. ABBOTT

American Standards Association:

Sectional Committee on Standardization of Letter

Symbols and Abbreviations for Science and Engineering, Z10..... S. L. CHERTOK

Sectional Committee on Motion Pictures, Z22.. C. R. KEITH, *Chm.*

A. N. GOLDSMITH, *Hon. Chm.*

F. T. BOWDITCH

E. K. CARVER

D. F. LYMAN†

Sectional Committee on Acoustical Measurements and Terminology, Z24..... F. C. SCHMID

Sectional Committee on Photography, Z38..... J. I. CRABTREE

Standards Council, ASA Member-Bodies..... D. E. HYNDMAN

Inter-Society Color Council..... R. M. EVANS, *Chm.*

J. A. BALL

F. T. BOWDITCH

M. R. BOYER

L. E. CLARK

A. M. GUNDELFINGER

H. C. HARSH

National Fire Protection Association..... A. S. DICKINSON

Radio Technical Planning Board..... P. J. LARSEN

E. I. SPONABLE†

* Advisory Member; † Alternate.

CONSTITUTION AND BY-LAWS*
OF THE
SOCIETY OF MOTION PICTURE ENGINEERS

CONSTITUTION

Article I

Name

The name of this association shall be SOCIETY OF MOTION PICTURE ENGINEERS.

Article II

Object

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

Article III

Eligibility

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

Article IV

Officers

The officers of the Society shall be a President, a Past-President, an Executive Vice-President, an Engineering Vice-President, an Editorial Vice-President, a Financial Vice-President, a Convention Vice-President, a Secretary, and a Treasurer.

The term of office of all elected officers shall be for a period of two years. Of the Engineering, Editorial, Financial, and Convention Vice-Presidents, and the Secretary, and the Treasurer, three shall be elected alternately each year, or until their successors are chosen. The President shall not be immediately eligible to succeed himself in office. Under such conditions as set forth in the By-Laws the office of Executive Vice-President may be vacated before the expiration of his term.

Article V

Board of Governors

The Board of Governors shall consist of the President, the Past-President, the five Vice-Presidents, the Secretary, the Treasurer, the Section Chairmen and

* Corrected to Apr. 1, 1947.

ten elected governors. Five of these governors shall be resident in the area operating under Pacific and Mountain time, and five of the governors shall be resident in the area operating under Central and Eastern time. Two of the governors from the Pacific area and three of the governors from the Eastern area shall be elected in the odd-numbered years, and three of the governors in the Pacific area and two of the governors in the Eastern area shall be elected in the even-numbered years. The term of office of all elected governors shall be for a period of two years.

Article VI

Meetings

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

Article VII

Amendments

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

BY-LAWS

By-Law I

Membership

Sec. 1.—The membership of the Society shall consist of Honorary members, Fellows, Active members, Associate members, Student members, and Sustaining members.

An **Honorary member** is one who has performed eminent services in the advancement of motion picture engineering or in the allied arts. An Honorary member shall be entitled to vote and to hold any office in the Society.

A **Fellow** is one who shall not be less than thirty years of age and who shall comply with the requirements of either (a) or (b) for Active members and, in addition, shall by his proficiency and contributions have attained to an outstanding rank among engineers or executives of the motion picture industry. A Fellow shall be entitled to vote and to hold any office in the Society.

An **Active member** is one who shall be not less than 25 years of age, and shall be (a) a motion picture engineer by profession. He shall have been engaged in the practice of his profession for a period of at least three years, and shall have taken responsibility for the design, installation, or operation of systems or apparatus pertaining to the motion picture industry; (b) a person regularly employed in motion picture or closely allied work, who by his inventions or proficiency in motion picture science or as an executive of a motion picture enterprise of large scope, has attained to a recognized standing in the motion picture industry.

In case of such an executive, the applicant must be qualified to take full charge of the broader features of motion picture engineering involved in the work under his direction.

An Active member is privileged to vote and to hold any office in the Society.

An Associate member is one who shall be not less than 18 years of age, and shall be a person who is interested in or connected with the study of motion picture technical problems or the application of them. An Associate member is not privileged to vote, to hold office or to act as chairman of any committee, although he may serve upon any committee to which he may be appointed; and, when so appointed, shall be entitled to the full voting privileges of a committee member.

A Student member is any person registered as a student, graduate or undergraduate, in a college, university, or educational institution, pursuing a course of studies in science or engineering that evidences interest in motion picture technology. Membership in this grade shall not extend more than one year beyond the termination of the student status described above. A Student member shall have the same privileges as an Associate member of the Society.

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

Sec. 2.—All applications for membership or transfer, except for Honorary or Fellow membership, shall be made on blank forms provided for the purpose, and shall give a complete record of the applicant's education and experience. Honorary and Fellow membership may not be applied for.

Sec. 3.—(a) Honorary membership may be granted upon recommendation of the Board of Governors when confirmed by a four-fifths majority vote of the Honorary members, Fellows, and Active members present at any regular meeting of the Society. An Honorary member shall be exempt from all dues.

(b) Fellow membership may be granted upon recommendation of the Fellow Award Committee, when confirmed by a three-fourths majority vote of the Board of Governors. Nominations for Fellow shall be made from the Active membership.

(c) Applicants for Active membership shall give as references at least one member of Active or of higher grade in good standing. Applicants shall be elected to membership by the unanimous approval of the entire membership of the appropriate Admissions Committee. In the event of a single dissenting vote or failure of any member of the Admissions Committee to vote, this application shall be referred to the Board of Governors, in which case approval of at least three-fourths of the Board of Governors shall be required.

(d) Applicants for Associate membership shall give as references one member of the Society in good standing, or two persons not members of the Society who are associated with the industry. Applicants shall be elected to membership by approval of a majority of the appropriate Admissions Committee.

(e) Applicants for Student membership shall give as reference the head of the department of the institution he is attending, this faculty member not necessarily being a member of the Society.

By-Law II

Officers

Sec. 1.—An officer or governor shall be an Honorary, a Fellow, or an Active member.

Sec. 2.—Vacancies in the Board of Governors shall be filled by the Board of Governors until the annual meeting of the Society.

By-Law III

Board of Governors

Sec. 1.—The Board of Governors shall transact the business of the Society between members' meetings, and shall meet at the call of the President, with the proviso that no meeting shall be called without at least seven (7) days' prior notice, stating the purpose of the meeting, to all members of the Board by letter or by telegram.

Sec. 2.—Nine members of the Board of Governors shall constitute a quorum at all meetings.

Sec. 3.—When voting by letter ballot, a majority affirmative vote of the total membership of the Board of Governors shall carry approval, except as otherwise provided.

Sec. 4.—The Board of Governors, when making nominations to fill vacancies in offices or on the Board, shall endeavor to nominate persons who in the aggregate are representative of the various branches or organizations of the motion picture industry to the end that there shall be no substantial predominance upon the Board, as the result of its own action, of representatives of any one or more branches or organizations of the industry.

By-Law IV

Committees

Sec. 1.—All committees, except as otherwise specified, shall be appointed by the President.

Sec. 2.—All committees shall be appointed to act for the term served by the officer who shall appoint the committees, unless their appointment is sooner terminated by the appointing officer.

Sec. 3.—Chairmen of the committees shall not be eligible to serve in such capacity for more than two consecutive terms.

Sec. 4.—Standing committees of the Society shall be as follows to be appointed as designated:

(a) *Appointed by the President and confirmed by the Board of Governors—*

Progress Medal Award Committee

Journal Award Committee

Honorary Membership Committee

Fellow Award Committee

Admissions Committees

(Atlantic Coast Section)

(Pacific Coast Section)

European Advisory Committee

(b) *Appointed by the Engineering Vice-President—*

Sound Committee

Standards Committee

- Studio Lighting Committee
- Color Committee
- Theater Engineering Committee
- Exchange Practice Committee
- Nontheatrical Equipment Committee
- Television Committee
- Test Film Quality Committee
- Laboratory Practice Committee
- Cinematography Committee
- Process Photography Committee
- Preservation of Film Committee
- (c) *Appointed by the Editorial Vice-President—*
 - Board of Editors
 - Papers Committee
 - Progress Committee
 - Historical Committee
 - Museum Committee
- (d) *Appointed by the Convention Vice-President—*
 - Publicity Committee
 - Convention Arrangements Committee
 - Apparatus Exhibit Committee
- (e) *Appointed by the Financial Vice-President—*
 - Membership and Subscription Committee

Sec. 5.—Two Admissions Committees, one for the Atlantic Coast Section and one for the Pacific Coast Section, shall be appointed. The former Committee shall consist of a Chairman and six Fellow or Active members of the Society residing in the metropolitan area of New York, of whom at least four shall be members of the Board of Governors.

The latter Committee shall consist of a Chairman and four Fellow or Active members of the Society residing in the Pacific Coast area, of whom at least three shall be members of the Board of Governors.

By-Law V

Meetings

Sec. 1.—The location of each meeting of the Society shall be determined by the Board of Governors.

Sec. 2.—Only Honorary members, Fellows, and Active members shall be entitled to vote.

Sec. 3.—A quorum of the Society shall consist in number of one-fifteenth of the total number of Honorary members, Fellows, and Active members as listed in the Society's records at the close of the last fiscal year.

Sec. 4.—The fall convention shall be the annual meeting.

Sec. 5.—Special meetings may be called by the President and upon the request of any three members of the Board of Governors not including the President.

Sec. 6.—All members of the Society in any grade shall have the privilege of discussing technical material presented before the Society or its Sections.

By-Law VI*Duties of Officers*

Sec. 1.—The President shall preside at all business meetings of the Society and shall perform the duties pertaining to that office. As such he shall be the chief executive of the Society, to whom all other officers shall report.

Sec. 2.—In the absence of the President, the officer next in order as listed in Article IV of the Constitution shall preside at meetings and perform the duties of the President.

Sec. 3.—The five Vice-Presidents shall perform the duties separately enumerated below for each office, or as defined by the President:

(a) The **Executive Vice-President** shall represent the President in such geographical areas of the United States as shall be determined by the Board of Governors and shall be responsible for the supervision of the general affairs of the Society in such areas, as directed by the President of the Society. Should the President or Executive Vice-President remove his residence from the geographical area (Atlantic Coast or Pacific Coast) of the United States in which he resided at the time of his election, the office of Executive Vice-President shall immediately become vacant and a new Executive Vice-President elected by the Board of Governors for the unexpired portion of the term, the new Executive Vice-President to be a resident of that part of the United States from which the President or Executive Vice-President has just moved.

(b) The **Engineering Vice-President** shall appoint all technical committees. He shall be responsible for the general initiation, supervision, and coordination of the work in and among these committees. He may act as Chairman of any committee or otherwise be a member ex-officio.

(c) The **Editorial Vice-President** shall be responsible for the publication of the Society's JOURNAL and all other technical publications. He shall pass upon the suitability of the material for publication, and shall cause material suitable for publication to be solicited as may be needed. He shall appoint a Papers Committee and an Editorial Committee. He may act as Chairman of any committee or otherwise be a member ex-officio.

(d) The **Financial Vice-President** shall be responsible for the financial operations of the Society, and shall conduct them in accordance with budgets approved by the Board of Governors. He shall study the costs of operation and the income possibilities to the end that the greatest service may be rendered to the members of the Society within the available funds. He shall submit proposed budgets to the Board. He shall appoint at his discretion a Ways and Means Committee, a Membership Committee, a Commercial Advertising Committee, and such other committees within the scope of his work as may be needed. He may act as Chairman of any of these committees or otherwise be a member ex-officio.

(e) The **Convention Vice-President** shall be responsible for the national conventions of the Society. He shall appoint a Convention Arrangements Committee, an Apparatus Exhibit Committee, and a Publicity Committee. He may act as Chairman of any committee, or otherwise be a member ex-officio.

Sec. 4.—The **Secretary** shall keep a record of all meetings; he shall conduct the correspondence relating to his office, and shall have the care and custody of records, and the seal of the Society.

Sec. 5.—The **Treasurer** shall have charge of the funds of the Society and disburse them as and when authorized by the Financial Vice-President. He shall

make an annual report, duly audited, to the Society, and a report at such other times as may be requested. He shall be bonded in an amount to be determined by the Board of Governors and his bond filed with the Secretary.

Sec. 6.—Each officer of the Society, upon the expiration of his term of office, shall transmit to his successor a memorandum outlining the duties and policies of his office.

By-Law VII

Elections

Sec. 1.—All officers and governors shall be elected to their respective offices by a majority of ballots cast by the Active, Fellow, and Honorary members in the following manner:

Not less than three months prior to the annual fall convention, the Board of Governors shall nominate for each vacancy several suitable candidates. Nominations shall first be presented by a Nominating Committee appointed by the President, consisting of nine members, including a Chairman. The committee shall be made up of two Past-Presidents, three members of the Board of Governors not up for election, and four other Active, Fellow, or Honorary members, not currently officers or governors of the Society. Nominations shall be made by three-quarters affirmative vote of the total Nominating Committee. Such nominations shall be final unless any nominee is rejected by a three-quarters vote of the Board of Governors present and voting.

The Secretary shall then notify these candidates of their nomination. From the list of acceptances, not more than two names for each vacancy shall be selected by the Board of Governors and placed on a letter ballot. A blank space shall be provided on this letter ballot under each office, in which space the names of any Active, Fellow, or Honorary members other than those suggested by the Board of Governors may be voted for. The balloting shall then take place.

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

The voter shall then indicate on the ballot one choice for each office, seal the ballot in the blank envelope, place this in the envelope addressed to the Secretary, sign his name and address on the latter, and mail it in accordance with the instructions printed on the ballot. No marks of any kind except those above prescribed shall be placed upon the ballots or envelopes. Voting shall close seven days before the opening session of the annual fall convention.

The sealed envelope shall be delivered by the Secretary to a Committee of Tellers appointed by the President at the annual fall convention. This committee shall then examine the return envelopes, open and count the ballots, and announce the results of the election.

The newly elected officers and governors of the general Society shall take office on January 1st following their election.

By-Law VIII

Dues and Indebtedness

Sec. 1.—The annual dues shall be fifteen dollars (\$15) for Fellows and Active members, ten dollars (\$10) for Associate members, and five dollars (\$5) for

Student members, payable on or before January 1st of each year. Current or first year's dues for new members in any calendar year shall be at the full annual rate for those notified of acceptance in the Society on or before June 30th; one-half the annual rate for those notified of acceptance in the Society on or after July 1st.

Sec. 2.—(a) Transfer of membership to a higher grade may be made at any time. If the transfer is made on or before June 30th the annual dues of the higher grade is required. If the transfer is made on or after July 1st and the member's dues for the full year has been paid, one-half of the annual dues of the higher grade is payable less one-half the annual dues of the lower grade.

(b) No credit shall be given for annual dues in a membership transfer from a higher to a lower grade, and such transfers shall take place on January 1st of each year.

(c) The Board of Governors upon their own initiative and without a transfer application may elect, by the approval of at least three-fourths of the Board, any Associate or Active member for transfer to any higher grade of membership.

*Sec. 3.—*Annual dues shall be paid in advance. A *new* member who has not paid dues in advance shall be notified of admittance but shall not receive the JOURNAL and is not in good standing until initial dues are paid. All Honorary members, Fellows, and Active members in good standing, as defined in *Section 5*, may vote or otherwise participate in the meetings.

*Sec. 4.—*Members shall be considered delinquent whose annual dues for the year remain unpaid on February 1st. The first notice of delinquency shall be mailed February 1st. The second notice of delinquency shall be mailed, if necessary, on March 1st, and shall include a statement that the member's name will be removed from the mailing list for the JOURNAL and other publications of the Society before the mailing of the April issue of the JOURNAL. Members who are in arrears of dues on June 1st, after two notices of such delinquency have been mailed to their last address of record, shall be notified their names have been removed from the mailing list and shall be warned unless remittance is received on or before August 1st, their names shall be submitted to the Board of Governors for action at the next meeting. Back issues of the JOURNAL shall be sent, if available, to members whose dues have been paid prior to August 1st.

Sec. 5.—(a) Members whose dues remain unpaid on October 1st may be dropped from the rolls of the Society by majority vote and action of the Board, or the Board may take such action as it sees fit.

(b) Anyone who has been dropped from the rolls of the Society for nonpayment of dues shall, in the event of his application for reinstatement, be considered as a new member.

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

*Sec. 6.—*The provisions of *Sections 1 to 4*, inclusive, of this By-Law VIII given above may be modified or rescinded by action of the Board of Governors.

By-Law IX

Emblem

*Sec. 1.—*The emblem of the Society shall be a facsimile of a four-hole film reel

with the letter *S* in the upper center opening, and the letters *M*, *P*, and *E*, in the three lower openings, respectively. The Society's emblem may be worn by members only.

By-Law X

Publications

Sec. 1.—Papers read at meetings or submitted at other times, and all material of general interest shall be submitted to the Editorial Board, and those deemed worthy of permanent record shall be printed in the JOURNAL. A copy of each issue shall be mailed to each member in good standing to his last address of record. Extra copies of the JOURNAL shall be printed for general distribution and may be obtained from the General Office on payment of a fee fixed by the Board of Governors.

By-Law XI

Local Sections

Sec. 1.—Sections of the Society may be authorized in any state or locality where the Active, Fellow, and Honorary membership exceeds 20. The geographic boundaries of each Section shall be determined by the Board of Governors.

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

Section Membership

Sec. 2.—All members of the Society of Motion Picture Engineers in good standing residing in that portion of any country set apart by the Board of Governors tributary to any local Section shall be eligible for membership in that Section, and when so enrolled they shall be entitled to all privileges that such local Section may, under the General Society's Constitution and By-Laws, provide.

Any member of the Society in good standing shall be eligible for nonresident affiliated membership of any Section under conditions and obligations prescribed for the Section. An affiliated member shall receive all notices and publications of the Section but he shall not be entitled to vote at sectional meetings.

Sec. 3.—Should the enrolled Active, Fellow, and Honorary membership of a Section fall below 20, or should the technical quality of the presented papers fall below an acceptable level, or the average attendance at meetings not warrant the expense of maintaining the organization, the Board of Governors may cancel its authorization.

Section Officers

Sec. 4.—The officers of each Section shall be a Chairman and a Secretary-Treasurer. The Section chairmen shall automatically become members of the Board of Governors of the General Society, and continue in such positions for the duration of their terms as chairmen of the local Sections. Each Section officer shall hold office for one year, or until his successor is chosen.

Section Board of Managers

Sec. 5.—The Board of Managers shall consist of the Section Chairman, the Section Past-Chairman, the Section Secretary-Treasurer, and six Active, Fellow, or

Honorary members. Each manager of a Section shall hold office for two years, or until his successor is chosen.

Section Elections

Sec. 6.—The officers and managers of a Section shall be Active, Fellow, or Honorary members of the General Society. All officers and managers shall be elected to their respective offices by a majority of ballots cast by the Active, Fellow, and Honorary members residing in the geographical area covered by the Section.

Not less than three months prior to the annual fall convention of the Society, nominations shall be presented to the Board of Managers of the Section by a Nominating Committee appointed by the Chairman of the Section, consisting of seven members, including a chairman. The Committee shall be composed of the present Chairman, the Past-Chairman, two other members of the Board of Managers not up for election, and three other Active, Fellow, or Honorary members of the Section not currently officers or managers of the Section. Nominations shall be made by a three-quarters affirmative vote of the total Nominating Committee. Such nominations shall be final, unless any nominee is rejected by a three-quarters vote of the Board of Managers, and in the event of such rejection the Board of Managers will make its own nomination.

The Chairman of the Section shall then notify these candidates of their nomination. From the list of acceptances, not more than two names for each vacancy shall be selected by the Board of Managers and placed on a letter ballot. A blank space shall be provided on this letter ballot under each office, in which space the names of any Active, Fellow, or Honorary members other than those suggested by the Board of Managers may be voted for. The balloting shall then take place.

The ballot shall be enclosed in a blank envelope which is enclosed in an outer envelope bearing the local Secretary-Treasurer's address and a space for the member's name and address. One of these shall be mailed to each Active, Fellow, and Honorary member of the Society residing in the geographical area covered by the Section, not less than forty days in advance of the annual fall convention.

The voter shall then indicate on the ballot one choice for each office, seal the ballot in the blank envelope, place this in the envelope addressed to the Secretary-Treasurer, sign his name and address on the latter, and mail it in accordance with the instructions printed on the ballot. No marks of any kind except those above prescribed shall be placed upon the ballots or envelopes. Voting shall close seven days before the opening session of the annual fall convention.

The sealed envelopes shall be delivered by the Secretary-Treasurer to his Board of Managers at a duly called meeting. The Board of Managers shall then examine the return envelopes, open and count the ballots, and announce the results of the election.

The newly elected officers and managers shall take office on January 1st following their election.

Section Business

Sec. 7.—The business of a Section shall be conducted by the Board of Managers.

Section Expenses

Sec. 8.—(a) As early as possible in the fiscal year, the Secretary-Treasurer of each Section shall submit to the Board of Governors of the Society a budget of expenses for the year.

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

(c) The Secretary-Treasurer of each Section shall send to the Treasurer of the General Society, quarterly or on demand, an itemized account of all expenditures incurred during the preceding interval.

(d) Expenses other than those enumerated in the budget, as approved by the Board of Governors of the General Society, shall not be payable from the general funds of the Society without express permission from the Board of Governors.

(e) A Section Board of Managers shall defray all expenses of the Section not provided for by the Board of Governors, from funds raised locally by donation, or fixed annual dues, or by both.

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

Section Meetings

Sec. 9.—The regular meetings of a Section shall be held in such places and at such hours as the Board of Managers may designate.

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

Section Papers

Sec. 10.—Papers shall be approved by the Section's Papers Committee previously to their being presented before a Section. Manuscripts of papers presented before a Section, together with a report of the discussions and the proceedings of the Section meetings, shall be forwarded promptly by the Section Secretary-Treasurer to the Secretary of the General Society. Such material may, at the discretion of the Board of Editors of the General Society, be printed in the Society's publications.

Constitution and By-Laws

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

By-Law XII

Amendments

Sec. 1.—These By-Laws may be amended at any regular meeting of the Society by the affirmative vote of two-thirds of the members present at a meeting who are eligible to vote thereon, a quorum being present, either on the recommendation of the Board of Governors or by a recommendation to the Board of Governors signed by any ten members of Active or higher grade, provided that the proposed amendment or amendments shall have been published in the JOURNAL of the Society, in the issue next preceding the date of the stated business meeting of the Society at which the amendment or amendments are to be acted upon.

Sec. 2.—In the event that no quorum of the voting members is present at the time of the meeting referred to in *Section 1*, the amendment or amendments shall

be referred for action to the Board of Governors. The proposed amendment or amendments then become a part of the By-Laws upon receiving the affirmative vote of three-quarters of the Board of Governors.

By-Law XIII

Student Chapters

Sec. 1.—Student Chapters of the Society may be authorized in any college, university, or technical institute of collegiate standing.

Upon written petition, signed by twelve or more Society members, or applicants for Society membership, and the Faculty Adviser, for the authorization of a Student Chapter, the Board of Governors may grant such authorization.

Chapter Membership

Sec. 2.—All members of the Society of Motion Picture Engineers in good standing who are attending the designated educational institution shall be eligible for membership in the Student Chapter, and when so enrolled they shall be entitled to all privileges that such Student Chapter may, under the General Society's Constitution and By-Laws, provide.

Sec. 3.—Should the membership of the Student Chapter fall below ten, or should the technical quality of the presented papers fall below an acceptable level, or the average attendance at meetings not warrant the expense of maintaining the organization, the Board of Governors may cancel its authorization.

Chapter Officers

Sec. 4.—The officers of each Student Chapter shall be a Chairman and a Secretary-Treasurer. Each Chapter officer shall hold office for one year, or until his successor is chosen. Officers shall be chosen in May to take office at the beginning of the following school year. The procedure for holding elections shall be prescribed in Administrative Practices.

Faculty Adviser

Sec. 5.—A member of the faculty of the same educational institution shall be designated by the Board of Governors as Faculty Adviser. It shall be his duty to advise the officers on the conduct of the Chapter and to approve all reports to the Secretary and the Treasurer of the Society.

Chapter Expenses

Sec. 6.—The Treasurer of the General Society may deposit with each Chapter Secretary-Treasurer a sum of money, the amount to be fixed by the Board of Governors. The Secretary-Treasurer shall send to the Treasurer of the General Society at the end of each school year an itemized account of all expenditures incurred during that period.

Chapter Meetings

Sec. 7.—The Chapter shall hold at least four meetings per year. The Secretary-Treasurer shall forward to the Secretary of the General Society at the end of each school year a report of the meetings for that year, giving the subject, speaker, and approximate attendance for each meeting.

JOURNAL AWARD AND PROGRESS MEDAL AWARD

In accordance with the provisions of Administrative Practices of the Society, the regulations for procedure in granting the Journal Award and the Progress Medal Award, a list of the names of previous recipients, and the reasons therefor, are published annually in the JOURNAL as follows:

JOURNAL AWARD

The Journal Award Committee shall consist of five Fellows or Active members of the Society, appointed by the President and confirmed by the Board of Governors. The Chairman of the Committee shall be designated by the President.

At the fall convention of the Society a Journal Award Certificate shall be presented to the author or to each of the authors of the most outstanding paper originally published in the JOURNAL of the Society during the preceding calendar year.

Other papers published in the JOURNAL of the Society may be cited for Honorable Mention at the option of the Committee, but in any case should not exceed five in number.

The Journal Award shall be made on the basis of the following qualifications:

(1) The paper must deal with some technical phase of motion picture engineering.

(2) No paper given in connection with the receipt of any other Award of the Society shall be eligible.

(3) In judging of the merits of the paper, three qualities shall be considered, with the weights here indicated:

- | | |
|---|--------------|
| (a) Technical merit and importance of material..... | 45 per cent. |
| (b) Originality and breadth of interest..... | 35 per cent. |
| (c) Excellence of presentation of the material..... | 20 per cent. |

A majority vote of the entire Committee shall be required for the election to the Award. Absent members may vote in writing.

The report of the Committee shall be presented to the Board of Governors at their July meeting for ratification.

These regulations, a list of the names of those who have previously received the Journal Award, the year of each Award, and the titles of the papers shall be published annually in the April issue of the JOURNAL of the Society. In addition, the list of papers selected for Honorable Mention shall be published in the JOURNAL of the Society during the year current with the Award.

The Awards in previous years have been as follows:

1934—P. A. Snell, for his paper entitled "An Introduction to the Experimental Study of Visual Fatigue". (Published May 1933.)

- 1935—L. A. Jones and J. H. Webb, for their paper entitled "Reciprocity Law Failure in Photographic Exposure". (Published Sept. 1934)
- 1936—E. W. Kellogg, for his paper entitled "A Comparison of Variable-Density and Variable-Width Systems". (Published Sept. 1935.)
- 1937—D. B. Judd, for his paper entitled "Color Blindness and Anomalies of Vision". (Published June 1936.)
- 1938—K. S. Gibson, for his paper entitled "The Analysis and Specification of Color". (Published Apr. 1937.)
- 1939—H. T. Kalmus, for his paper entitled "Technicolor Adventures in Cinemaland". (Published Dec. 1938.)
- 1940—R. R. McNath, for his paper entitled "The Surface of the Nearest Star". (Published Mar. 1939.)
- 1941—J. G. Frayne and Vincent Pagliarulo, for their paper entitled "The Effects of Ultraviolet Light on Variable-Density Recording and Printing". (Published June 1940.)
- 1942—W. J. Albersheim and Donald MacKenzie, for their paper entitled "Analysis of Sound-Film Drives." (Published July, 1941.)
- 1943—R. R. Scoville and W. L. Bell, for their paper entitled "Design and Use of Noise-Reduction Bias Systems". (Published Feb. 1942; Award made Apr. 1944.)
- 1944—J. I. Crabtree, G. T. Eaton, and M. E. Muehler, for their paper entitled "Removal of Hypo and Silver Salts from Photographic Materials as Affected by the Composition of the Processing Solutions". (Published July 1943.)
- 1945—C. J. Kunz, H. E. Goldberg, and C. E. Ives, for their paper entitled "Improvement in Illumination Efficiency of Motion Picture Printers". (Published May 1944.)
- 1946—R. H. Talbot, for his paper entitled "The Projection Life of Film". (Published Aug. 1945.)

The present Chairman of the Journal Award Committee is J. I. Crabtree.

PROGRESS MEDAL AWARD

The Progress Medal Award Committee shall consist of five Fellows or Active members of the Society, appointed by the President and confirmed by the Board of Governors. The Chairman of the Committee shall be designated by the President.

The Progress Medal may be awarded each year to an individual in recognition of any invention, research, or development which, in the opinion of the Committee, shall have resulted in a significant advance in the development of motion picture technology.

Any member of the Society may recommend persons deemed worthy of the Award. The recommendation in each case shall be in writing and in detail as to the accomplishments which are thought to justify consideration. The recommendation shall be seconded in writing by any two Fellows or Active members of the Society, who shall set forth their knowledge of the accomplishments of the candidate which, in their opinion, justify consideration.

A majority vote of the entire Committee shall be required to constitute an Award of the Progress Medal. Absent members may vote in writing.

The report of the Committee shall be presented to the Board of Governors at their July meeting for ratification.

The recipient of the Progress Medal shall be asked to present a photograph of himself to the Society and, at the discretion of the Committee, may be asked to prepare a paper for publication in the JOURNAL of the Society.

These regulations, a list of the names of those who have previously received the Medal, the year of each Award, and a statement of the reason for the Award shall be published annually in the April issue of the JOURNAL of the Society.

Previous Awards have been as follows:

The 1935 Award was made to E. C. Wente, for his work in the field of sound recording and reproduction. (Citation published Dec. 1935.)

The 1936 Award was made to C. E. K. Mees, for his work in photography. (Citation published Dec. 1936.)

The 1937 Award was made to E. W. Kellogg, for his work in the field of sound reproduction. (Citation published Dec. 1937.)

The 1938 Award was made to H. T. Kalmus, for his work in developing color motion pictures. (Citation published Dec. 1938.)

The 1939 Award was made to L. A. Jones, for his scientific researches in the field of photography. (Citation published Dec. 1939.)

The 1940 Award was made to Walt Disney, for his contributions to motion picture photography and sound recording of feature and short cartoon films. (Citation published Dec. 1940.)

The 1941 Award was made to G. L. Dimmick, for his development activities in motion picture sound recording. (Citation published Dec. 1941.)

No Awards were made in 1942 and 1943.

The 1944 Award was made to J. G. Capstaff, for his research and development of films and apparatus used in amateur cinematography. (Citation published Jan. 1945.)

No Awards were made in 1945 and 1946.

The present Chairman of the Progress Medal Award Committee is F. E. Carlson.

SOCIETY OF MOTION PICTURE ENGINEERS

MEMBERSHIP*

Changes for Period January-December 31, 1946

	Hon.	Sustg.	Fel.	Act.	Assoc.	Stu.	Total
<i>Membership, Jan. 1, 1946</i>	7	32	151	439	1322	15	1966
New Members		32		116	379	54	581
Reinstatements				13	11		23
	7	64	151	568	1712	69	2571
Less: Resignations			-2	-9	-44	-1	-56
Suspended				-8	-52	-8	-68
Deaths	-1		-2	-3	-9		-15
	6	64	147	548	1607	60	2432
Changes in Grade:							
Active to Fellow			7	-7			
Associate to Active				21	-21		
Active to Associate				-1	1		
Student to Associate					1	-1	
<i>Membership, Dec. 31, 1946</i>	6	64	154	561	1588	59	2432

NONMEMBER SUBSCRIPTIONS TO JOURNAL

<i>Subscriptions, Jan. 1, 1946</i>	349
Renewals and New Subscriptions, Jan.-Dec. 1946	537
	886
Less: Expirations	107
<i>Subscriptions, Dec. 31, 1946</i>	779

* Grades: Honorary, Sustaining, Fellow, Active, Associate, and Student.

SOCIETY OF MOTION PICTURE ENGINEERS

REPORT OF THE TREASURER

JANUARY 1-DECEMBER 31, 1946

<i>Members' Equity, Jan. 1, 1946:</i>	\$75,901.36
<i>Receipts, Jan.-Dec. 1946:</i>	
Membership Dues	\$21,485.90
Sustaining Memberships	20,250.00
Publications (Journals, Subscriptions, Reprints, Standards, Book, etc.)	13,067.99
*Test Films	52,550.49
Other (Interest, etc.)	855.94
	\$108,210.32
<i>Disbursements, Jan.-Dec. 1946:</i>	
General Office (Salaries, Rent, Supplies, Tel. & Tel., Equipment, Travel, Postage, etc.)	\$27,971.92
Publications (Journal, Reprints, Stand- ards, Binder, etc.)	15,008.43
*Test Films	57,210.12
Dues and Fees to other organizations (ASA, RTPB, NFPA, ISCC)	1,235.00
Sections (Atlantic, Midwest and Pacific)	1,089.18
Committee Activities	1,693.64
Other (Conventions, Awards, etc.)	985.73
	105,194.02
<i>Excess Receipts Over Disbursements, 1946:</i>	3,016.30
	\$78,917.66
Accrued Interest on Savings Accounts	67.10
Less: Adjustment on Bond for Accrued Interest at Purchase	10.98
	56.12
<i>Members' Equity, Dec. 31, 1946:</i>	\$78,973.78

* Subject to Renegotiation.

Respectfully submitted,
E. I. SPONABLE, *Treasurer*

The cash records of the Treasurer were audited for the year ended December 31, 1946, by Sparrow, Waymouth and Company, certified public accountants, New York, and are in conformity with the above report.

M. R. BOYER,
Financial Vice-President

SOCIETY ANNOUNCEMENTS

FADER SETTING STANDARD WITHDRAWN

All American Standards on motion pictures developed by the motion picture industry are published officially for the industry by the American Standards Association. The procedure used in the past was somewhat involved, but has been simplified in the light of experience gained in standardization during the war and the preceding ten years. At present, American Standards may be proposed by any competent individual, organization or industrial group and it is expected that they will substantiate their claims that such new proposals are desirable. Safeguards are necessary, of course, to ensure that the proposed standardization will not prejudice technical development in motion pictures, and the ASA procedure does this as well as make certain that anyone stating his opinions for or against any new proposal has an equal opportunity to be heard.

The withdrawal of existing standards is as carefully supervised as the preparation of new ones, and the same procedures are observed. An example is the **American Recommended Practice for Motion Picture Film, Theater Sound Fader Setting Instructions, Z22.32-1941**, which was officially approved for withdrawal by the ASA on March 7, 1947. Therefore, this standard is no longer valid and will not be considered as having industry sanction in the future.

Sometime prior to 1941, the industry adopted the practice outlined in this standard, because at that time it was felt necessary to provide more than one type of recording for certain feature releases. Fader setting instructions to projectionists were inserted as a 15-frame strip of information located in the first 20 frames of the synchronizing leader of every release print. Prints which had normal equalization and recording characteristics, were marked "Regular" prints, while all other prints were either "Hi-Range" or "Lo-Range". This practice has not been followed recently, and since no studio is now using it as outlined, the Research Council of the Academy of Motion Picture Arts and Sciences recommended to the ASA Sectional Committee on Motion Pictures, Z22, that it be withdrawn because continued existence of the published standard implied that the practice was still being observed.

The Sectional Committee voted in favor of the withdrawal and on Dec. 31, 1946, the secretary of that committee asked the SMPE Board of Governors, which acts as its sponsor, to transmit formally this recommendation for final action by the ASA Standards Council. The Board did so and official ASA approval of the withdrawal was announced on March 7, 1947.

At the present time, American Standards on Motion Pictures number from Z22.1 through Z22.54. Two of them, Z22.1 and Z22.32, have been officially withdrawn leaving 52 valid standards on the current list. Of these, twenty-six were recently revised and published in the SMPE JOURNAL for April and September 1946. They are available in complete sets, bound in a heavy loose-leaf

binder, from the general office of the Society in the Hotel Pennsylvania, New York.

The remaining twenty-six standards are now in various stages of revision, and as they are completed and approved will also be announced in the JOURNAL. Individual notices of all new standards and revisions, as well as withdrawals, will be sent to all who have purchased binders, so that they may keep their records current.

A number of proposals for new motion picture standards have been submitted to the SMPE and are now being considered by various Society engineering committees. Reports of these committees' activities are scheduled to appear in the JOURNAL and will give an indication of current standards work.

Recently adopted standardization procedure of the SMPE provides for publication of all new standards proposals in the JOURNAL in the form of a complete committee report outlining the past history of each new standard, the story of its progress through Society committees, and a review of its ultimate effect on the industry. Following publication of this report, and a suitable waiting period of about 60 days, each new standard will go to letter ballot of the Committee on Standards if no unfavorable comments or criticisms are received. However, if any serious objection to the new proposal has been raised as a result of this publication, the standard will go back to the committee that prepared it with appropriate instructions from the engineering vice-president and the chairman of the Committee on Standards to assure that each serious comment receives thorough consideration. Then, following approval by the Committee on Standards, the customary standardization procedures are observed and the standard ultimately published.

SECTION INSPECTS NEW RKO PATHE STUDIOS AND PATHE LABORATORIES

One of the largest groups ever to attend a meeting of the Atlantic Coast Section of the Society turned out on March 19 to inspect the new quarters of RKO Pathe Studios and Pathe Film Laboratories at Park Avenue and 106th St., New York. Walton C. Ament, vice-president and general manager of RKO Pathe Studios, reviewed the history of the building in which the new studios are housed and described certain features of the building that make it applicable to modern motion picture production. Frank Wooley, chief recording engineer, described the plan and production setup and facilities.

Nick Tronolone, vice-president and general manager of Pathe Laboratories, discussed the organization and laboratory facilities, and explained work being done in the laboratories.

Following these discussions in the Scoring Room, the audience broke up into small groups for an inspection tour of the studios and laboratory. A motion picture depicting the work of Alexander Graham Bell, produced by the studio, opened the meeting. An unexpectedly large attendance exceeded seating arrangements, and it was necessary to use an adjoining studio to accommodate the overflow. The attendance was estimated at 450.

MAGNETIC RECORDING AND PHOTOEMISSIVE TUBES DESCRIBED

Dr. S. Paksver, chief engineer of Continental Electric Company, presented a paper entitled "Factors Influencing the Life of Photoemissive Tubes," at the March 13 meeting of the Midwest Section of the Society in the Western Society of Engineers Hall, Chicago. Dr. Paksver outlined the fundamental theory of the phototube with special reference to the *S-1* and *S-4* types. His paper included numerous graphs showing the characteristics of these tubes and the time relation between fatigue and exposure. Microphonic effects and causes were also discussed.

The second paper on the program was presented by Marvin Camras, research physicist of the Armour Research Foundation, entitled "Magnetic Sound for Motion Pictures." Mr. Camras explained the principles of magnetic recording and described particularly the possibilities of using a metallic coating for a sound track on 35-, 16-, and 8-mm film. He elaborated on further developments and improvements made with this type of recording since he first presented the principles at the Hollywood Convention of the Society in October 1946. [His paper was published in the January 1947 JOURNAL—*Ed.*] Mr. Camras concluded his talk with an interesting presentation of magnetic sound recording on 16-mm film.

A. Shapiro, chairman of the Section, announced that the regular monthly meeting for April would be canceled in view of the 61st Semiannual Convention to be held in Chicago on April 21-25.

We are grieved to announce the deaths of L. D. Strong, Active member of the Society, on April 27, 1947, in Chicago, Ill., and S. E. Hawkins, Active member of the Society, on April 24, 1947, in Hollywood.

JOURNAL OF THE SOCIETY OF MOTION PICTURE ENGINEERS

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No. 5

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FLASHTUBES

A POTENTIAL ILLUMINANT FOR MOTION PICTURE PHOTOGRAPHY?*

F. E. CARLSON**

Summary.—This paper presents a preliminary appraisal of flashtubes from the point of view of motion picture studio photography. Such sources have been widely and successfully used for still photography for several years. In this field the short duration and high intensity of the flash, its color quality and high efficiency have been important factors in its favor. Most of these advantages, while equally important in the motion picture studio, cannot necessarily be realized to the same degree in this field. Furthermore, many problems, the magnitude of which cannot be predicted at this time, appear inevitable and will undoubtedly require thorough analysis before a final evaluation is possible.

Ryder, in a recent paper¹ before the Society, voiced the modernization desires not only of his studio, but of many others as well. The subject of lighting occupied a prominent place in his timely review of the problems of the industry, and he has suggested that the solution to some of those problems may be found in the developments of World War II just as sound and radio were largely derivatives of World War I. Flashtubes, while predating the recent war by a considerable margin, were so improved and the scope of their usefulness so broadened as a result of the part they played in that conflict that in their present form they may be considered to some extent a product of World War II. It is appropriate, therefore, that they be critically examined at this time to determine their possible application to the lighting problems of the motion picture studio.

Motion picture film is exposed on the set by a series of light impulses of short duration, and motion picture film is viewed in the

* Presented Jan. 10, 1947, at a meeting of the Pacific Coast Section of the Society in Hollywood, and at the SMPE Convention in Chicago on Apr. 24, 1947.

** General Electric Company, Lamp Department, Cleveland, Ohio.

theater in precisely the same way. The sources of illumination used in both instances are "continuous" in the sense that they are continuously emitting light and the impulses are obtained by using mechanical shutters which intercept, or throw away, approximately one-half of the available light. In so far as the mechanics of the operations just described are concerned, it would appear possibly more advantageous to use sources of intermittent light from which, conceivably, less light need be wasted. The flashtube is such a source of intermittent light.

Types of Flashtubes.—The characteristics of flashtube types currently available have already been described^{2,3} and are, therefore, only briefly summarized here. A flashtube consists simply of a



FIG. 1. Examples of straight flashtubes and a special curved tube. Straight tubes have been made in lengths ranging from less than 4 in. to a little more than 5 ft.

gas-filled envelope containing two electrodes. In all of the flashtubes currently in use, the envelope is a slender tube of glass or quartz with the electrodes at each end. Some types consist of straight or curved tubes, Fig. 1, for use in trough reflectors; in others the tubing is coiled in the form of a helix, Fig. 2, to produce relatively concentrated sources suitable for use with lenses or reflectors which are surfaces of revolution.

Flashtube Operation.—The light emitted by a flashtube results from the discharge of a condenser, or the application of a pulse of energy between the electrodes. In order to avoid the damaging effects of high peak currents, characteristic of a condenser discharge, most tubes, at present, are of a type such that no switch is required in the discharge circuit. This is accomplished through adjustments

in tube design so that the tube will not flash over when full operating voltage is applied to the two electrodes. In this case, flashover can be made to occur when desired by ionizing the tube so that it becomes conductive. When the impressed voltage has dropped to a low value, as it does near the end of a condenser-discharge cycle, the tube ceases to conduct, and is then ready to be flashed again. With this arrangement the tube may be connected continuously to the source of supply and thus eliminate the hazards of switch failure.

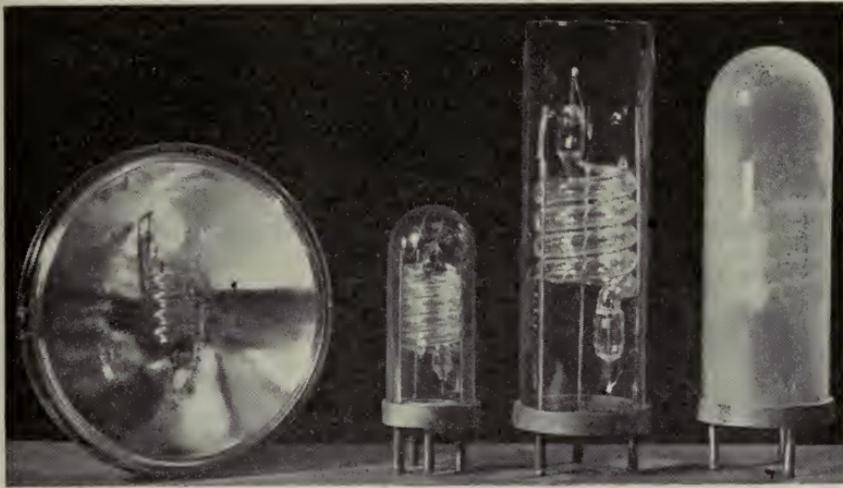


FIG. 2. Flashtubes of the helical type are assembled with various bulb and base combinations to protect the user from exposed electrical parts and to facilitate their use in lighting equipment. Some assemblies provide for forced air cooling, or they may be incorporated in integral reflectors.

Ionization of tubes used as described in the preceding paragraph is accomplished by applying a very high voltage externally to the wall of the tube for a brief instant—only a few microseconds at most. Such an ionizing pulse can be obtained from a small step-up transformer much like the spark coil used with car ignition systems. The basic elements of a typical power supply employing a condenser discharge are shown in Fig. 3.

Special problems arise in the design of a power supply for repetitive operation of flashtubes. For example, in the case of condenser-discharge systems, if the voltage to the condenser and flashtube is allowed to build up too rapidly after the tube has been flashed, or if the interval between flashes is too brief, the tube may not have time

to deionize and, in this event, is conductive at less than the desired operating voltage. This may be corrected in the first case by limiting the charging rate. Other corrective measures include the introduction of impedance in the discharge circuit to swing the voltage to

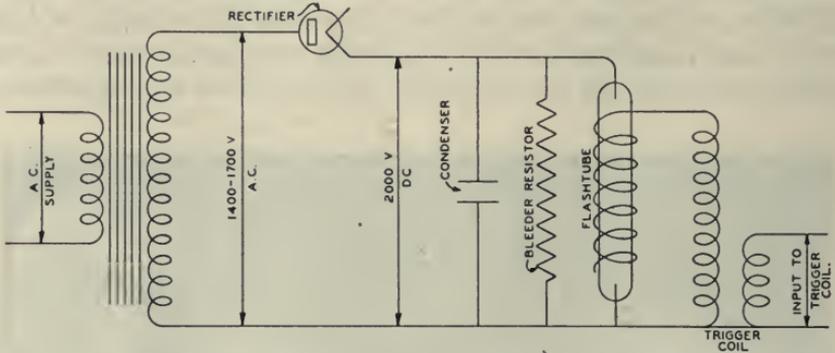


FIG. 3. Schematic diagram of a condenser-discharge type of power supply for operating flashtubes.

zero (or even slightly negative) or, in the extreme cases, the use of a switch tube in the discharge circuit.

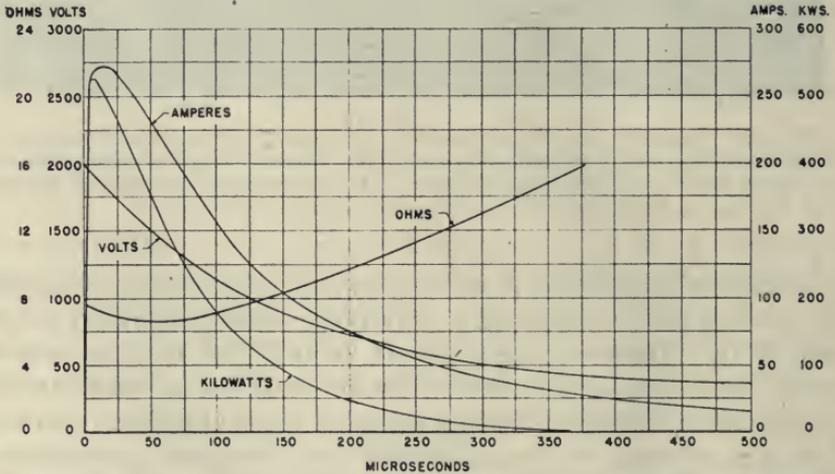


FIG. 4. Electrical characteristics of a typical flashtube during the discharge cycle. The 26- μ f condenser was charged to 2000 v.

Time-Light Characteristics.—The duration of the flash of light and its variation in intensity with respect to time are intimately related to the electrical discharge or pulse cycle. Fig. 4 shows typical

curves of voltage and current variation during the cycle of a condenser discharge through a flashtube with negligible impedance in the circuit; the electrical loading, per flash, is in the range used for still photography. Fig. 5 shows the variation of light output during that discharge cycle. Note the similarity of the curves for light output and current. The flash duration, now unnecessarily short for most motion picture applications, can be increased by adjustments in the characteristics of the discharge circuit. Such adjustments would, at the same time, substantially reduce the peak current. Studies of tube performance characteristics under such conditions are being made but are incomplete at this time.

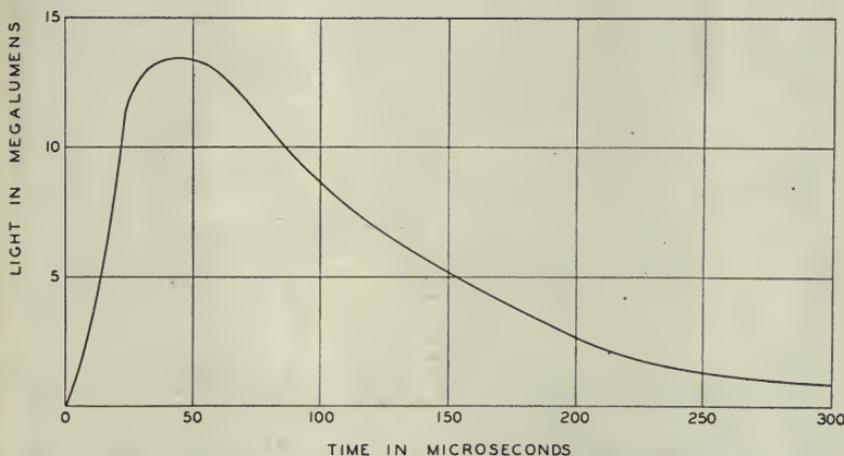


FIG. 5. Approximate time-light curve of a typical flashtube operated under the conditions shown in Fig. 4.

Flash duration encountered with conventional condenser discharge systems may be calculated from the empirical formula

$$\text{Duration (in microseconds)} \equiv K \frac{C^{0.69}}{V^{0.625}}$$

where C is capacity in microfarads, V is voltage in kilovolts and K is a constant, depending upon what part of the total flash is considered to constitute the useful duration. The value of K for flash durations to one-third peak is 20, and for flash durations to one-half peak, 14.5.

Flashtube Efficiency and Photographic Effectiveness.—Flashtubes convert electrical energy into visible light with greater efficiency than do tungsten filaments. A comparison of efficiencies alone

is always misleading when attempting to evaluate relative performance for photographic purposes because photographic materials evaluate differences in color quality of the light differently from the human eye. Tungsten filament sources used for photographic purposes have color temperatures of the order of 3200 K to 3400 K while flashtubes can have spectral energy distributions also closely approximating those of black body radiators but at color temperatures

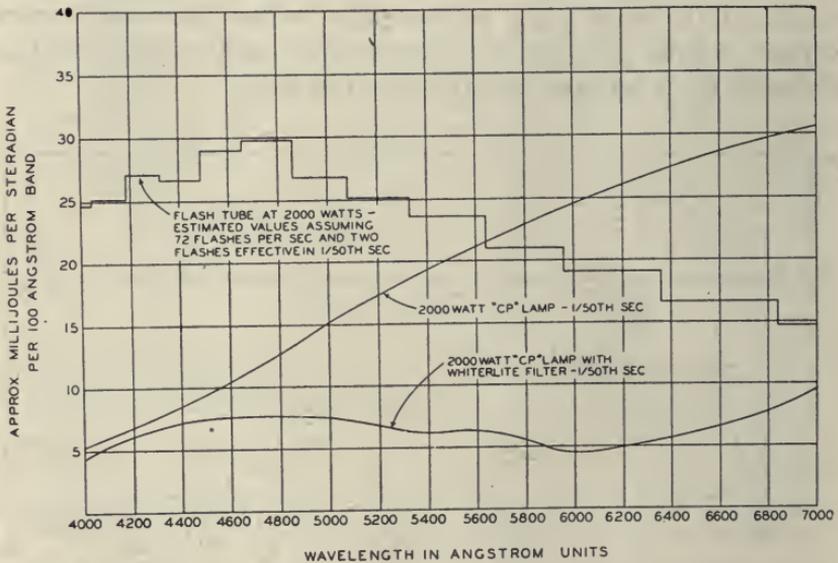
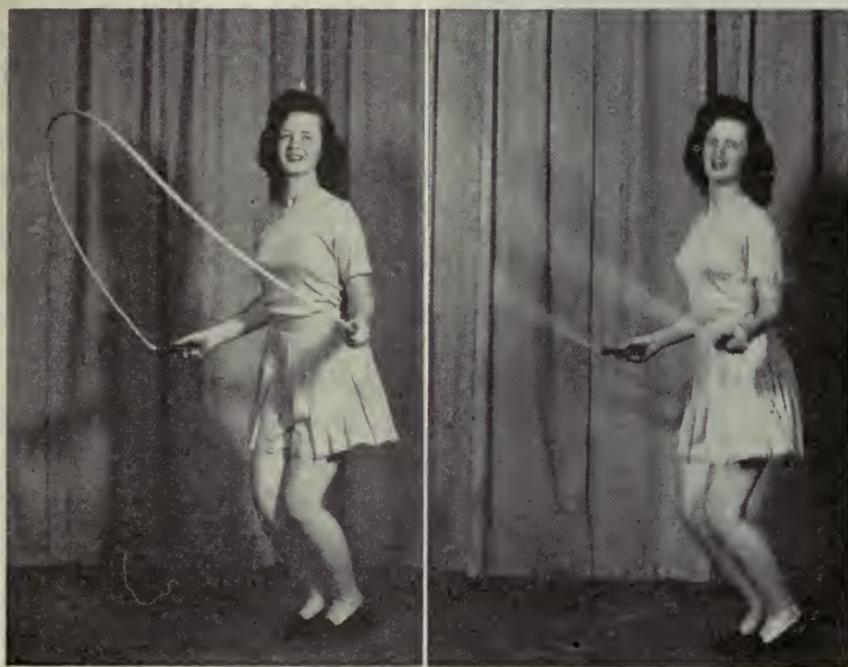


FIG. 6. Spectral energy distribution of a typical xenon-filled flashtube, a *CP* filament lamp, and a *CP* lamp and Whiterlite filter. The approximate energies emitted are calculated for a time interval of $1/50$ sec.

ranging from about 7000 K to infinity. The increase in photographic effectiveness of a source with increase in color temperature is already well established for a part of this range.

In order to provide a more fundamental basis for the comparison of tungsten filament sources and flashtubes, values of radiant energy have been determined for each type of source for wavelengths in the visible portion of the spectrum. To compare such data on a common basis it was, of course, necessary to assume some interval of time during which the radiation is effective. This time interval has been taken as $1/50$ of a second, the approximate maximum exposure time for a frame of motion picture film. From an examination of these data, Fig. 6, it is apparent that, given a

flashtube capable of repetitive operation for relatively long intervals under the conditions described, it should prove more effective photographically, per watt of input to the source, than the familiar *CP* tungsten filament lamps. Such a tube does not exist at the present time. The energy values used in the comparison were accordingly taken from data applying to single-flash operation. It is also apparent that such sources should produce less heat on the set.



(a)

(b)

FIG. 7. Direct comparison of the sharpness of the recorded image when the exposure is made (a) with flashtube; (b) with continuous illumination during an exposure interval of $\frac{1}{50}$ sec.

From the foregoing discussion, it would appear that flashtubes merit serious consideration as a light source for motion picture photography. There are, however, many other factors which must also be considered. Some of them are already apparent to those who have been working on the problem; others can only be surmised at this stage of the investigation. In the following paragraphs an attempt is made to define the probable difficulties as well as they can be stated at this time.

Referring again to the data presented in Fig. 6, several factors enter into the final evaluation of photographic effectiveness in comparison with other sources. For example, effectiveness is influenced by the relative actual exposure times employed. Also, since there seems to be a shift in contrast of the developed image, caused



FIG. 8. When two exposures occur in $\frac{1}{60}$ sec., multiple images are recorded. This is the appearance of a portion of a single frame of motion picture film when the film is moving at a rate of 24 frames per sec and the tube is flashing at the rate of 72 flashes per sec. Compare with Figs. 7(a) and 7(b).

perhaps by short exposure time, and since this can be controlled within limits by development, the speed of emulsions may be subject to further variations, which are unpredictable at this time.

Most of the data on flash-tube performance characteristics available today relate to single-flash operation in the field of still photography, where there is only moderate heating of the tube from one flash to the next. In this case, relatively high energy input levels per flash may be employed without detrimental effects, and minor variations in light output or in time to peak of flash are not of serious consequence. It is at these high energy input levels that greatest tube efficiency is realized, but the flashtube has not yet been developed which can be operated repetitively

and reliably at these levels for intervals such as would be required for studio lighting. In the absence of such tubes, it is impossible to predict not only their cost and efficiency but also the over-all economics of a system employing them.

Flicker Versus Flashing Rate.—The problems of flicker with respect to the comfort of those working under intermittent illumination will undoubtedly require special consideration. Most of the literature relating to this subject is limited to conditions where the

dark interval is equal to or less than the light interval and the intervals are uniformly spaced relative to time. With flashtubes, it may well be that the dark intervals will be as long as, or longer than, the light intervals and that an asymmetric spacing of the intervals relative to time would be desirable. It is known that the presence of some "continuous" illumination on which the intermittent illumination is superimposed reduces the flicker effect, but even this part of the program has not been adequately explored for the special conditions which might prevail should such lighting be used in the motion picture studio. Whatever the solution to these problems may be, tests have demonstrated that the apparent level of illumination on the set is noticeably less than is required with continuous illumination.

In any event, it appears improbable that a flashing rate of 24 per sec would ever be tolerable where live talent must be employed, even though there is a marked improvement in the sharpness of the photographic image, Fig. 7. A flashing rate of 48 per sec might prove acceptable but, from the standpoint of over-all efficiency, would be undesirable because only half of the flashes would be utilized. A flashing rate of 72 per sec is quite comfortable to work under and is more efficient than 48 per sec because it should be practicable to utilize two out of every three flashes per frame of film. No foreseeable advantages exist for higher flashing rates.

The presence of multiple flashes per frame, as in the case of 72 flashes per sec, introduces another problem which must be considered. With normal rates of object movement within the picture area, the resultant effect on motion picture film is very similar to that obtained with continuous illumination and conventional shutters providing exposure times of the order of $\frac{1}{50}$ of a second. However, when rapid rates of movement are encountered, two well-defined images of the rapidly moving object are recorded on the film, Fig. 8, with sufficient separation so that when projected it produces an effect different from that to which audiences are accustomed. The extent to which this is a detriment, and the extent to which it can be reduced by circuit design details previously mentioned remains to be determined.

Effect on Sound Recording.—It is still too soon to predict the extent to which operation of flashtubes from either a condenser discharge of a pulsed source of electrical energy may effect sound recording. Quite obviously, intermittent operation of sources of this

type will create electrical transients which, if not properly shielded, could interfere.

There is also some audible sound resulting from the flash, and it may be that means will have to be provided for its elimination.

Artificial Cooling.—As with all present sources of illumination, the operating limits for flashtubes will undoubtedly be dependent upon the presence or absence of some form of artificial cooling. Both air and liquid cooling are being investigated but insufficient information is available to define the limits of operation for each condition.

Reliability.—It would appear that, with properly designed power supplies, there would be negligible differences in exposure from one flash to the next. It must be recognized, however, that failure of a tube to flash due to any cause for even one cycle would have a detrimental effect on the final result. This means that the design of the entire system, including the source itself, must be such as to ensure maximum reliability of performance.

Power Supply.—Because the energy must be delivered to the flashtube in pulses of relatively short duration, there may be special problems in power supply design to keep the size, weight, and cost at a minimum.

Conclusions.—Thus, it is apparent that flashtubes hold considerable promise as a source of high photographic effectiveness adaptable to the exposure of either monochrome or color films. Because of its actinic and the fact that the source is not continuously emitting radiation, there is a marked reduction in sensible heat in the picture area. Visually, too, the level of illumination to produce a given photographic result is noticeably less.

On the other hand, it seems probable that new flashtubes, extensive equipment, and new methods of silencing and of distributing power to flashtubes on sets would have to be developed in order to employ such sources for general motion picture photography. The practicability of such systems will, in the end, depend largely upon the costs involved, and these cannot be predicted accurately at this time.

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DISCUSSION

MR. DOVER: Would there be any future possibility that flashtubes could be made with the light source sufficiently small so that it could be focused by lenses?

MR. CARLSON: Some experimental work has been done on such sources.

DR. BACK: Several years ago we made exposures for some still pictures from the inside of the stomach, and we made some pictures with flashbulbs, and the exposure was too short.

I think if you take the condenser and step it down to approximately 100 volts, it might work better. In this case the exposure time is increased. This might give a satisfactory result.

MR. CARLSON: We have done experimental work over a relatively wide range of voltages. The highest efficiency of conversion of electrical energy into visible radiation occurs when the tube is operated at a relatively higher voltage although, as you point out, the flash duration is longer at the lower voltage.

DR. KELLOGG: Sometime ago we tried to modulate mercury lamps and we found that there was too much energy stored in the arc stream. Can you tell us anything about the problem that you are up against in the storage energy in the arc stream of a flashtube?

MR. CARLSON: There does not seem to be any problem in that respect, particularly at the flashing rates discussed in this paper. I say that because such tubes have been used widely at higher flashing rates. It is very common, for example, to use tubes of similar design at flashing rates of the order of 1000 per sec or more. In fact, I have had reports of a flashing rate of 20,000 per sec. I do not think there is any modulation problem involved.

DR. KELLOGG: Would not there be with mercury?

MR. CARLSON: Yes. That is one reason why mercury is not a very satisfactory material to use for this type of source. These are filled with gases, usually xenon. Sometimes argon or krypton is used or mixtures of these gases.

MR. RESS: How does the human eye stand up under this tremendous amount of lumens?

MR. CARLSON: The eye seems to integrate the flash of that sort as the visual sensation is similar to that resulting from a relatively longer exposure time of much lower intensity. I have not heard of any instances where the high intensity of light had any detrimental effects.

MR. LEE: Have you tried examining the effect of completely random pulsing the light source to eliminate these stroboscopic effects? You might have to go to higher rates, but I think you would get 50 per cent efficiency with a 180-deg shutter.

MR. CARLSON: Such tests have not been made, but it would appear that the result would also be random exposures per film frame.

MR. REED: I noticed that when the baton was being twirled it seemed somewhat jumpy when the exposures were made with flashtubes. Of course with uni-

form illumination it was quite blurred. Do you have any opinion which looks more nearly like the original?

MR. CARLSON: I think the blurred image looks more natural. This, however, does not appear equally true when more normal rates of movement are photographed.

MR. REED: I would like to know if you have any indications what the life might be, operating at 48 cycles?

MR. CARLSON: Complete data are not available. Tubes capable of operation at a few hundred watts seem to be showing lives of the order of 10 million flashes or more.

HISTORICAL DEVELOPMENT OF SOUND FILMS*

E. I. SPONABLE**

PART 3. COMMERCIALIZATION OF MOVIE-TONE BY FOX

Aug. 1926: De Forest brought suit against Fox and Case, charging infringement of the Ries recording and reproducing patents, two of his patents covering the use of a gas discharge for sound recording, and a patent on the use of a light-sensitive cell with an audion amplifier. (De Forest had purchased the Ries recording patent October 15, 1925. He did not, however, actually acquire the Ries reproducing patent until November 16, 1926, although it is believed he held an option on this and several Ries applications before this time.)

De Forest did not press the suit for trial; it was finally allowed to lapse on the court calendar.

Aug. 1926: At the time of the formation of the Fox-Case Corporation, Sponable came to New York to take part in commercializing the Case system. With him came Mr. D. B. Eldred to assist in the business management of the company. Eldred, Case's brother-in-law, had joined the Case Laboratories in 1925. Courtland Smith was made general manager of the Fox-Case Corporation. "Movietone" was chosen as the name of the sound picture system. The industry is greatly indebted to Courtland Smith for his foresight and aggressiveness in hastening the commercialization of sound-on-film. He did more than anyone else to convince the "doubting Thomases" of the business that sound motion pictures were a reality and that the days of the silent film were numbered. He was instrumental in starting and developing Movietone News and later the Newsreel Theater.

During this time plans were worked out for a sound picture producing unit. Sponable designed and built two studios at the Fox Annex at 460 West 54th Street. These were the first studios, except

* Presented Oct. 22, 1946, at the SMPE Convention in Hollywood. (Parts 1 and 2 published in the preceding issue of the JOURNAL, p. 275.)

** Twentieth Century-Fox Film Corporation, New York.

for experimental rooms, wholly designed for sound recording purposes. They were built to exclude all outside noise and with the best acoustic treatment known at the time. Dr. Paul Sabine, acoustic engineer of the Riverbank Laboratories at Geneva, Illinois, acted as a consultant in this work.

Sept. 1926: Fox and Smith negotiated with the General Electric Company for rights to use vacuum-tube amplifiers commercially. The deal was nearly completed and General Electric equipment was brought from Schenectady to New York. At the final closing the parties did not agree, and General Electric withdrew their equipment.

It is interesting to note here that, if this arrangement had gone through, the whole setup of the future sound business would have been changed. The Western Electric Company would probably have concentrated more and more on disk, and the Fox-General Electric group would have led in the development of sound-on-film.

Oct. 25, 1926: The first test recording was made on the new Fox-Case Corporation stage. The next day a test recording was made of Harry Lauder. Typical of his Scotch character, he stopped singing during the middle of the recording of the song "Roamin' in the Gloamin'" and said, "This is a test"—to be sure it would not be used commercially.

Nov. 4, 1926: Work was begun on making a number of one-reel short subjects with Racquel Meller, using regular motion picture production technique.

Dec. 1926: Prior to this time, negotiations were carried on with the Western Electric Company to give Fox rights to use their amplification patents and apparatus commercially. These culminated in an agreement or sublicense from the Vitaphone Corporation (see Part 5) in which Fox, among other things, agreed to pay a royalty of about 8 per cent of his gross business in the sound field.

Jan. 21, 1927: The first public showing of Fox-Case "Movietone" subjects was given at the Sam Harris Theater in connection with the première of "What Price Glory". The sound features were not advertised. The showing was made using a Case sound attachment with Western Electric main amplifiers. No stampede resulted, but neither was there an unfavorable audience reaction.

Feb. 1927: Sponable developed a screen suitable for picture projection and still transparent to sound without causing distortion. This enabled the use of loudspeakers directly behind the screen and

was a great help in improving the illusion. This was immediately accepted by the industry.

Feb.-Mar. 1927: The first field recording unit was assembled. With it, out-of-door recordings of a West Point review were made and the outfit was then sent to Italy for the purpose of making a record of the Pope and Mussolini.

Mar. 11, 1927: The Roxy Theater, designed by S. L. Rothafel as the "last word" in motion picture palaces, opened in New York. Two weeks after its opening, Fox obtained control of the Roxy and laid plans to convert it for showing sound on film.

Apr. 1927: Fox-Case made a new agreement with Electrical Research Products, Inc., superseding the Vitaphone sublicense. Electrical Research Products had been formed January 1, 1927 as a subsidiary of the American Telephone and Telegraph Company, for the purpose of handling the sound equipment business, instead of the Western Electric Company.

May 1927: A showing of a West Point review as a sound feature was given at the Roxy Theater.

May 6, 1927: Fox-Case Corporation's Field Outfit No. 1 recorded a speech by Mussolini and a number of Italian army subjects. This work was done by B. Miggins as cameraman and E. Kaw and D. F. Whiting as soundmen.

May 25, 1927: A program was opened at the Harris Theater containing Movietone subjects. This included a silent version of "Seventh Heaven" and several sound shorts.

June 12, 1927: Fox-Case recorded the Lindbergh welcome at Washington. Charles Gilson operated the camera, E. H. Hansen the sound equipment. The showing of this, together with his take-off, and the Mussolini pictures referred to above, created the second big sensation in the public showing of sound pictures (the "Jazz Singer" being the first).

Sept. 1927: An all-sound program made up of the feature picture "Sunrise" with synchronized score, and the Mussolini pictures, opened at the Times Square Theater. This showing was made on a Western Electric sound-on-film installation.

Oct. 28, 1927: The first "Movietone News" was shown at the Roxy Theater. The issue contained the following subjects:

- (a) Niagara Falls
- (b) Romance of the Iron Horse

- (c) Army-Yale Football game at Yale bowl
- (d) Rodeo in New York

Oct.-Nov. 1927: Sponable surveyed the Fox West Coast studios with a view to converting them for sound work, and drew up designs for the first unit. The building of these studios was held up by Fox, owing—among other reasons—to the estimated cost of \$250,000 being too high.

Nov. 1927: Case suggested “noise reduction” in an affidavit dated November 28, 1927, quoted below:

“It is of great advantage when photographing sound on film to have the ground noise level as low as possible between words or sounds when there is nothing on the film in the form of modulation to cover up the ground noise. A method of doing this has suggested itself to my mind as follows: If the recording light which itself is modulated or by another method is modulated mechanically is only eliminated while modulation is not going on in the circuit this would mean that when no modulation is present the light would be reduced to a minimum automatically or might even be put out entirely. This would mean that between modulation or between words or between sounds the negative sound record would be unexposed or white upon development. This, on the positive, would be reversed or black thereby reducing any ground noise that there might be between words or sounds. The method of accomplishing this could be the same as is at present used in the transoceanic telephony where it is essential that automatically only one sending station is in operation. As soon as active modulation ceases in one direction and starts in the other direction the modulation passing in the circuit actuates a relay mechanism to instantly put into action this sending station. In other words in our simple modulation circuit any alternating or pulsating currents would actuate a mechanism to bring the recording light up to the brilliancy desired for the best operation of the system and while no modulation was passing, the light would automatically be reduced to the point where no record would appear on the film.

“This is signed and witnessed at 9:40 A.M., November 28, 1927 and I am now going to call up Dr. McKenzie at the Western Electric Company and inform him of this idea so that it can be put into operation, if they so desire, on their mechanical method of recording sound.

/s/ Theodore W. Case”

During the last of 1927 and the first months of 1928, there was much activity in organizing and in developing sound equipment by the Fox-Case Corporation. Sound News outfits were put in the field at the rate of one or two a month. Various short subjects and productions were made in the studios, largely to learn the best uses for sound and its limitations. Many silent pictures were synchronized. A test was made combining Technicolor with sound. A cartoon was made with sound effects.

May 10, 1928: A non-exclusive agreement was made between ERPI and Fox-Case—effective April 2, 1927. The royalty arrangement was changed from 8 per cent of the gross to \$500 per negative reel for domestic release and a schedule for release in foreign countries that added up to a second \$500.

May 1928: Equipment for three studio recording units was ordered by Fox-Case in anticipation of its coming West Coast studio demands.

During the spring of this year, Winfield Sheehan, in charge of production at the Fox West Coast Studio's, who did not believe too strongly in sound in the beginning, came East and was anxious to arrange to get started on West Coast studio sound productions. He had taken over two news outfits that were originally assigned to West Coast news work. With these the Fox studio made a two-reel dialogue comedy, "The Family Picnic".

June 18, 1928: This opened as part of the program with "The Air Circus" (synchronized sound) at the Globe Theater in New York.

June 25, 1928: A Movietone field projector truck was used on Broadway to ballyhoo "The Red Dance" at its première. This out-of-door portable sound projection unit was a development of Fox-Case that has been used to some extent for political and commercial purposes.

It now became Sheehan's desire to get into sound as quickly as possible. This was accelerated by the fact that other producing companies were already starting. He brought various members of his producing staff East to work out a way of starting this work, and placed his Movietone development under the direction of his studio manager, Ben Jackson. They returned to Hollywood on July 12, 1928, taking practically the entire staff of engineers from Fox-Case. Operations were planned on a large scale.

July 1928: Equipment for nine West Coast recording units was ordered.

July 28, 1928: Several Movietone stages were started at Fox Hills, on a location which was previously used to corral Tom Mix's horses. These were erected under the direction of Mr. Sheehan, with C. H. Muldorfer as architect and H. K. Weeks as construction engineer. The completion of these sound studios and accessory buildings was accomplished with great speed and with much credit to the men responsible for the work. The whole plant took form in approximately ninety days.

Aug. 1928: Equipment for twelve more West Coast recording units was ordered, making a total of twenty-four.

Sept. 1928: Equipment for three European recording units was ordered. These orders from Fox, together with those of other companies coming into the field, swamped the facilities of the Western Electric Company and made deliveries of equipment very uncertain.

This period was marked by a rapid growth of the technical staff of the Fox-Case Corporation. Many contributions were made by various individuals, particularly L. B. Hoffman, L. W. Davee, A. J. Sanial, H. E. Bragg, H. F. Jermain, Walter Hicks, R. F. Nicholson, and W. F. Jordan. Nineteen newsreel field outfits were operating. The crews of these units did much to overcome the initial difficulties of field operation.

Sept. 1928: Fox Movietone City was dedicated. (This is the present Twentieth Century-Fox Studios at Beverly Hills, Calif.)

Oct. 6, 1928: The Fox Movietone News release was increased from one to two issues per week.

Dec. 1928: "In Old Arizona", the first out-of-door recorded feature picture, was shown at the Criterion Theater in Los Angeles. Quoting Franklin: "This film was photographed and recorded outdoors against a sweeping background of natural beauty, and in its sound recording achieved its highest artistic success up to that time. Filmed and recorded right in the vast open spaces, the scenes and human voice and all the accompanying sounds were reproduced with a clearness and naturalness that attracted wide attention. The Movietone process caught and reproduced with fidelity not only the voices of the actors, but actually the natural sounds of the outdoors: the whispering of the wind, the song of the birds. The picture was thus notable in combining the perfected technique of the silent film with the faithful recording of music, dialogue and sound."

Subsequent Fox pictures that were well received and helped to

advance the art of sound recording included the all-talking pictures "Through Different Eyes" and "Hearts in Dixie".

Dec. 3, 1928: Fox Movietone News release was increased to three issues per week.

During the year 1928, appreciable general progress was made in perfecting Movietone technique; one point of note was the perfecting of the Aeo lights by Case, increasing their useful life and uniformity.

Sponable organized a research department to which was assigned the problem of improving sound recording apparatus, particularly with a view to reducing its weight and improving its portability and ease of operation—as well as the over-all problem of improving recording and reproducing equipment and techniques. Fifty-six field units were scheduled for assignment all over the world; three special Aviation Units were activated; to meet the need for such an increase in personnel, Bragg was sent to interview recent graduates at various technical institutions. Well over 100 engineers were now engaged in the sound recording field.

Feb. 28, 1929: Fox acquired control of Loew's and MGM.

Mar. 1929: Fox announced that all silent product would be discontinued and only Movietone pictures would be made.

July 15, 1929: The Fox Movietone News release schedule was increased to four issues per week.

July 18, 1929: William Fox was injured in an automobile accident; this may have seriously affected the following up of his involved negotiations.

July 1929: British Movietone News, the first foreign sound newsreel producing company, was started.

Aug. 1929: A merger of Fox Film, Fox Theaters, and Loew's was planned.

Sept. 20, 1929: Fox negotiated a deal acquiring Fox-Case stock from Case and exchanging Fox Theater stock to be redeemed September 1, 1930. Fox then formed the Fox-Hearst Corporation, Hearst acquiring about 24 per cent of original Fox-Case stock with option to buy about 25 per cent more.

Fox made a separate agreement with Case to have the latter run his laboratory until July 23, 1930.

Sept. 1929: Fox and Hearst united their sound newsreels and agreed that each would release two per week.

Sept. 17, 1929: An all-Grandeur show opened at the Gaiety Theater with Grandeur News and "Fox Movietone Follies".

Sept. 28, 1929: Hearst Metrotone News released its first issue.

Nov. 2, 1929: The Embassy Theater was opened with the first all-sound news program and called "The Newsreel Theater".

1930: The crash of 1929 found the Fox structure in such a condition of over-expansion that it became necessary for Fox to sell out.

Controlling interests in Fox Film and Fox Theaters were acquired by a group headed by Harley Clarke, who became president of the Fox companies.

Sound-on-film by this time was well established as a commercial success and was displacing sound-on-disk as a release medium. The Western Electric light-valve method of sound-on-film recording was commercially perfected. As Fox Film was a licensee of ERPI, and as such paid the regular royalty rates, it decided to give up its own method of Aeo light recording and use in entirety the Western Electric system.

PART 4. FOREIGN PROGRESS IN SOUND FILMS AND RELATIONS WITH FOX

Sept. 1922: The first showing of acoustic films was made at the Alhambra Theater, Berlin. These were made using the Tri-Ergon method with the sound recorded on a film about 42-mm wide and the sound placed outside the sprocket holes. (This system was worked out by three inventors—Engl, Massole, and Vogt, who had formed a sound-film company called the Tri-Ergon A.G., of Zurich.)

July 1926: F. A. Schroeder, who was the American representative of the German group, brought their system to the attention of Courtland Smith.

Aug. 1926: John Joy went to Europe to investigate Tri-Ergon for Fox.

Dec. 1926: At Joy's request Dr. Engl brought a complete unit of the German apparatus to New York for examination and tests. Records were made and shown under the direction of Dr. Engl; the results were judged to be fair, but not so good as Movietone. This was to some extent the result of the use of condenser loudspeakers in the German system. The equipment as a whole was typically German in design and offered few features that could be advantageously combined with the Movietone system.

July 1927: Fox took over rights to the German system for North

America and rejected a chance to acquire the world rights. This soon proved to be a mistake, since the patents became troublesome in foreign countries, and royalties were collected on them.

Shortly thereafter, Joy and Shroeder went to Europe to get an extension of scope to the Fox agreement to permit use throughout the world. Also during this time, UFA of Germany acquired a license under the German system.

Feb. 1928: During the interval since July 1927, Tri-Ergon had tried to bring together all German companies interested in sound pictures including Siemens and Halske, AEG, and others. This was not entirely successful as Siemens and Halske and AEG wanted too much and Tri-Ergon would not agree to their stand.

Aug. 1928: Tri-Ergon formed a German operating company backed by the Commerce and Private Bank and called Tonbild Syndicate A.G. (or Tobis) with rights in Germany, Switzerland, and Austria.

Sept. 1928: Negotiations were carried on by Joy and Rogers for Fox with Tri-Ergon and Tobis to make a working arrangement to record and reproduce sound throughout the world under Tri-Ergon patents. No agreement was reached.

Nov.-Dec. 1928: Schlesinger, of London and South Africa, who had purchased the de Forest Phonofilm Company, attempted negotiation with Tobis and Tri-Ergon for joining de Forest and Tri-Ergon on a world basis. This did not go through.

Jan. 1929: Siemens and Halske and AEG combined interests in the sound picture field by organizing a company called Klangfilm.

Klangfilm attempted to release a picture made by RCA in America in one of the UFA Theaters in Berlin. Tobis stopped this with an injunction on the grounds that the picture was recorded by double system, *i. e.*, sound and picture separate, and recombined in a single positive. It was claimed this infringed Tri-Ergon patents. The result of the court's decision, sustained by the higher court, made Klangfilm make a working agreement with Tobis.

During this time Fox interests kept up communication with representatives of Tobis and Tri-Ergon for the purpose of making a working arrangement through American Tri-Ergon to permit Fox to record and reproduce throughout the world under the German patents. No such arrangement was agreed upon.

Apr. 1929: Attempts were being made at this time by various groups to join together the various Tri-Ergon interests and

Klangfilm in opposition to Western Electric progress in foreign countries. Nothing resulted from this.

June 1929: Kuckenmeister, a German phonograph manufacturer, through connections with Oyens and Sons, a Holland banking firm, became interested in organizing a holding company to unite various Tri-Ergon interests, not controlled by Fox, into one group. This was concluded in June 1929, and called "Acoustic Products Company of Holland".

About this time Tri-Ergon started suits against Electrical Research Products, Inc.; and during the summer obtained injunctions restraining the reproduction of all American pictures on ERPI apparatus in Germany. Some of the original decisions have since been sustained so that, except by special agreement with Tobis, American sound films were prevented from being released in Germany. Warner Brothers obtained a special license from Tobis and have released their films.

May-Aug. 1929: Joy attempted to obtain a working agreement with Tobis to protect Newsreel recording and allow release of Fox products in Germany. No arrangement was concluded.

Various conferences were held among representatives of ERPI, Tobis, Siemens, and AEG both in Europe and in America. No agreement was reached.

Sept. 1929: Schlesinger concluded an arrangement with Kuckenmeister in which his British company was allied with Tobis and Klangfilm. Advantages Fox could have had were now being acquired by others.

Oct. 1929: Tobis brought suit against Movietone in Germany and Austria. All Fox Newsreel trucks were removed from these countries.

During the last six months of 1929, both Tobis and Klangfilm moved forward, both in theater installations and in the production of sound pictures. They made an alliance with a French producing company, and arranged to begin sound work in France.

June 1930: Will Hays headed a committee in Paris which met to deal with foreign sound problems and to attempt a settlement of German relations. This tangled situation was finally ironed out and a compact was arrived at on July 22 permitting the showing of American films abroad.

PART 5. SOUND WORK UNDER THE WESTERN ELECTRIC SYSTEMS

1925-'26: Major development of the disk system of sound motion pictures, later trade-named "Vitaphone", was carried on by a group in the Bell Telephone Laboratories headed by Dr. J. P. Maxfield. At about the same time, another group headed by Dr. Crandell and Dr. MacKenzie were working out a sound-on-film system using a "light valve" designed by Dr. Wentz in the recording.

Apr. 20, 1926: Western Electric Company entered into a contract with Warner Brothers and W. J. Rich, a financier, giving them an exclusive license for recording and reproducing sound pictures under the Western Electric system. The Vitaphone Company was formed.

June 1926: The Vitaphone Company opened a recording studio at the Old Manhattan Opera House, 34th Street, New York.

Aug. 6, 1926: Warner Brothers gave their first public performance of Vitaphone at the Warner Theater, New York; showing a scored picture "Don Juan" and several shorts including a talk by Will Hays, and songs by Martinelli, Marian Talley, and others. This received favorable comment from some papers, enthusiastic comment from others, and grave doubts from the industry that talking pictures would ever be commercial.

Dec. 1926: The Vitaphone corporation gave Fox a sublicense to use Western Electric equipment in the field of sound pictures.

Dec. 31, 1926: Western Electric had equipped about twelve theaters with sound installations for Vitaphone.

Jan. 1, 1927: Electrical Research Products, Inc. (ERPI) was formed as a subsidiary of Western Electric and AT&T to commercialize equipment for the sound motion picture field, the equipment business having been bought back from the Vitaphone Company. The name Vitaphone was retained by Warner Brothers for their sound picture system.

Spring 1927: Vitaphone recording was moved to Hollywood.

Feb. 23, 1927: MGM, First National, Paramount, Universal, and PDC, termed "The Big Five", agreed to stand together for the purpose of determining the right sound system and used the facilities of the Hays organization for this investigation.

Apr.-Aug. 1927: ERPI made their first light-valve installation in the Fox Movietone studio at 54th Street and 10th Avenue, New York. This was installed at ERPI's expense and operated

experimentally by Bell Telephone Laboratory engineers. The ERPI film processing specifications were rigid and their technique of operation was not sufficiently advanced to impress the Fox group that the light-valve system offered any commercial improvement over the Case system then in use.

Apr. 19, 1927: Warners secured 100 per cent ownership in Vitaphone by purchase of W. J. Rich's interests.

Oct. 1927: Warners released "The Jazz Singer". This is spoken of as the turning point in the coming of sound, and served to convince the industry of its potentialities.

Dec. 31, 1927: One hundred and fifty-seven theaters were equipped for sound, of which fifty-five included film units. The rest were disk only.

Apr.-May 1928: ERPI contracts were signed by the "Big Five" group. This ensured the general use of talking pictures. The Warner contract was revised when ERPI took over the equipment business and a new Fox license was also signed about this time. Victor and First National announced the release of their product under the name of "Firatone". The ERPI licenses granted during this period included the following companies: Paramount, United Artists, Metro-Goldwyn-Mayer, First National, Universal, Christie, Hal Roach, and Victor Talking Machine Company.

May-Dec. 1928: There was great activity in getting studios equipped for recording. Everyone wanted to start at once and equipment was at a premium, with deliveries most indefinite.

At about this time, sound equipment and recordings were standardized to a sufficient extent that apparatus made by either RCA or ERPI could satisfactorily play the product made with the other equipment. In the beginning, ERPI tried to restrict the use of its equipment to sound tracks made on the Western Electric system.

July 1928: Paramount began recording in Hollywood on a temporary channel and first used sound in their picture "Warming Up", with Richard Dix.

July-Sept. 1928: Their first all-talking picture was "Interference", directed by Roy Pomeroy. This was followed by "The Doctor's Secret" and others. During this early work in a temporary studio, many of the scenes were made at night to avoid outside noises.

Dec. 1928: Paramount began recording in its new sound studios on regular channels.

Dec. 31, 1928: ERPI had 1046 theaters wired for sound, of which 1032 were for sound-on-film.

Jan. 1929: Warner Brothers became interested in the Pacent sound system and approved Pacent installations in April 1929. ERPI began suit against Pacent for patent infringements.

Aug. 3, 1929: The first issue of Paramount Sound News was released.

Dec. 31, 1929: The tremendous growth of the sound motion picture business in a little over two years is evidenced by the fact that there were 77 ERPI recording channels in operation in the United States. ERPI also had equipped about 4000 theaters in this country and some 1200 in Europe. Most of the theater installations were for both sound-on-film and sound-on-disk.

Also at this time it became evident that there was a trend to favor sound-on-film over sound-on-disk for theater release purposes.

Apr. 1930: Warner Brothers announced the purchase of an interest in the T. H. Nakken patents. These patents related to the use of a photoelectric cell and an amplifier. (Subsequently they were used as a basis for litigation.)

PART 6. SOUND WORK UNDER THE RCA SYSTEM

1925: About this time, a small group of engineers at Schenectady, headed by C. A. Hoxie, experimented on recording sound on film photographically, using a special oscillograph as the recording unit and making records of the variable-area type. This sound-on-film system was called the "Pallophotophone". Also at this time, Hewlett (a research engineer in the General Electric laboratory) was perfecting his induction-type loudspeakers, and Rice and Kellogg (also General Electric research men) were developing their electrodynamic cone speakers.

Feb. 1927: During the year 1926, probably stimulated by the work of Western Electric and others, the General Electric group combined their Pallophotophone with moving pictures and held a demonstration at the State Theater, Schenectady, in February 1927, before a group of newspaper men and engineers. Their system of combined pictures and sound was called the "Kinographophone". The demonstration included speech and several musical numbers produced by amateur talent. Later this demonstration was given at the Rivoli Theater in New York.

Mar. 1927: It was reported that five of the big producers were negotiating with General Electric to compete with Movietone and Vitaphone.

1926-'27: The research laboratory of the Westinghouse Electric and Manufacturing Company, not to be outdone, carried on the development of a system of sound recording, using for its light modulator the Kerr cell based on the principle of the rotation of a beam of polarized light by electrostatic means.

Toward the end of 1927, Paramount released its picture "Wings", with a sound score prepared by the General Electric group. This score was used in several different ways. At the Criterion Theater, New York, the airplane sounds were taken from disk recordings using a multiple turntable device and synchronized by an operator back stage. The effects were reproduced in other theaters through the use of condenser-discharge devices as well as from a score recorded on film.

1928: The sound picture work of General Electric and Westinghouse was combined into one system and handled by a new subsidiary of the Radio Corporation of America called RCA Photophone, Inc. The variable-density Kerr cell method of recording was dropped, and the variable-area system further perfected under the name of Photophone. RCA Photophone announced to the trade that it had perfected reproducing apparatus and would equip theaters.

Oct. 1928: Shortly thereafter, RCA acquired the B. F. Keith and Orpheum chain of theaters and the FBO Producing Company. A subsidiary was formed called Radio-Keith-Orpheum. Through this producing organization, sound pictures made by Photophone's methods were introduced to the public. The first efforts along these lines were limited to the presentation of musical accompaniment; the first picture was "The Perfect Crime", which included some dialogue sequences. Important stage plays were acquired by the RKO producing organization, including the very successful "Rio Rita", which they produced as a sound picture.

Feb. 9, 1929: RKO Productions, Inc., announced that they had selected "Radio Pictures" as the trade name for RKO Productions (which was the motion picture producing and distributing unit of the Radio-Keith-Orpheum Corporation, sponsored by the General Electric Company, the Westinghouse Electric and Manufacturing Company, and National Broadcasting Company).

An affiliation was subsequently effected with the Pathe Exchange, Inc., which adopted the RCA Photophone System of recording in the production of sound motion pictures. The first Pathe production shown with a musical synchronization was "Captain Swagger" with Rod La Rocque; and this was followed by several others in rapid succession. The Pathe organization also released a sound newsreel recorded by the Photophone process.

Jan. 1929: RCA closed a deal for the acquisition of the Victor Talking Machine Company.

Mar. 1929: RCA, Tobis, and Klangfilm announced a working agreement.

Dec. 31, 1929: RCA Photophone had equipped for sound about 1200 theaters in the United States, and about 600 abroad.

Dec. 1929: It was announced that RCA Photophone would shortly center all of its sound picture development work at Camden, N. J., combining the General Electric and Westinghouse groups who had previously operated independently.

PART 7. MISCELLANEOUS SOUND SYSTEMS

May 22, 1926: Thomas A. Edison declared no field exists for talking pictures.

Nov. 1926: A device called the "Remaphone" was brought out. It consisted of a Victor "Electrola" with two turntables connected by a shaft to the two projection machines in the booth.

Feb. 1927: Synchronophone Corporation offered a new synchronization device for use in small theaters and provided music from disks.

Spring 1927: Vocafilm and Orchestraphone were made available for synchronizing pictures. The Orchestraphone was designed primarily for small theaters and initially tried in Chicago.

July 1927: Vocafilm gave a showing using its sound picture system at the Longacre Theater, New York.

Dec. 1927: Orchestraphone, marketed by the National Theater Supply Company, was shown at the Tivoli Theater, New York.

Bristolphone was demonstrated before the Franklin Institute.

Apr. 1928: Motion pictures were transmitted over telephone between Chicago and New York.

Aug. 1928: M. A. Schlesinger bought control of the de Forest Phonofilm Company. He had previously held an option to pur-

chase the company; this option had expired in 1927. General Talking Pictures was formed as the new operating company.

Nov. 1928: Acoustic Products (Sonora) acquired manufacturing, distributing, and licensing rights to Bristolphone.

Dec. 1928: Cinetone, a sound device for home use, was offered by DeVry.

Jan. 1929: Pacent started installations approved by Warners.

Sept. 1929: Powers Cinephone was placed on the market.

Dec. 1929: At the end of this year, there were 234 different types of theater sound equipments in use; most of these, produced by the independents, were for sound-on-disk. The total number of theaters equipped for sound of all makes in the United States was 8741. Of these installations, ERPI and RCA had provided 4393.

As has been indicated in the introduction, these notes have treated certain developments very fully and have made only the briefest mention of some others. This is not to be construed as a judgment of relative importance *alone*: rather, it also has been decided on the basis of what has previously been written on the subject, and the author's more intimate knowledge of certain details. For example, the material on the Case work has, for the most part, never before been made public; and even this could not be reviewed in great detail in an article of this kind. It is hoped, however, that enough has been told to give the reader a concise picture of what took place during this rather brief development period.

It has seemed appropriate to end this history in the early thirties, since at this time sound-on-film had completed the initial stages of its development; and had justified its existence as a commercial achievement of the first order.

[*Ed. Note.*—Following Mr. Sponable's paper a film was exhibited demonstrating early sound-on-film, containing following subjects:]

Subject	Projection Speed	Date
T. W. Case, close-up	75	March 1924
Man with harmonica	75	March 1924
T. W. Case (tuxedo)	80	April 1924
Man playing harp	80	April 1924
Man and duck	85	May 12, 1925
T. W. Case, close-up	85	May 1925
Chinese boy playing ukulele	85	June 1926
Raquel Meller	90	November 1926
Harold Murray	90	November 1926
Sunrise (Scored silent)	90	June 1927

THE CONTRIBUTION OF THEATER SERVICE TO TWENTY YEARS OF MOTION PICTURE SOUND PROGRESS*

E. S. SEELEY**

Summary.—The history of the sound motion picture industry is told from the point of view of the service organization. Particular emphasis is given to the part played by the service forces in the steady improvement of sound quality to its present standard.

The paper also discusses possible theater problems of the future which service will help solve.

On August 6, 1926 the Sound Motion Picture was officially born. On that date the world premier of the Vitaphone was held at Warners Theater, New York, the program consisting of "Don Juan" with a synchronized sound-on-disk score and a group of Vitaphone musical shorts together with a brief introductory talk by Will Hays, then czar of the motion picture industry. This was the official beginning of commercially successful sound and talking motion pictures.

The public and a great number of the producers were highly skeptical concerning the new sound pictures. Then on Oct. 6, 1927 came Al Jolson in "The Jazz Singer" which, with two short dialogue sequences and several song numbers was a picture admirably suited to the taste of the entertainment-seeking public. This picture broke all existing box-office records wherever shown and convinced everyone that sound pictures were no longer a novelty but were here to stay.

Revolution seized the entire motion picture industry. The equipment companies were besieged with thousands of exhibitors waving certified checks and begging for equipment. Many were glad to obtain a nine-month delivery promise. This sudden

* Presented Nov. 13, 1946, at a meeting of the Atlantic Coast Section of the Society in New York.

** Chief Engineer, Altec Service Corporation, New York.

demand for equipment placed a heavy strain on the principal manufacturers, Western Electric and RCA, despite their great facilities.

But the greatest strain was placed on the new organizations whose role it was to install the equipment. These organizations mushroomed. For some time all sources of the required type of personnel were scoured for men of suitable abilities and background at the rate of 75 to 100 per month for one of these organizations alone. Because of the urgent need for men in the field, the training period was all too brief for these men to master the technical mysteries of the sound systems, the mechanics of good installation practices, and the lore of the theater.

Beginnings of Service (1927).—To add to the burden, it immediately became evident that the new equipment had a perverse tendency to break down when the house was packed with expectant patrons. It was soon apparent that in order to ensure continuous and satisfactory operation it would be necessary to establish an additional corps of trained specialists to service the sound equipment rather than leave it in the hands of those who were not familiar with this new complex electrical and mechanical apparatus. It was felt that the security of the future of sound pictures depended upon continued satisfactory operation, and consequently in the Spring of 1927 a service department was organized by ERPI in order to maintain the equipment in operation without interference with the high-pressure installation schedule. The service department gradually emerged from its lowly beginnings and in 1937 became separated from ERPI to be known as Altec Service Corporation with the sole functions of maintaining and improving quality performance in theaters.

Inevitable growing pains were experienced by the young operating organization. The new men, rushed into the field to handle sometimes three installations at a time, often without help from their own supervisors, could not achieve completely what we consider the full standard of installation practice and improper conditions were sometimes left behind them. The new science of theater sound projection was growing rapidly and the problem of applying the latest knowledge in the field developed. Furthermore, as the need for new men began to moderate somewhat it was considered necessary to recontact the field personnel to supply some of the training which it was not possible to give them when the pressure was most intense.

To accomplish these several purposes a new group was formed who were known as Technical Inspectors. The Technical Inspectors, selected from the field on the basis of special technical ability, were given more advanced schooling in all parts of the sound systems. They then contacted the installation and service inspectors to further the training of the latter, and made detailed inspections of the new and established installations, perfected adjustments, reoriented horns, eliminated hums, made acoustic surveys and performed other valuable service functions to ensure proper functioning mechanically, electrically and acoustically according to improved standards.

The technical inspection group continued in action until about 1930, by which time the field personnel, now mostly service engineers, had been raised to the level of ability of the TI. The training of the service inspector, however, has never abated. Special schools, new test methods, improved instrumentation and technical bulletins have been the means of maintaining steady growth in competence of the service he renders exhibitors.

The day-by-day work of the service inspector is known to many of you; his emergency service which quickly restores the health of a stricken system; his periodical inspections and tests which keep the system healthy. These functions have long since been recognized as essential to guard the life blood of the theater. Service is a vital part of the motion picture industry. But this is not history and our interests are presently centered on the contributions of the service inspector to the twenty-year development of sound quality.

Projectionist Schools (1930 and 1931).—It was, of course, perfectly obvious that the success of the sound show was and will always be in the hands of the projectionist. But he had much to learn during the time that the installation was being made and the one-or two-week instruction period that followed installation.

Projectionists wanted to learn more about the fundamentals of sound recording and reproduction. To meet this demand in 1930 and 1931 one man uniquely qualified was assigned to the full-time job of conducting classes for the projectionists. These classes were held twice a day every day for about a month in space provided by the union locals in a considerable number of the larger cities where a sufficient number of projectionists could be brought together. The genuine desire of projectionists to master the new job of sound projection was attested by the consistently good attendance at these classes.

Calibrated Test Film and Transmission Test.—It was inevitable that the inspectors scattered throughout the country tended more and more to become individualists. Several hundred pairs of ears did not interpret sound quality in the same manner. The TI group was an equalizing influence to some extent but with the termination of that organization the need was felt acutely for means of ensuring that each equipment was maintained to the same standard. The solution was the calibrated multifrequency test film and the transmission test.

For several years technical inspectors and a few service inspectors had been using copies of a test film known as *XX22*. Readings were taken from this film, curves plotted, heads were scratched, but the inevitable question—"So what?"—remained unanswered. Means of interpreting the readings and standards of performance were required.

Even at this early day a considerable variety of systems was found in booths. But most of them were made up from a much smaller variety of components. The method was therefore adopted of determining standards of performance or "normals", as they are called, for the various amplifiers, optical systems, *etc.*, and thus equipping the inspector to determine the over-all or total normal for any particular system from such component normals. Thus was born the well-known Transmission Test. By this powerful tool an inspector could determine whether any sound system was performing in the manner normal for that particular equipment. The test at once proved so effective in revealing substandard performance and leading to correction of long-standing troubles that it became clear that it must be placed in the hands of all inspectors in this country and in the organizations in foreign countries that enjoyed the benefits of service development here.

Suitable compact meters were developed with the aid of the foremost meter manufacturer. The provision of calibrated multifrequency test films still presented a major problem. Repeated efforts failed to produce uniformly satisfactory prints from a negative—satisfactory, that is for testing purposes. The recording experts suggested the "toe recording" method which obviates the printing process entirely, every foot of test film being recorded directly in the recording machine. R. O. Strock, then of Eastern Service Studios, worked out the practical details of large-scale production of test films by this process, and the result was an expensive but high-

quality product that fully met our requirements. Through succeeding years, Mr. Strock recorded well over a million feet of test film for us.

Each of the test films had to be individually calibrated against standards originally provided by the Bell Telephone Laboratories. Later, our own method of calibration known as the "inverse-speed" method was developed; and this method is still our standard means of calibration.

With complete test equipment in the hands of all inspectors, the transmission test became a standard part of sound service. The test was somewhat enlarged and today this test includes measurements of frequency response, system gain, amplifier gain, required net gain for full house operation, system overload point, amplifier impedance, speaker impedance, and system noise. Limits of departure from normal for most of these tests are provided for most equipment. At regular intervals, each inspector applies all of these tests to each system which he services. His detailed report is studied by his supervisor to ensure that irregularities of importance are corrected. By this means, all theaters which receive this kind of service are assured that the correct standard of performance is maintained.

Historically, the introduction of the Transmission Test on a universal basis eliminated much of the individualism in service and provided organization-wide standard performance.

Noiseless Recording (1931).—The problems faced by the producing organizations with the advent of sound and how the methods of production were revolutionized to solve them is an intriguing story that cannot be told here. Suffice it to say, however, that these problems were presently solved. Attention was then directed to means of improving the quality of recording. One of the defects of early film recording was the high level of noise present on the sound track. This film noise was not objectionable during loud passages, but during low-level intervals the noise was all too evident. It was found that darkening the track during the low-level sections greatly reduced background noise without interfering with the recording itself. This technique, still called "noise reduction", gave us what was publicized as "noiseless recording". The name was perhaps not an overstatement for 1930 to 1931 but recording engineers have striven valiantly in the succeeding fifteen years to produce true noiseless recording and are still hard at it. However, the improvement was dramatic.

Reduction of recorded noise, however, revealed the many noises produced by the reproducing system, noises which for the most part were not objectionable with the earlier recording. The first picture produced with noise reduction, "The Right to Love", with Ruth Chatterton, was widely publicized as having noiseless recording. The tremendous job fell upon the service forces to quiet reproducing systems during the first run period of this picture so that the publicized marvels of the new recording might be brought to the ears of the theater patrons. Late in 1930 and early in 1931 a "flying squadron" was formed from men brought in from all over the country and given a thorough training in a quickly improvised technique of making systems quiet—eliminating clicks, microphonics, hisses, hums, *etc.* These men then scattered over the land and applied the new techniques to all equipments serviced by them. The expenditure for the training and the intensive field campaign was close to \$100,000. Some of the stunts devised under pressure bordered on the fanciful, including hanging lead weights on vacuum tubes to reduce microphonics; but they served their immediate purpose and the improvement in recording was well received. Soundly engineered improvements, such as low microphonic tubes, soon replaced the haywire and the systems were left with the improvements in permanent and substantial form.

We emphasize the part performed by the entire service organization in making this historical advancement in recording effective in theaters. It illustrates nicely the functioning of the entire team, the liaison with the producer organizations, the part played by the headquarters engineering department and the broadcast action of the field forces.

Wide-Range and High Fidelity (1934).—Further developments in recording resulted in extending the recorded frequency range. Simultaneously, the equipment manufacturers developed systems which were capable of delivering the increased range to the listening public. This two-front development resulted in the introduction of wide-range and high-fidelity equipment and later the Mirrophonic systems, bringing with them new problems. Again the necessity arose of providing additional training of the service personnel in the intricacies of horn placement, draping, phasing, equalization, control of back-stage effects, and many other details required by this new horn system. Again, men were brought in from all districts and put through an intensive instruction course. In addition, trained

specialists from headquarters traveled extensively throughout the field to assist in those cases where exceptional conditions were introduced by troublesome acoustical situations.

Flutter Measurement (1936).—Very important among the causes of poor quality in sound reproduction in the early sound systems was flutter. Flutter is a frequency modulation or warbling of the reproduced sound caused by nonuniform velocity of the film past the light beam. Flutter was present, often to serious extent, in all film drives. The logical first step in correction of such a condition is to measure it. Designers of new equipment had laboratory-type flutter measuring systems but none of these was suitable for use by the service inspectors. The need for a small portable instrument became acute and in 1936 the *TA-7421* Flutter Bridge was developed. This instrument was small, light in weight, simple to operate and economical of cost. A large number of these instruments are still in use in this country and many foreign countries. Similar equipment was later adopted by other service organizations.

Equalization of One-Way Systems.—The Wide-Range, Microphonic and high-fidelity systems introduced a new standard of sound quality in those theaters which were able to purchase this relatively expensive equipment. Thousands of theaters, however, had equipment of sturdy design which was still performing reliably and would evidently continue to perform reliably for some years, and a great many exhibitors did not consider themselves able to afford replacing their equipment at that time. The Altec service organization considered it a duty to improve the quality of performance of such equipments in so far as possible within the limited financial means available to those exhibitors.

The equipment installed in a large percentage of such theaters were the early Western Electric systems which had large horns equipped with *555W* receivers. It was found that this loudspeaker equipment was deficient in reproducing the lowest frequencies and the highest frequencies, but that suitable equalization introduced in the amplifier circuits could in large measure compensate for these deficiencies. It remained to determine what equalization curve or curves would be required to do the best possible job.

To facilitate the determination of the best equalizer characteristics in a considerable variety of theaters, a special equalizer of extreme versatility was developed which could be controlled from the listening position in an auditorium. This apparatus, described

before the Atlantic Coast Section of this Society in 1939, consisted of a portable amplifier which was set up in the booth and an equalizer unit which was placed at any selected listening position in the auditorium with long cables interconnecting the two units. The equalizer system was arranged for insertion into any existing type of sound system and consisted of a number of mutually independent sections each controlling a portion of the spectrum and each adjustable in calibrated steps over a considerable range of response changes. In practice, an engineer seated himself before the equalizer unit and, while a suitable diversity of program material was reproduced, manipulated the various equalizer sections until the resulting quality was considered the best obtainable. The resulting response curve was then measured. Theaters were selected for the tests to provide a full variety of acoustical conditions and auditorium shape.

These curves revealed that a relatively small degree of variation from a more or less universal curve would accommodate nearly all theaters but that a few required more significant departures from the average. The universal curve included a large rise at the lower end of the spectrum to re-enforce the base response and a larger rise to about 5000 cycles to provide good presence and a suitable reproduction of sibilance. Without separate low-frequency speakers, the lowest base frequencies could not be reproduced by this horn equipment regardless of the amount of equalization employed, but the cut-off of the horns was low enough for the equalization to provide a big improvement in the over-all base region. An inexpensive equalizer known as the *AQ-1030* Equalizer was designed for insertion in most types of theater amplifiers.

Improvement in the high-frequency response made more apparent than ever the flutter produced by the sound reproducer. Development of new sprockets provided a much better accommodation to the current normal film shrinkage than the sprockets originally included in the equipment, and reduction of cam action in the film drive sprocket made it possible to reduce the flutter in these older sound systems to values which were not evident to most casual listeners and were not distressing to the discriminating.

A further shortcoming of the earlier systems lay in the somewhat deficient power capacity of the final amplifier. This deficiency was aggravated by the equalization. In co-operation with one of the largest tube manufacturers, a new tube was developed which increased the power capacity of a very large number of amplifiers from

about $1\frac{1}{2}$ watts to about 8 watts. The new tube had characteristics somewhat similar to one of the later Western Electric tubes but being designed for this particular application, it had a special type of base and a special filament voltage. One of the features of the design was the much longer life and greater reliability than obtainable from commercial receiving tubes. These modifications were offered to those exhibitors who were not prepared to purchase new sound equipment, but care was exercised not to discourage exhibitors able to purchase new equipments from doing so. The program received the commendation of the Research Council of the Academy of Motion Pictures Arts and Sciences and it was highly successful in the field. The modifications were made in approximately 1500 theaters over a short period of time, and it is believed that this constituted one of the major improvements in the quality of motion picture sound presentation when the total number of theaters affected is taken into account.

Acoustic Measurements.—A broad study was inaugurated by the Academy Research Council to determine the variation in acoustic-response characteristics in a large number of theaters. Nondirectional microphones, tripods, cables and related gear were supplied the field organization to operate in conjunction with the emergency amplifiers and output meters carried by all service inspectors. The signal source for measurements of this type was a warble film. Some misgivings were felt in connection with the make-up of warble films currently in use, and a theoretical study was made of this subject which was presented before this Society. The standard Academy warble film followed the principles set forth in this study.

It was felt that a proper interpretation of acoustic response measurement required knowledge of the reverberation time characteristic of the auditorium in which the measurements were made. Existing reverberation measurement equipment was very cumbersome, expensive, slow, and time-consuming, and required very expert analysis for evaluation of reverberation time. Our service organization, therefore, developed a compact, inexpensive, easily operated, and easily interpreted instrument for this measurement. For the instrument to be practicable for use by field forces in theaters on any significant scale, it required the foregoing characteristics; and in addition it had to be capable of yielding the desired data with a minimum expenditure of time during off-show hours. The resulting instrument as distributed in the field had these

qualities, and the degree to which it minimized the time consumed is best revealed by an actual demonstration.

Postwar Speaker Systems (1945).—New theater speaker systems, of which we have installed many in the past twelve months, ushered in the postwar era in advancement of theater sound quality. For service, this major improvement in speakers brought a new challenge to raise the standards of performance of the rest of the system. Hums previously inaudible were now disturbing because of the extended low-frequency range of the new speakers. The improved presence necessitated closer attention to balance between machines, and the better over-all characteristic of the speakers made worthwhile the most careful selection of the best system response characteristic for the individual house.

Maintenance of Quality.—This discussion has traced the evolution of quality in reproduction of sound motion pictures and the part service played in making these improvements effective in the theater. It has been an evolution largely by sudden changes. The recording industry has done its best to preserve improvements once introduced. It is the responsibility of the service organization to preserve the improvements that have been made in sound presentation. If we may paraphrase a famous quotation, eternal vigilance is the cost of continued good sound quality. Whether the sound equipment is of early vintage or one of the most recent, high standards of quality will not be maintained unless intelligent periodic attention is given to the many sources of degradation of quality or introduction of foreign noises. Even such basic factors as continuity of operation and keeping emergency situations to a minimum requires that all parts of the sound system be examined dutifully and deteriorated parts replaced or readjusted as required. A characteristic of deterioration of sound quality caused by lack of proper service is the gradual manner in which deterioration occurs. Little by little, performance drops and the change may be so gradual as to pass unnoticed by the theater manager; yet the net effect be very serious. An effort will be made to demonstrate that gradual deterioration can creep in unnoticed because the change occurs in small amounts.

Service During the War Years.—World War II presented us with reduced manpower, priorities, curtailed production, gasoline rationing, and the many other regulations. While we do not think our wartime problems were any more severe than those of other

organizations, we do know that in spite of these many handicaps we kept the theaters running.

To many a well-meaning Government agency, the motion picture theater was just another unnecessary form of amusement in the same class with the juke box and pinball machine. Much can be said for the ingenuity of the individual service engineers during these early days of restrictions. All sorts of haywire arrangements were used to keep the shows running.

As various Government agencies were formed and regulations issued, our representatives were sent to Washington to interview the headquarters of these agencies in order to correlate and interpret the regulations with regard to the theater industry. They were given a rather cool reception.

Meanwhile, other Government bureaus were busy turning out propaganda films cautioning the public regarding the conservation of materials; dramatizing the activities of the FBI; exploiting the sale of war bonds and action pictures of our fighting forces. The conflict between the divergent views in Washington was finally resolved by President Roosevelt, who, in a public statement, recognized the necessity of keeping the motion picture theaters operative to maintain the morale of the public and to present to them the various propaganda films.

This clearly necessitated servicing and maintaining the sound equipment. Altec representatives again made trips to headquarters in Washington and were now more cordially received. It was realized that they represented an established organization serving over 6000 theaters, more than one-third of the theaters in the country, and knowing exactly their sound parts requirements. The advantage of dealing with a single agency instead of 6000 individual theaters was apparent, and we became the focal point and the clearing house for the sound equipment needs of the theaters.

As a result of our efforts, and those of representatives of certain major chains, a blanket priority classification *AA2* was issued covering all repairs and replacement of equipment for theater sound systems. Even with such a high priority, a real problem remained of getting manufacturers and suppliers to furnish the equipment necessary to keep the theaters running. Our ability to purchase in volume, our distribution facilities, and close contact with all phases of the situation solved this problem economically and effectively. Then, too, the equipment in closed theaters and the spare parts

carried in each theater became a vast stock pile available through the service organization to all theaters. Basements and garages of service inspectors proved gold mines of now-prized parts which were once considered junk. Frequently, when we found the stock bin empty and desperate need arising, distress signals were broadcast to the inspectors and 250 men flushed the needed parts out of dusty corners, second-hand stores, and even pawn shops.

Many unusual means were adopted for getting the last useful hour of operation out of each and every part of the sound systems. Testing and repair procedures were set up for vacuum tubes to conserve these parts so vital to the armed forces. Many electrical and mechanical parts which had formerly been discarded when they became defective were returned to our repair shop for rehabilitation. To conserve copper, we devised a unique method of repairing bellows assemblies, since each contains 14 ounces of strategic copper and there were several thousands used in theaters. While on the subject of copper, it can be mentioned that our field engineers served as the collection agency for copper drippings from arc-lamp carbons, and many pounds of this vital material were collected and turned over to salvage depots.

One of our most difficult problems was that of getting sufficient gasoline for the field engineers to provide rapid transportation to theaters in case of emergency. The frequently changing regulations and their nonuniform interpretation by the local rationing boards made it difficult, and in some cases, impossible for these men to secure gasoline. Here, again, through correspondence, telephone calls, and trips to Washington, we finally succeeded in having a special regulation issued covering this situation.

Space is not available for further details of the battle to keep the thousands of theaters operating through these troubled days, but we are proud to report that there was not a single instance of a theater serviced by us which shut down because of nonavailability of replacement equipment.

Future Service and Future Developments.—Now, in closing, let us try to see what the crystal ball shows. The most reliable crystal ball in this case is a mirror which shows the future as an extension of the past. The pattern will not change radically, and step-by-step improvements will continue to reach the motion picture theater. These improvements will result in greater complexity in the technical sense than those of the past and they will be brought speedily

into the theater by the service organization. The training of service inspectors will be as important as it has been in the past to provide them with the necessary knowledge to adapt the improvements to the individual theater and new tools and test equipment will be required to ensure that all theaters are operating at their peak of performance.

What will be the nature of the new developments? A specific answer to this is not available to us, but we know that a great deal of competent engineering attention is being given to such things as control track, automatic volume control, stereophonic sight and sound, television, panoramic or wide angle sound origin, extended range, and new color film which will require modification of reproducing equipment. Means of standardizing auditorium loudness—to ensure that each picture is reproduced at the volume intended by the recording director—must be developed to ensure the greatest listening comfort and to bring out the full quality recorded in the picture. Until the details of any of these developments crystallize, we cannot foretell today precisely the action that they will require on the part of our service organization. However, it is likely that improvements will come more or less abruptly and that large-scale efforts on our part will be required to ensure that no theater will be scooped by its competitor. History tells us that voluminous technical information must be prepared and distributed to the field men and that new standards of performance will be established for uniform maintenance to preserve the advancement.

The following steps will illustrate the manner in which a complete service organization proceeds as new developments are brought to the point where they are ready for the theater:

- (a) Close liaison with and participation in the activities in Hollywood and those of the equipment manufacturers allow us to anticipate and prepare for the development.
- (b) A competent headquarters engineering staff appraises the approaching development in relation to the individual problems presented by all the numerous specific types of sound reproducing equipment, and prepares the required technical information for the field, adaptation details where required, and the necessary tools and test methods.
- (c) The field organization copes with the actual application of the innovation in each particular theater.

- (d) Following the exciting period during which the innovation is introduced, the service inspectors guard the equipment performance to ensure that the new standard of quality is maintained and all new components are watched on a nation-wide basis to correct at the earliest possible time frailties which may develop in the first few cases during operation.

It is obvious that the individual or small local service group cannot possibly render the complete and comprehensive service that is required by the exhibitor. Contact with the producer and equipment suppliers must be completely lacking; a competent and informed engineering department cannot provide the essential firm foundation for their activities, or provide them with up-to-the-minute information, instructions, tools, and techniques; equipment troubles must be experienced in a large percentage of the theaters involved before remedial measures can be developed; service improvements in reliability of apparatus and quality standards will generally be lacking entirely.

With the protection accorded him by our complete organization, the exhibitor may welcome approaching evolution with confidence and without apprehension. Thousands of exhibitors, the backbone of the industry, will continue to attest to the necessity to them of such a complete organization.

SMPE HONOR ROLL AWARDS

Ed. Note.—By action of the Board of Governors, Oct. 4, 1931, an Honor Roll was established to perpetuate the names of distinguished pioneers who are now deceased. It is published monthly on the inside back cover of the JOURNAL of the Society and now contains seventeen names. In 1946 three outstanding early workers in motion picture sound were approved by the general membership to be added to the Honor Roll, and the high lights of their activities in this field are published below.

THEODORE W. CASE

Theodore Willard Case, American scientist, was born in Auburn, N. Y., Dec. 12, 1888, and died May 13, 1944. Son of Willard Erastus Case and of Eva Fidelia (Caldwell), Mr. Case received his preparatory education at Cloyne House School, Newport, R. I., and at St. Paul's School, Concord, N. H. He then entered Yale University, where he was graduated with the degree of B.A. in 1912. He received an honorary Sc.M. from George Washington University and was a member of the American Association for the Advancement of Science, the American Electrochemical Society, American Museum of Natural History, American Physical Society, New York Electrical Society, Optical Society of America, and the Royal Society of Arts, London, England.

Mr. Case was married at Auburn, New York, Nov. 26, 1918, to Alice Gertrude Eldred, daughter of George Field Eldred, a merchant of that city. They had four children.

Mr. Case began experimenting on sound recording while a student at Yale. In 1914 he started a research laboratory at Auburn, N. Y., and began intensive studies to find the substances sensitive to light.

Probably the most important outcome of this early research was the Thalofide Cell (a light-sensitive change of resistance material similar to selenium but a form of thallium sulfide particularly sensitive to infrared radiation). This was used by the Navy as the receiving element in an infrared signal and communications system developed for them during World War I. During this war the Case Laboratory, working in conjunction with the Naval Experimental Station at New London, Conn., was entirely devoted to war work

and carried on extensive research in the transmission and amplification of speech and signals in connection with its infrared system.

After the war, Mr. Case discovered the barium photoelectric cell and began its development. In its final form it was used in a recorder of daylight and sunlight.

In 1922 he constructed a crude sound camera and made a sound picture using a modulated oxyacetylene flame. This was the same manometric flame that had previously been developed for use in infrared telephony.

Shortly thereafter Case found that the gas discharge in an argon filled oxide-coated vacuum tube, formerly used in his infrared signal system, could be easily modulated at a low voltage and that it seemed suitable for sound recording purposes. This led to the development of the Aeo light and was a big step in making this system of sound recording practical. The Aeo light operated on direct current at 200 to 400 v and was highly actinic.

From this point on, the Movietone system of sound recording was developed and perfected step by step under his sponsorship. Included in this development was the Physical Slit using a cover-glass of quartz with the portion over the recording aperture less than 0.001 in. thick. This solved the problem of recording with a flashing lamp without having the slit fill with dust and dirt and was one of the fundamental steps in making the Movietone system practical.

A projection attachment was designed to fit below the standard Simplex head. The first model is still in existence, and is practically identical in design with some of the latest type theater units. Every step in recording and reproducing sound was carefully studied and developed at the Case Laboratories to the end that in 1926 the Movietone system of sound recording was sold to William Fox, substantially complete in every detail.

A glimpse of Mr. Case's activities may be gained through a list of some of his scientific papers, published articles and patents as follows:

"Preliminary Notes on a New Way of Converting Light into Electrical Energy", read before the New York Electrical Society, June 14, 1916.

"Notes on the Change of Resistance of Certain Substances in Light", *Physical Review*, April 1917.

"A Cuprous Oxide Photo-Chemical Cell", presented at the meeting of the American Electrochemical Society, May 2, 1917.

"Thalofide Cell, a New Photo-electric Substance", *Physical Review*, April 1920.

"A Photo-Electric Effect in Audion Bulbs of the Oxide-Coated Filament Type", presented at a meeting of the American Electrochemical Society, Apr. 21, 1921.

"The Effect of a Photo-Electric Material on the Thermo-Electric Current in High Vacuum Audion Bulbs", *Journal of the Optical Society*, August 1922.

"A Photo-Electric Effect in Audion Bulbs of the Oxide Coated Filament Type", presented at a meeting of the American Electrochemical Society, Apr. 21, 1921.

"The Effect of a Photo-Electric Material on the Thermo-Electric Current in High Vacuum Audion Bulbs", *Journal of the Optical Society*, August 1922.

"Infra-Red Telegraphy and Telephony", *Journal of the Optical Society*, June 1922.

"New Advances Made in Talking Movies", *Yale Scientific Magazine*, May 1927.

"Thalofide Cell", *Bulletin*, No. 4, 1921, Case Research Laboratory, Inc.

"Barium High Vacuum Photo-Electric Cell", *Bulletin*, No. 6, Mar. 6, 1928.

(The last two papers were also read before the Physical and Optical Societies Joint Discussion in England, June 4, 1930.)

UNITED STATES PATENTS ISSUED TO THEODORE CASE.

	Issued
1,398,457 Variable Resistance	Mar. 25, 1919
1,298,627 Variable Resistance	Mar. 25, 1919
1,301,227 Variable Resistance	Apr. 22, 1919
1,309,181 Variable Resistance	July 8, 1919
1,316,220 New Compound Showing Variable Resistance Under the Influence of Light	Sept. 16, 1919
1,316,350 Light Reactive Resistance and Method of Forming Same	Sept. 16, 1919
1,318,196 Electrical Device	Oct. 7, 1919
1,342,842 Resistance Element	June 8, 1920
1,369,781 Signaling System	Mar. 1, 1921
1,376,604 Process of Producing Photo-Electric Cells	May 3, 1921
1,376,605 Photo-Electric Cell	May 3, 1921
1,376,606 Photo-Electric Cell	May 3, 1921
1,379,166 Radiant Energy Signaling System	May 24, 1921
1,379,167 Wireless Receiver	May 24, 1921
1,390,883 Radiant Energy (Detecting and Trans. Device)	Sept. 13, 1921
1,406,149 Electrical Device	Feb. 7, 1922
1,412,385 Signaling System	Apr. 11, 1922
1,455,074 Apparatus for Recording Light	May 15, 1923
1,517,103 Photo-Electric Cells	Nov. 24, 1925
1,557,979 Apparatus for Determining and Measuring X-Ray Active Grid	Oct. 20, 1925
1,584,728 Methods of Manufacturing Mirrors	May 18, 1926
1,588,168 Microphone	June 8, 1926
1,588,169 Microphone	June 8, 1926
1,588,170 Method and Apparatus for Translating Sound Wave Variations	June 8, 1926
1,593,690 Phonograph	July 27, 1926
1,605,526 Transparent Covering for Slots	Nov. 2, 1926
1,605,527 Reproducing Apparatus	Nov. 2, 1926

1,605,528	Slot Unit	Nov. 2, 1926
1,605,529	Slot Unit	Nov. 2, 1926
1,605,530	Method of Producing Slot Units	Nov. 2, 1926
1,605,531	Slot Unit	Nov. 2, 1926
1,624,314	Electrical Apparatus	Apr. 12, 1927
1,625,409	Light Reactive Apparatus	Apr. 19, 1927
1,628,822	Photo-Electric Device	May 17, 1927
1,631,085	Electrical Apparatus	May 31, 1927
1,638,392	Talking Moving Picture Machine	Aug. 9, 1927
1,638,393	Talking Picture Machine	Aug. 9, 1927
1,638,472	Translating Device	Aug. 9, 1927
1,647,502	Electrical Apparatus	Nov. 1, 1927
1,647,503	Reproducing Amplifier	Nov. 1, 1927
1,647,504	Sound Producing Apparatus	Nov. 1, 1927
Reissue:		
16,910	Talking Picture Machine	Mar. 20, 1928
1,718,999	Method and Apparatus for Translating or Transmitting Sound Waves	July 2, 1929
1,724,872	Photo-Active Thermo-Elec. Devices	Aug. 13, 1929
1,747,225	Apparatus for Producing Photographic Records of Light Variations Corresponding to Sound Variations	Feb. 18, 1930
1,747,287	Source of Light	Feb. 18, 1930
1,749,412	Talking Picture Apparatus	Mar. 4, 1930
1,753,022	Camera	Apr. 1, 1930
1,759,434	Apparatus for Producing Photographic Records	May 20, 1930
1,774,253	Reproducing Slit	Aug. 26, 1930
1,781,945	Talking Picture Machine	Nov. 18, 1930
1,785,070	Inductive Light Source	Dec. 16, 1930
1,788,355	Source of Light	Jan. 6, 1931
1,790,898	Method and Apparatus for Transmitting Motion Pictures	Feb. 3, 1931
1,803,278	High Frequency Control of a Kerr Cell	Apr. 28, 1931
1,816,825	Aeo Light	Aug. 4, 1931
1,822,865	Method and Apparatus for Producing Photographic Records	Sept. 8, 1931
1,861,738	Cell Capable of Showing the Kerr Effect	June 7, 1932
1,865,055	Photographic Apparatus	June 28, 1932
1,872,404	Camera Shutter	Aug. 16, 1932
1,872,675	Cell and Method of Making the Same	Aug. 23, 1932
1,896,682	Method of Eliminating Noises in Spliced Film	Feb. 7, 1933

Similar patents in leading foreign countries were also granted.

EDWARD B. CRAFT

In 1925 the talking picture was presented to the motion picture industry as a practical reality. The technological development

which made this possible was due largely to the personal leadership of one man—Edward Beech Craft.

Up to that time there had been numerous attempts to make pictures talk, but none had produced more than a scientific novelty. None had displayed the quality of sound reproduction, the volume of sound, in short, the realism needed for commercial success.

Mr. Craft had become interested in this problem several years earlier. He had been directing, in the laboratories of the Bell System, a program of development which had produced the public address system, radio broadcasting, and the electrical recording which was to bring about the revival of the phonograph industry. These were products of research in telephone communication, and one of Craft's outstanding qualities was the urge, and with it the ability, to guide the products of research as rapidly as possible into practical channels.

The development of sound pictures went hand-in-hand with that of electrical phonograph recording. As a matter of fact, before the phonograph industry had become interested, Craft gave the first showing of a motion picture with the new sound system outside the laboratories. This was when he demonstrated, at Woolsey Hall, New Haven, on Oct. 27, 1922, a film describing the three-element vacuum tube, the action being explained by a lecture delivered from electrically recorded disks.

In spite of the fact that during the time when these developments were going on he was, as chief engineer of the Western Electric Company, responsible for the company's entire program of research and development, he found time to give his close personal attention to the work, suggesting many of the steps and making many of the decisions. An indication of the amount of research carried on in the laboratories under Craft's direction in the field of sound pictures is the fact that, up to the time of the release of "Don Juan" in the Warner Theater on Aug. 6, 1926, several hundred patent applications had already been filed for the laboratory engineers covering disk and film recording and reproducing methods, loudspeaking apparatus, microphones, synchronizing, and regulating systems, light valves, and photoelectric cells.

Had it not been for Craft's will power and faith the application of these developments to talking pictures might have been postponed for a long time. Fortunately, however, he possessed the imagination and enthusiasm to follow through to a successful conclusion,

and he had in addition a personal influence that inspired those who worked with him to carry on even when the going was far from smooth.

At one stage, in order to carry on the work on electrical recording when circumstances made it difficult to do so in what he considered an adequate manner in the Bell System Laboratories, Craft brought about the formation of the Phonic Laboratories, a company organized by a group of those people, few at that time, who believed in the commercial future of the development. Some of the experimental work which later resulted in the electrical recording system adopted by the phonograph industry was done in the Phonic Laboratories. This system formed the basis of the sound system used for talking pictures. It was due to Craft's untiring zeal that efforts of this sort were made and that sound pictures were demonstrated to the industry in 1925 in a sufficiently advanced state to capture the imagination of the Warner brothers and result in the formation by them of the Vitaphone Corporation in 1926.

The sketch of E. B. Craft's life which follows speaks eloquently of the character and ability which carried him so directly to the goal that he set for himself and enabled him to push to a triumphant conclusion what proved to be his last job.

He was born in Cortland, Ohio, on Sept. 12, 1881. He received common and high school education in the nearby town of Warren, where he started to work. From 1900 to 1902 he was superintendent of the Warren Electrical and Specialty Company, which position he gave up to join the Western Electric Company in Chicago because he felt that it was doing the kind of work he wanted.

He was soon put in charge of a group doing development work, and his first patent was for an indicating device for telephone fuses which has since remained constantly in use. With the consolidation of the development and research work in the Bell System in 1907, Craft and a nucleus of the force which he had formed in Chicago moved to New York City, where he became development engineer and later, in 1918, assistant chief engineer of the Western Electric Company.

During the first world war he served as a captain and later as a major in the Signal Corps, U. S. Army, and as a technical advisor, U. S. Navy in England. His interest in radio and other applications of research, and his insight into research problems, not only made his advice of value to the armed forces but later resulted in his being

put in charge of all Western Electric's research as well as development activities in 1922 as chief engineer. With the incorporation of Bell Telephone Laboratories at the end of 1924 he became its executive vice-president, and soon after a member of the Board of Directors.

Among his publications were a joint paper with E. H. Colpitts presented before the American Institute of Electrical Engineers in 1919, which described the early work in radio telephony in which he took part; a joint paper with L. F. Morehouse before the AIEE on dial switching, to which Craft made many individual contributions; and a paper on Airways Communications Service published in the *Bell System Technical Journal* in 1928.

In addition to his active duties in the Bell System, he was vice-chairman of the Division of Engineering and Industrial Research of the National Research Council, chairman of the Board of Engineering Societies Library, a Fellow of the AIEE, and one of its managers from 1920 to 1924, a Fellow of The Institute of Radio Engineers, a member of the Council of the American Institute of Weights and Measures, a member of the Society of Automotive Engineers, and representative of the Bell System in the Aeronautical Chamber of Commerce.

During the middle of 1928 an ailment of some years standing became acute, and from October of that year he was absent on sick leave. His health grew worse and death occurred on the twentieth of August 1929.

On receiving an honorary degree of Doctor of Engineering from Worcester Polytechnic Institute in 1926 he was cited as:

"Engineer, Inventor, and Organizer of Research; whose inventions take part daily in each of more than fifty million telephone conversations; whose genius, initial conception of panel systems for machine switching, and continued supervision of its development have contributed largely to the present system of telephony; whose technical experience devoted to the service of his country during the World War hastened advances in radio-communication with aircraft; whose organizing ability continuously applied for a quarter of a century to engineering development and industrial research has increased the social and economic significance of research."

SAMUEL L. WARNER

"Come on, Ma, listen to this." These six words spoken in the Warner Bros. picture, "The Jazz Singer", touched off public acceptance of talking pictures that was to revolutionize the motion

picture industry overnight. For Sam Warner, this was the climax to his efforts and the vindication of his faith in the future of talking pictures. Although he was never to share in the triumph which he had done so much to create, he will be remembered as the one man in the motion picture industry who had confidence and belief in the future of sound motion pictures.

To appreciate fully the vision and courage of Sam Warner, it is important to recognize that he set out to introduce talking pictures at the very moment when the art of the silent film was at its highest. Talking pictures were virtually experimental, while the industry was experiencing its greatest success and popularity, as it released bigger and more spectacular features to the public.

While other leaders in the industry were skeptical, or even hostile, Sam Warner was enthusiastic. He took the risks necessary to make talking pictures a reality; he contributed technical development by bridging the gap between laboratory performance and commercial and artistic practicability; he contributed showmanship by recognizing that the way to demonstrate the power of the talking picture was to film performances of the finest musical artists in the world.

Lee deForest, writing in the *JOURNAL* in January 1941, said: "Unquestionably, it was the absolutely unique prescience and courage of Sam Warner, and later his brothers, which finally resulted in arousing the motion picture industry to the belated realization that here at last science and invention had created a new instrumentality."

Sam Warner was born Aug. 10, 1888, in Youngstown, Ohio, and died Oct. 5, 1927. He had an early introduction to show business by carrying water backstage for the Youngstown Grand Opera House when he was ten years old. While working at the Opera House, he met an electrician who became a good friend of Sam's, and taught Sam the art of taking a projector apart and putting it together again. The machine, in those days, was operated by hand and used a calcium light.

Once he learned how to run a projector, he got a job as an experienced operator to run Hales Tours, at White City Park in Chicago. In the tonneau of an old-fashioned motor car, he ran pictures of "A Trip Through Yellowstone Park". The admission price was ten cents, and the show, which could accommodate fifteen people, ran for five or six minutes. This so intrigued Sam that he wanted a machine of his own. So he pawned his watch and borrowed enough money from his father to raise \$600 to buy a

projection machine and a set of slides from a woman who ran a boarding house for actors. Her son wanted to get rid of the outfit anyway and return to vaudeville; so he was willing to part with it.

That night, Sam borrowed the horse and wagon used by his father to deliver meat and groceries from the family market, loaded in the projector, and brought it to the house. There his first show was run for the family and neighbors on the lawn; and everyone was afraid that the gas lamp on the old Enterprise machine might explode and set the house on fire. Eventually, through easy stages, he got the people to see the show in the house.

Soon he rented a store in Niles, Ohio, and gave shows for the public, charging an admission of five cents. Sam ran the projector, his sister, Rose, took the tickets and then played the piano, and his brother, Jack, led the singing to the slides. Soon another brother, Abe, came on from Pittsburgh to manage the business and then Brother Harry joined the venture at Newcastle, Pa., to handle the finances. Pictures were rented from the Pittsburgh Calcium and Light Company, but competition was growing, so they began to buy films for themselves and also to rent to others. They called themselves the Duquesne Amusement and Supply Company. In 1912, they went to New York and began to make pictures for themselves at the old Vitagraph Studio in Brooklyn. A few years later they acquired space for a studio in Hollywood and made most of their features there, keeping the Brooklyn Studio for short subjects.

In 1925, Sam saw a demonstration of sound pictures at the Bell Telephone Laboratories, which was arranged for him by Major Nathan Levinson, of the Western Electric Company, who had helped him get a radio transmitter for the company. Sam was enthusiastic and began a campaign to sell the idea of sound pictures to his brothers. His brother Harry thought it might be well to use the sound as a musical accompaniment for pictures. But he knew only too well the magnitude and risks of the business enterprise they were undertaking. Sam understood fully the technical difficulties which had to be solved; but he had faith that they could be overcome. He was the most mechanically minded of the brothers and set out to do all he could to make a really commercial sound picture.

With the help of the Western Electric engineers, he made a series of experiments with sound pictures during the autumn and winter of 1925-'26. He had a crew of cameramen, soundmen, actors, writers, musicians, and studio technicians make simple sound

sequences at the Vitagraph Studio while his brothers continued to make silent pictures in Hollywood. He had Herman Heller, who conducted the orchestra at one of the Warner Theaters, bring the orchestra, a tenor and a pianist to the studio for test recordings. He worked day and night; and slept, ate, and lived sound pictures.

In April 1926, the Vitaphone Corporation was formed to develop and market talking pictures and talking picture apparatus. Sam was made vice-president of the company.

His experiments were interfering with the company's normal business of making silent films, and it soon became necessary to find a place other than the Vitagraph Studio to carry on further tests. The Manhattan Opera House in New York City was leased for this purpose, and sound recording apparatus was installed in the auditorium and on the stage.

Recordings were made with a number of great artists for Vitaphone Shorts, and the New York Philharmonic Orchestra was recorded with an especially prepared score for the feature, "Don Juan". With all its success, the heads of all other film companies, except one, decided against the production or exhibition of sound pictures. They were still not convinced that sound had come to stay.

Sam Warner started shifting his crew to the Hollywood Studios, where two new stages were built especially for sound pictures. He had learned a lot in two years of experimenting in Brooklyn and New York; and the new installation was the last word in equipment and acoustical engineering.

Sam and Jack began making "The Jazz Singer" early in 1927. This was to be a feature picture with singing sequences recorded by Vitaphone. These sequences were an innovation in feature pictures and a tremendous technical achievement. The six words of dialogue were ad libbed by Al Jolson at the beginning of a song and were so novel that it was decided to leave them in the picture. And on Oct. 6, 1927, that impromptu speech delighted and thrilled the first-night audience in New York City. Talking pictures were a hit.

But Sam Warner was not there to share in the triumph he had done so much to create. He had been working hard, all hours of the day and night, for the past two years. He did not feel well enough to go to New York for the premiere. A sinus operation developed into pneumonia and he died the day before the showing. The entire motion picture industry owes a debt to the courage and tenacity of Sam Warner.

INCREASED LIGHT FOR PROJECTION OF 16-MM FILM WITH CARBON ARCS*

R. J. ZAVESKY AND W. W. LOZIER**

Summary.—A new 6-mm experimental carbon is described which makes it possible to project $2\frac{1}{2}$ times as much light for 16-mm film as the present 6-mm "Pearlex" high-intensity carbons. A 7-mm "Suprex" carbon offers twice as much light as the "Pearlex" carbon and longer burning life than the 6-mm experimental carbon. Measurements of radiant energy intensity at the film aperture and spectral composition are given.

The greatly increased usage of 16-mm film for educational and entertainment purposes during the past few years has advanced this particular phase of motion picture projection to a much more significant place in the industry than ever before.

The use of the small-size 16-mm picture aperture brings with it technical problems which require special attention. One of these problems is the task of providing adequate light for projection of the picture on the screen. The projection of a given amount of light through a 16-mm film aperture requires approximately fourfold the concentration of radiant energy, compared with 35-mm film. Great concentration of light can come only from a source of high brightness. Fortunately, the 6-mm "Pearlex" high-intensity carbon arc is available^{1, 2} for this task and has proved a valuable tool in the projection of 16-mm film. Interest has been shown in still more powerful carbon arc sources. Therefore, attention will be directed in this paper toward new developments and possibilities in such sources which will make available much greater amounts of light for this service.

Present Carbon Arcs for Projection.—At present, the carbon trim used for 16-mm film projection consists of 6-mm \times 8 $\frac{1}{2}$ -in. "Pearlex" positive and 5.5-mm \times 6-in. "Pearlex" negative carbons,

* Presented Oct. 25, 1946, at the SMPE Convention in Hollywood.

** National Carbon Company, Fostoria, Ohio.

operated at 30 amp and 28 v at the arc. This trim, used in a projection system employing a $10\frac{1}{4}$ -in. diameter $f/1.6$ mirror and a 2-in. focus untreated $f/1.6$ projection lens provides a total of 2300 screen lumens with no shutter, film or filters. A previous paper² has shown that this amount of light is capable of illuminating screens of 75 per cent reflectivity of about 8-, 11.3-, and 16-ft width, respectively, to the maximum, optimum, and minimum brightness levels of 20, 10, and 5 ft-L recommended for 16-mm film³. The recommended optimum brightness of 10 ft L is identical with the preferred value for viewing 35-mm film as specified by ASA Standard Z-22.39-1944.

"Pearlex" carbons also are designed to furnish a continuous burning time of 60 min at the above current and voltage, and have the color of the light adjusted toward the quality deemed desirable for the projection of Kodachrome.

Experimental Systems.—Consideration has been given to carbon arc sources capable of properly illuminating screens considerably larger than presently possible in 16-mm projection.

Experimental work has led to the development of a new 6-mm positive carbon capable of operating at currents as high as 50 amp. A positive carbon of this type paired with a suitable 5.5-mm negative carbon and operated at 50 amp and 40 v, provides $2\frac{1}{2}$ times as many screen lumens as the present trim with identical $f/1.6$ optics. The significantly greater light output is attributable to a maximum crater brightness of 750 candles per sq mm compared with 350 candles per sq mm for the 30-amp "Pearlex" positive carbon.

In order to realize this great increase in light output, a positive carbon consumption of about 20 in. per hr is reached in comparison with 6 in. per hr for the present trim. An $8\frac{1}{2}$ -in. carbon thus has a life of only 15 to 20 min instead of 60 min.

Since this higher burning rate might limit the application of this trim, further work was conducted to relate light output and life at lower operating currents. In addition, the effect of using 7-mm rather than 6-mm positive carbons was investigated. "Suprex" positive carbons were considered for the 7-mm size.

Comparative screen light output and burning rates are shown in Fig. 1 for 6-mm "Pearlex", 6-mm experimental and 7-mm "Suprex" positive carbons at various currents. The screen lumen values were measured without shutter, film or filters using the $f/1.6$ optics previously described.

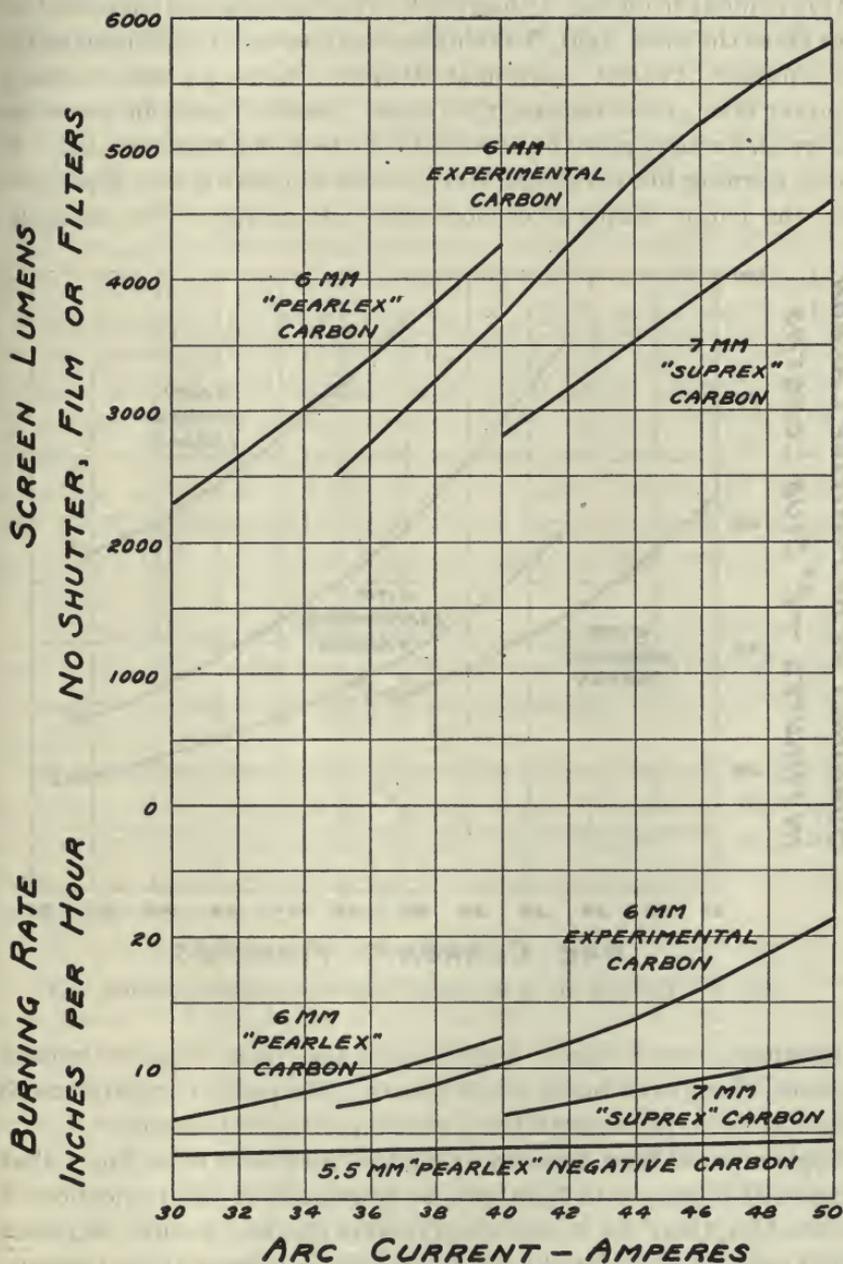


FIG. 1. Screen lumens and burning rates with carbon arc 16-mm film projection systems.

It is evident from Fig. 1 that the 6-mm experimental carbon at 50 amp gives the most light, 5800 lumens compared to 2300 lumens for the standard "Pearlex" carbon at 30 amp. In cases where economy of power is of great concern, the 6-mm "Pearlex" carbons are to be preferred, for they give the most light in the lower current range. If a long burning life is desired and increased power is not objectionable, the 7-mm "Suprex" carbon offers advantages. For example,

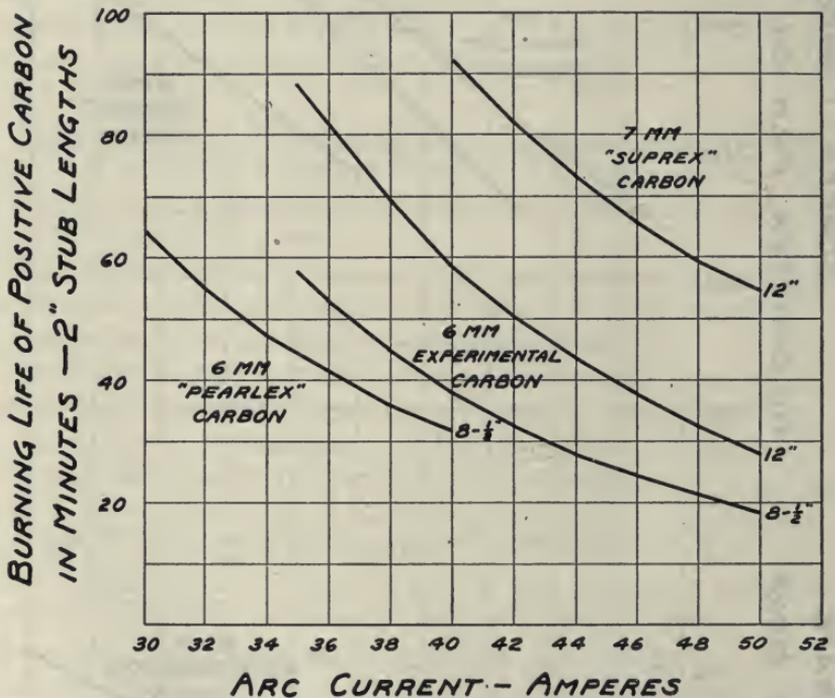


FIG. 2. Burning life of indicated lengths of positive carbons.

to produce a screen light of 4600 lumens, the 7-mm "Suprex" carbon requires 50 amp and burns at the rate of 11 in. per hr compared to 43 amp and 13 in. per hr with the 6-mm experimental carbon.

Application of New Sources.—While it is evident from Fig. 1 that significant increases in light can be provided for the projection of 16-mm film, there are a number of factors incident to such increases which must be considered prior to any application of these systems. Among these is the time of continuous burning required. Shall this be 60 min or shall it be 20 to 25 min, as is the practice for 35-mm film projection? Also, there are questions of the color quality of the

light needed for 16-mm film projection and of the effect on film of the radiant energy at the aperture. The proper combination of light increase, screen size, and desirable continuous burning time involves a multitude of factors which cannot be resolved here. However, the physical factors such as length and size of carbons, and required lamps and mirrors and lenses, *etc.* have a degree of flexibility which can be utilized to best advantage by the industry.

An example of some possibilities in respect to length of burning life is afforded by Fig. 2, where burning life of the positive carbons has been plotted against arc current. It will be noted that one hour life can be obtained with the 8¹/₂-in. length carbon only at the lower limits of the indicated current ranges. The 7-mm "Suprex" carbon, 12 in. long, will give one hour life and 4200 lumens when operated at 48 amp. This represents an 80 per cent increase in light and the same life compared with the 6-mm "Pearlex" carbon at 30 amp. The 6-mm experimental carbon, 12 in. long, operated at 50 amp. provides 2¹/₂ times as much light and about one-half hour instead of one hour life.

The 5800 lumens provided by the 6-mm experimental carbon at 50 amp is adequate to illuminate a 19-ft screen to the preferred 10 ft L value with a shutter having a 50 per cent transmission and without film or filters.

Measurements have been made of the radiant energy intensity at the center of the film aperture for the 6-mm "Pearlex" carbon at 30 amp and the 6-mm experimental and 7-mm "Suprex" carbons at 50 amp. The technique used was the same as described in previous papers⁴ published in the JOURNAL.

The data in Table 1 give the radiant intensity in watts per sq mm incident at the center of the film aperture for the systems listed and also show the breakdown of the energy in various spectral bands. The wavelengths 6300 A, 11,250 A, and 42,000 A are those appropriate to the filters used. In addition, the fraction of the total energy within the 4000 to 7000 A wavelength limits of the visible region has been calculated from combination with spectral energy distribution data in the visible. The maximum intensity of 1.45 watts per sq mm for the 6-mm experimental carbon at 50 amp is greater than the value of 1.05 watts per sq mm reported in a previous paper as a maximum encountered in 35-mm projection. This difference is caused mainly by the greater speed of the 16-mm optical system.

TABLE 1
Radiant Energy Intensity at Center of Film Aperture

Item	Carbons		Arc Amp	Lamp Optics	Watts per Sq. Mm	Measured Per Cent of Total		Calculated Per Cent of Total (4000- 7000A)		
	Positive	Negative				Below 6300 A	11,250- 42,000 A			
(1)	6-mm "Pearlex"	5.5-mm "Pearlex"	30	28	10 ¹ / ₄ -in. dia., f/1.6 mirror	0.90	27	35	38	33
(2)	6-mm Experimental	5.5-mm "Pearlex"	50	40	10 ¹ / ₄ -in. dia., f/1.6 mirror	1.45	37	32	31	45
(3)	7-mm "Suprex"	5.5-mm "Pearlex"	50	37	10 ¹ / ₄ -in. dia., f/1.6 mirror	1.10	39	33	28	48

The significance of the levels of radiant energy intensity listed for items (2) and (3) in Table 1 in terms of effect on 16-mm film have not been defined completely. There is some indication that the smaller frame size is better able to withstand the distortion from high-intensity radiant energy and that with certain precautions as described by Kolb, Robertson, and Talbot⁵, 16-mm film can be projected without heat damage with amounts of light discussed in this paper.

It will be noted also in Table 1 that the proportion of energy in various spectral bands is about the same for both 50-amp arcs (items (2) and (3)). In addition, each of these projects has a greater proportion of the total energy in the useful visible region and so gives less heat per unit of light than the present standard "Pearlex" carbon at 30 amp (item 1).

In addition to these differences in radiant energy, the 50-amp sources give a whiter light than the color modified "Pearlex" carbon, a color similar to that used for 35-mm film projection. Here again, the question of exactly what color quality of light will be required for 16-mm film projection remains unanswered. As exemplified by the color modified "Pearlex" carbon, the color of the light from the carbon arc can be modified to some extent. The indications are, however, that such modifications will result in a loss of light per unit heat and perhaps a loss in total light output, other conditions of operation being equal.

Although the specific trends and applications of 16-mm film projection for the future are not clearly evident, a demand for larger

screens and for more light seems certain. This paper has indicated that it is possible to extend 16-mm film projection to larger screens maintaining recommended light levels. Although such questions as continuous burning time, color quality of light, and effects of heat on film are still incompletely resolved, there is little doubt that the versatile industries in the 16-mm motion picture field can adopt carbon arc equipment to meet the requirements to come.

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RADAR SCOPE PHOTOGRAPHY*

RICHARD C. BABISH**

Summary.—The color and persistence of the image formed on the P-7 tube, commonly used on radar sets presenting a map-type picture, make it necessary to employ different films and techniques in making still and motion pictures. Satisfactory motion pictures have been made on reversible Super XX film exposed through a No. 106 Plexiglas filter in a 16-mm camera equipped with a specially designed $f/0.7$ lens.

Good still pictures can be obtained on fine-grain panchromatic or orthochromatic films at $f/3.5$ without the use of filters, although the use of a blue filter improves definition by minimizing "ghost" images not yet completely faded from previous scans.

An automatic camera permitting the operator to view the tube while pictures are being taken has been devised.

Introduction.—The Radiation Laboratory of Massachusetts Institute of Technology made a practice of producing a motion picture describing the features of each major new radar set it developed. One of the greatest problems in the making of these pictures was to produce a photographic record that reasonably approximated the map-type image on the cathode-ray tube as it appeared to a person whose eyes had adapted themselves to a low light level.

Appearance of Map-Type Images.—One of the most popular methods of presenting radar information in map-like form makes use of the PPI, or Plan Position Indicator, in which the image appears to be developed by a radial line rotating at a constant speed, usually at the rate of from 5 to 20 rpm. The PPI image is an almost distortion-free map of the area surrounding the radar antenna. Targets which return strong radar echoes, such as cities, appear as bright areas on the map. Land areas which do not return very strong echoes appear as dimmer areas. Rivers, lakes, and other water-covered areas which return very weak echoes appear as dark

* Presented Oct. 22, 1946, at the SMPE Convention in Hollywood.

** Vitarama Corporation, Huntington, N. Y.

areas on the tube. A typical PPI image as it momentarily appears to the operator appears in Fig. 1.

Because the speed of rotation is so low, radar indicator tubes are usually coated with the *P-7* cascade screen which retains the image for several seconds. At the end of this time the image is almost faded from the tube so that a new picture can be generated.

Characteristics of P-7 Screen Images.—The *P-7* screen is composed of two materials coated one over the other. The first coating is activated by the electron beam emitting blue light with extremely short persistence. The second coating is activated by the



FIG. 1. Instantaneous appearance of radar image.

blue light, re-emitting a yellow light of longer persistence. The brightness of the persistent image varies inversely with time.

The light from these two phosphors lies in fairly well-separated portions of the spectrum, as can be seen from the curves in Fig. 2. These curves were determined separately and for convenience the peaks for each phosphor have been normalized at 100. Actually the blue, nonpersistent light is relatively bright. Since it is seen only in the generating trace, and since it is annoying to the operator, the blue light is commonly filtered out with a No. 106 or No. 121 Plexiglas filter. Transmission curves for these filters are given in Fig. 3. The light from each phosphor transmitted by these filters is given in Fig. 4.

Brightness Range.—Since the strength of the echoes returned

from radar targets varies enormously, the brightness of spots representing these targets cannot be made proportional to the strength of the signals over the entire range. Usually, after a certain signal strength is reached all signals are represented by spots of the same brightness. Therefore, there are generally gradations of tone only for the weaker signals. To bring out gradations of tone, as in land areas, skillful adjustment of the radar controls is necessary.

The brightness of radar images is so low as to have negligible effect on the usual type of exposure meter. However, the brightness of the

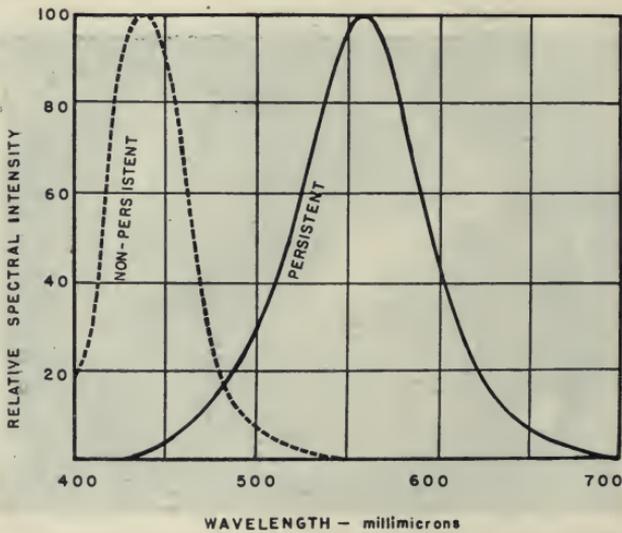


FIG. 2. Emission of *P-7* phosphor components. These curves were determined separately and the peaks were normalized at 100.

radar image is so low that it has always been necessary to operate the tube at maximum brightness in making motion pictures, even when the fastest lens and film combinations are used. Still pictures can be made with moderately fast lenses.

Spot Size.—Under the best conditions it is possible to resolve lines as close as 0.2 mm apart on the 5-in. tube used in airborne equipment. For a 7-in. tube the spot is about 20 per cent larger. Thus, under best conditions, a 5-in. tube will resolve about 600 elements along a diameter, while a 7-in. tube can resolve about 750 elements. In practice, this resolving power is seldom attained, nor is it necessary, since radar detail is often coarser than this.

Though the behavior of the *P-7* tube is much more complicated than this simplified description may imply, sufficient information has been given to permit a qualitative analysis of the photographic problems.

Still Photography.—The first problem encountered in radar photography was the making of single photographs for analysis or record. Instantaneous exposures were found impractical because parts of the image would have faded from the tube and would consequently not be recorded. The simple solution was to expose the

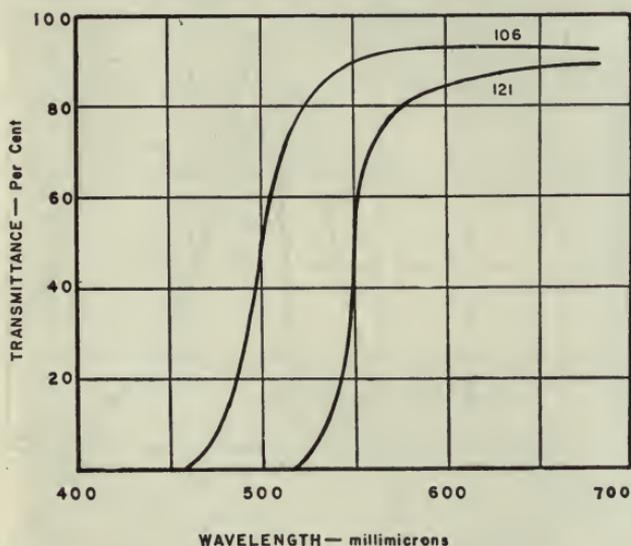


FIG. 3. Transmittance of Plexiglas Nos. 106 and 121 filters used for viewing *P-7* coated tubes.

film during the entire time required for the trace to go through one revolution. Since this time averaged several seconds, it was simple to do this with a bulb exposure. Much more uniformly exposed pictures resulted, as can be seen in Fig. 5. Later, electrical methods were used to synchronize the exposure to the antenna rotation.

Frame Size.—It is obviously desirable to use the smallest frame size that will adequately resolve the radar detail. The spot size of the cathode-ray tube is the limiting factor. Using the resolving power of the tube and the published resolving power data for several commonly used films, Table 1 has been computed showing the smallest frame size which will record radar detail:

TABLE 1

	<i>Minimum Picture Size</i>	
	5-In. Tube	7-In. Tube
Super XX	12 mm	15 mm
Plus X	11 mm	14 mm
Panatomic X	10 mm	12.5 mm

Satisfactory recordings can, therefore, be obtained on a 35-mm sound frame. Since these figures were based on an optimum spot

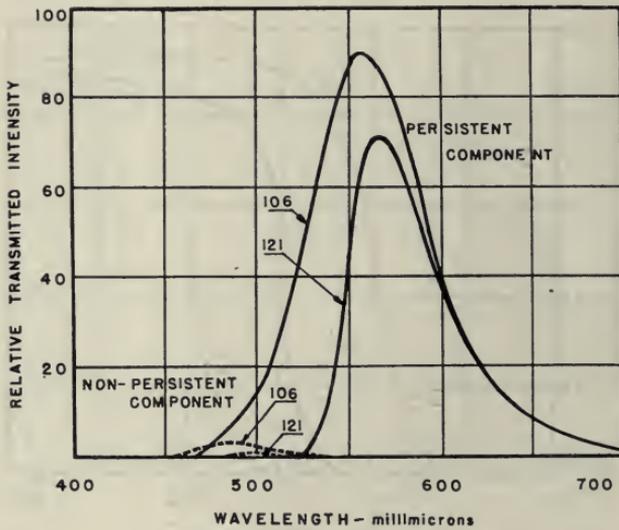


FIG. 4. Portions of *P-7* light components transmitted by Plexiglas filters Nos. 106 and 121.

size, satisfactory results for some applications are obtainable on 16-mm films if suitable emulsions and processing techniques are used. Practical tests have confirmed these conclusions.

Scopix Camera.—The earliest camera was devised simply to allow a radar operator to photograph the most interesting scope presentations either for record or for further analysis (Fig. 6). It was simply a fixed focus 35-mm candid camera mounted at one end of a tube. The tube excludes extraneous light during an exposure while holding the camera the proper distance from the tube face. In use, the open end is held or clamped to the tube face. A bulb exposure is then made, keeping the shutter open for one rotation of the sweep. At the Radiation Laboratory, a Kodak 35 camera body was generally

used with a prefocussed 2-in. Wollensak Velostigmat $f/3.5$ lens. Standard 36-exposure cartridges were used. In later models, a data chamber containing a data card, watch, and range setting was added.

O-5-A Radar Recording Camera.—In time, it became necessary to design a completely automatic camera which would continuously photograph the same scope the operator was viewing while causing him the least possible inconvenience. A camera meeting these requirements was designed and built by the Fairchild Camera

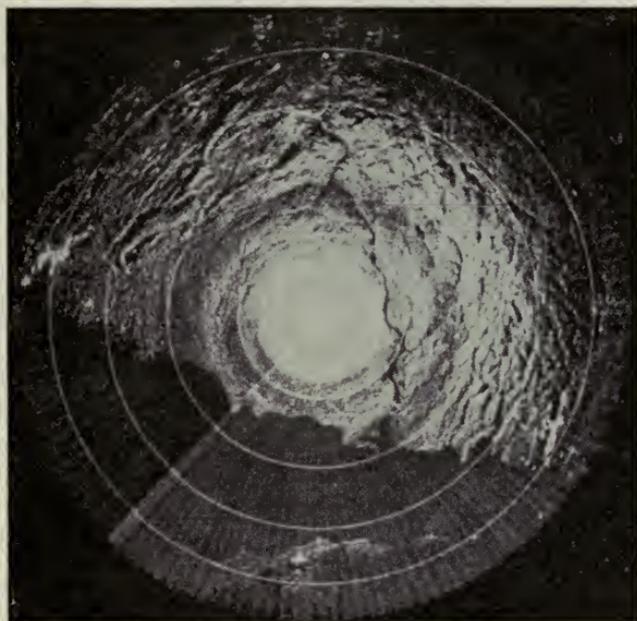


FIG. 5. Radar still picture showing Connecticut shore, Long Island Sound, and tip of Long Island.

and Instrument Company under an NDRC contract with the Radiation Laboratory (Fig. 7). This camera was designated the O-5-A by the Armed Services. It consists of a camera body, magazine, beam splitter, and control box. Adapters and junction boxes have been designed to fit the camera to various radar sets. It is compactly arranged, since the camera folds back over the radar indicator taking a minimum of the operator's space.

The camera action is synchronized to that of the radar set. Synchronization can be achieved by several forms of electrical signals which can be readily supplied by most radar systems. The radar

operator controls the camera through a small control box containing a power switch and a single selector switch controlling the interval at which pictures are made.

The camera records on a 35-mm sound frame the radar picture, a data card, counter, watch, range and code lights. The radar image is reflected 180 deg by two RCA beam splitters, a feature which allows the camera to be folded back compactly. The properties of this beam splitter are such that the photographic record is made mainly by

the blue nonpersistent component while the operator views the yellow persistent image. The camera uses a 35-mm $f/2.3$ Bausch & Lomb Baltar lens.

The magazine holds a 100-ft reel of 35-mm motion picture film. The film pull-down and the film supply and take-up functions are separated. During pull-down, the film loop alone is moved by a claw and pilot pin arrangement, allowing fast pull-down. After the pull-down, the take-up and feed reels are rotated allowing slower acceleration and deceleration for these heavier duties, resulting in smoother performance. No sprockets are used to move the film so that the film path is so simple



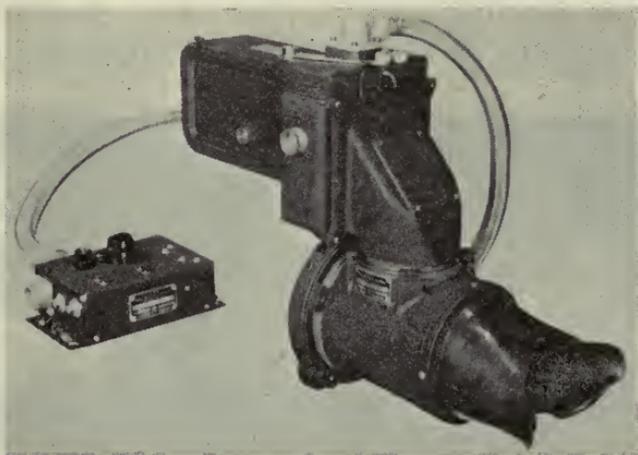
FIG. 6. Scopix camera.

that the magazine may be loaded in the dark if necessary. The magazine is clamped to the camera body by simple levers, allowing rapid and easy change, even by a gloved operator. A photograph of an *O-5-A* frame is shown in Fig. 8.

Film.—In the average case, the cameras used for still radar photography are equipped with lenses sufficiently fast so that film speed is not a determining factor in choosing a film. Cameras utilizing single-frame 35-mm or 16-mm film are in general restricted to the use of finer grain films. Where Leica frame (double-frame 35-mm) cameras are used, even resolving power of the film ceases to be a

limiting factor. Cameras of this type have yielded photographs on Super XX film showing all the detail presented on the 7-in. tubes of high resolving power radar sets.

It is generally impossible to state exactly what the lens diaphragm setting must be to obtain the best picture of the radar image, since many factors are involved. Some of these factors are the speed of



(Photograph courtesy Fairchild Camera and Instrument Co.)

FIG. 7. Fairchild 0-5-A radar recording camera.

rotation of the antenna, the maximum range appearing on the tube, and the brightness at which the individual operator prefers to operate the tube. Even the ambient illumination has an effect, since it will influence the operator in adjusting the image brightness.

TABLE 2

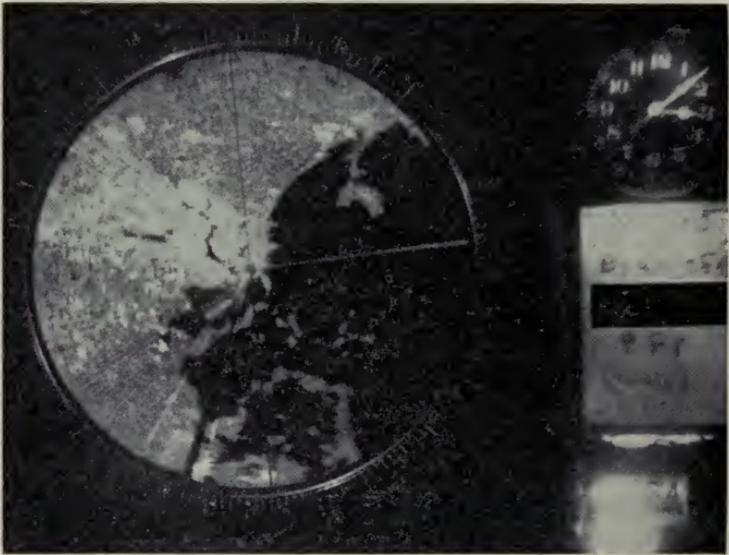
Exposure Table

(*Exposure in f/units for AN/APS-15 Scopes, 3-Sec Rotation*)

Film	No Filter	Plexiglas	
		No. 106 (Yellow)	No. 121 (Orange)
Super XX	5.6	2.8	2.3
Tri-X Aero	5.6	2.8	2.0
Tri-X Ortho	5.6	2.8	1.7
Agfa Fluorapid	5.6	3.3	1.5
Recording Neg. Ortho	5.6	2.8	2.3
Background X-Ortho	4.0	2.0	...
Fine-Grain Recording Neg.	4.0	1.7	...
Recording Positive	1.7

The exposures listed in Table 2 are, therefore, intended to show the relative sensitivities of the films when photographing the radar image directly or through the commonly used viewing filters. The tests from which these data were compiled were made with a 16-mm camera.

It is seen that the differences between panchromatic and orthochromatic films are not very pronounced when photographs are made either with no filter or through the yellow filter. The differences appear chiefly those that accompany grain size. Since either filter practically eliminates the blue, nonpersistent component of the light,



(Photograph courtesy Fairchild Camera and Instrument Co.)

FIG. 8. Frame photographed by 0-5-A camera.

it is seen that the yellow, nonpersistent image contributes only between one-quarter to one-third of the total exposure when photographing the bare tube.

Pictures taken with the slow recording positive film were unsatisfactory since the film had a clear base with no antihalation backing.

Blue Trace Photography.—The bulb exposure produces a negative which is formed by the combined action of the instantaneous blue light of the generating trace and the integrated yellow light of the persistent image. The latter contributes roughly from one-quarter to one-third of the total exposure. The fact that the

persistent image contributes so much photographically often proves undesirable, since images two or three sweeps old may be recorded, degrading the image or showing spurious signals. When the exposure is made through the viewing filter, only the persistent image is photographed and the effect is even more pronounced. Where this effect is undesirable, only the instantaneous blue trace should be photographed.

This can be done by using a tube coated with the blue phosphor alone. Though ideal photographically, it is seldom used because the tube cannot also be used for visual work. Films sensitive only to the blue light may be used, but these films are generally slow.

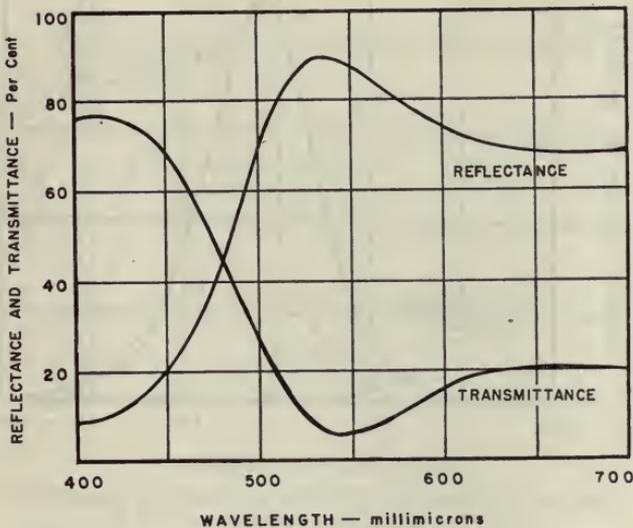


FIG. 9. Transmittance and reflectance of RCA beam-splitter used in *O-5-A* camera for light at 45 deg incidence.

The *P-7* tube can be photographed through a blue filter placed over the lens. Almost any of the Wratten blue filters are suitable since even the light blue filters cut down the persistent image to a reasonably low value. Most effective are the Wratten filters Nos. 34, 39, and 47, which require about two stops more exposure. Even better are the Corning glass filters Nos. 5030 and 5543 which also require almost two stops more exposure.

More interesting is a beam splitter produced by RCA which reflects a high percentage of blue light and a low percentage of yellow light. On the other hand, it transmits a high percentage of yellow

and a low percentage of blue. It can, therefore, be used to divide the light between two separate paths, one of which is more suited for photographic and the other for visual work. This beam splitter coating is used for both reflectors in the *O-5-A* camera. The increase in exposure required when this filtering method is used is less than two stops. Color curves are given in Figs. 9, 10, and 11.

Making the Exposure.—Of the several factors operating to cause variations in the brightness of radar images, the one most troublesome is the personal factor. It is generally best to have the operator

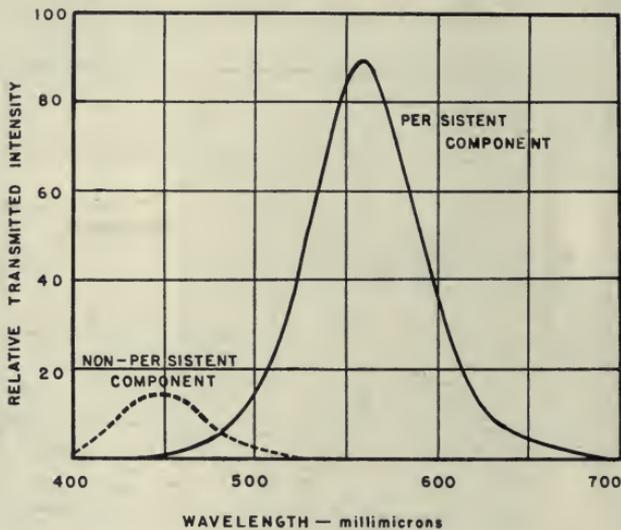


FIG. 10. Portions of *P-7* light components transmitted by RCA beam-splitter.

make several test strips under operating conditions to determine the aperture at which he gets best general results. The latitude of the film can usually accommodate the other variations. It is better to do this than to try to force him to decide what brightness will photograph best at a given *f*/number. However, if the operator finds that the aperture setting falls much below *f*/5.6 when photographing the bare tube, he should seriously consider whether or not he is operating the tube at too high a level. If this is the case, spot size may be increased and "blooming" may be in evidence, resulting in loss of detail. On some of the higher resolving power sets using the 7-in. tube, best results are obtained when the lens setting is around *f*/3.5 on Super XX film.

Processing.—After exhaustive tests best results were found to be obtained when the directions on the package were followed. For 16-mm or 35-mm films, fine-grain developers of the *D-76* type should be used. When paper prints are to be made, best average results are obtained when the film is developed to a gamma of about 0.8. If a motion picture print is to be made, development to a lower gamma might be advisable. High contrast development of map-type pictures should be avoided except where the picture is composed of a simple pattern of lines or points. Fig. 5, showing the tip of Long

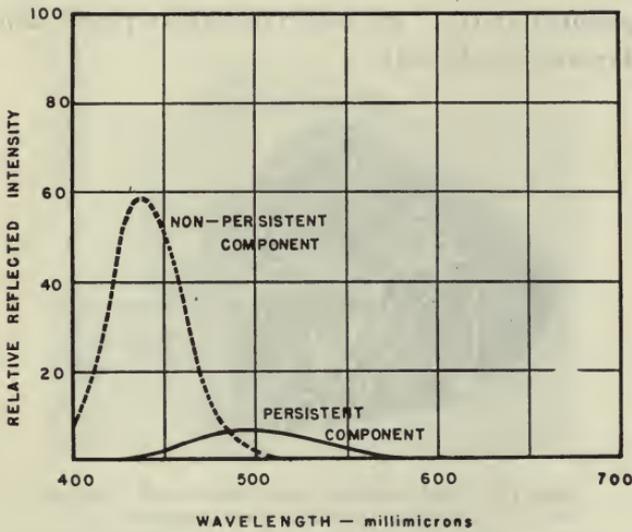


FIG. 11. Portions of *P-7* light components reflected by RCA beam-splitter, after two reflections.

Island and the coast of Connecticut, was reproduced from a high definition 7-in. scope on Leica frame Super XX film at $f/3.5$. It was developed to approximately $\gamma = 0.8$ and printed on No. 3 paper.

Viewing.—For selecting the frames to be printed from reels of 16-mm or 35-mm film, Recordak or Microfilm viewers can be used. Better yet, advantage can be taken of the fact that the pictures are made on motion picture film by projecting the films as motion pictures yielding highly speeded-up records of the radar mission.

Motion Pictures.—In making radar still pictures it was found desirable to photograph the instantaneous blue component of the emitted light. However, in making motion pictures, it is necessary to photograph the much weaker persistent image, which is what the

operator actually views. It is desired to show the image just disappearing from the screen in the area just preceding the generating trace. For still pictures, an exposure of several seconds at $f/2.8$ was required to photograph the persistent image. Because parts of the image have faded to very low brightness levels, a lens much faster than $f/2.8$ is required for making motion pictures, even if the tube is operated at a brightness level considerably above normal.

Polaroid Lens.—For making scope motion pictures a lens was especially designed by the Polaroid Corporation of Cambridge, Massachusetts. This lens has a focal length of approximately 2 in. and an aperture of $f/0.7$. Its design includes a plastic Schmidt-type aspherical correcting element.

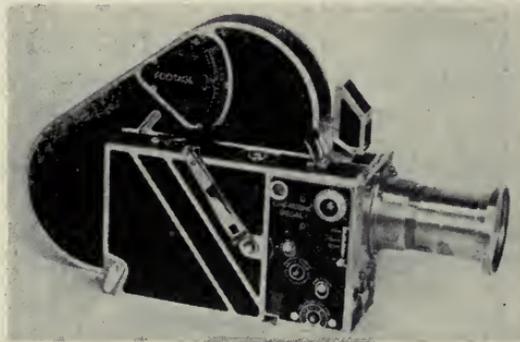


FIG. 12. Ciné-Kodak Special fitted with Polaroid $f/0.7$ lens for radar photography.

The results of a test made on this lens by the Army Signal Corps are given in Table 3.

TABLE 3

Equivalent Transmission Aperture— $f/0.64$

Axial	Resolving Power
2.5 deg	300 lines per mm
5.0 deg	252 lines per mm
7.5 deg	224 lines per mm
10 deg	80 lines per mm
	56 lines per mm

Since the cathode-ray tube screen is convex towards the lens, and since at this aperture and the customary close working distances the depth of field is extremely shallow, the results are not quite so good

as the results of this test might lead one to expect. The picture is adequately sharp for the purpose, however.

Camera.—This Polaroid lens is fitted to a Kodak Ciné-Special 16-mm camera. It has 200-ft magazines and has motor drives operating from 110 v a.c., and from 24 v d.c. The camera and lens are shown in Fig. 12.

Film.—A search was made for the film most sensitive to light of the color of the persistent image. Eastman Kodak Company co-operated fully in this manner, sending several rolls of film, some of which were standard emulsions and some of which incorporated

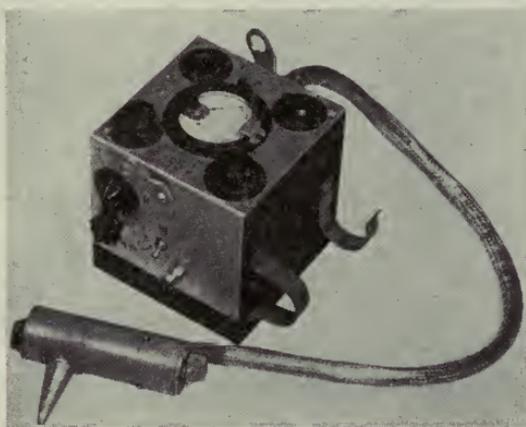


FIG. 13. Electronic photometer used for measuring the low light levels encountered in radar photography.

special dye sensitizers. These were all exposed in the same camera running at one speed, to the same picture on tube testing laboratory equipment which was first allowed to run for some time to ensure stable operation. These films were returned to Eastman Kodak for processing to gamma 0.8. The resulting films were projected simultaneously with the Super XX negative as a standard so that comparisons could be made. Several conclusions were reached:

(1) One sample emulsion *N4X-15753*, a Tri-X type with special dye sensitizer, showed greater speed than the Super XX reversal film No. 2601 used as the standard. The sample film was much too grainy for use in 16-mm size, however.

(2) Standard Super XX reversal developed as negative and

standard Tri-X were equally sensitive. Tri-X had a higher fog density and showed appreciable grain.

(3) No emulsion but the one mentioned was faster than Super XX Reversal. Those equally fast were either grainier or had no particular advantage in other respects to warrant using the special emulsion.

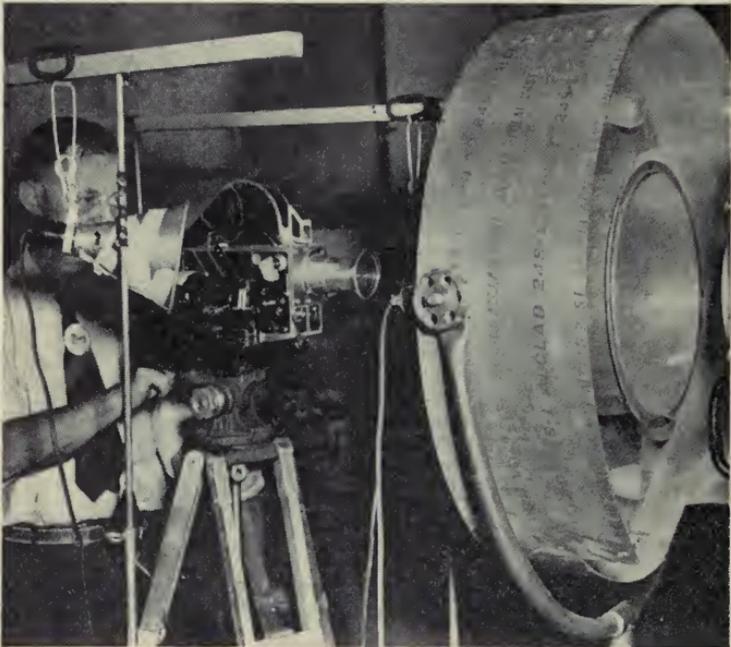


FIG. 14. Reflector used to control separately the levels of illumination on the scope face and on the surrounding area.

As a result of this test, Super XX Reversal No. 2601 has been used exclusively for making motion pictures of *P-7* scopes at the Radiation Laboratory.

Operation of Radar Indicator.—While it would be most desirable to operate the tube at normal brightness, it proves necessary to operate the tube as high as possible. The tube brightness is adjusted to just below the point at which a faint halo begins to appear around the generating trace. This halo might appear to be too dim to record on the film, but it is actually dim only in comparison to the generating trace. It is often overlooked. Actually, it is as bright

as the persistent image not many degrees removed from the generating trace, and will appear in the projected image.

Face Lighting.—The Naval Photographic Science Laboratory first published data on a method by which more of the extremely faint portions of the radar image could be recorded photographically. Auxiliary lights are used so that the tube face is illuminated slightly. Tests made at the Radiation Laboratory confirmed the results claimed in the PSL report. One experiment was conducted on a 12-in. tube on which a short-range sweep was rotated at 6 rpm. The angle through which radar detail could be seen was almost doubled in that part of the test in which face lighting was employed. There is a further psychological advantage in employing face lighting. The entire tube face is reproduced at a low brightness level, much as the operator sees it, giving a sense of completeness to the picture previously lacking.

Photometer (Fig. 13).—When making motion pictures at $f/0.7$ the illumination required for face lighting is lower than can be read with an ordinary exposure meter. Lacking other means of measurement, Prof. W. B.

Nottingham of M.I.T. adapted for our use a very sensitive self-contained photoelectric meter which he had designed. With this

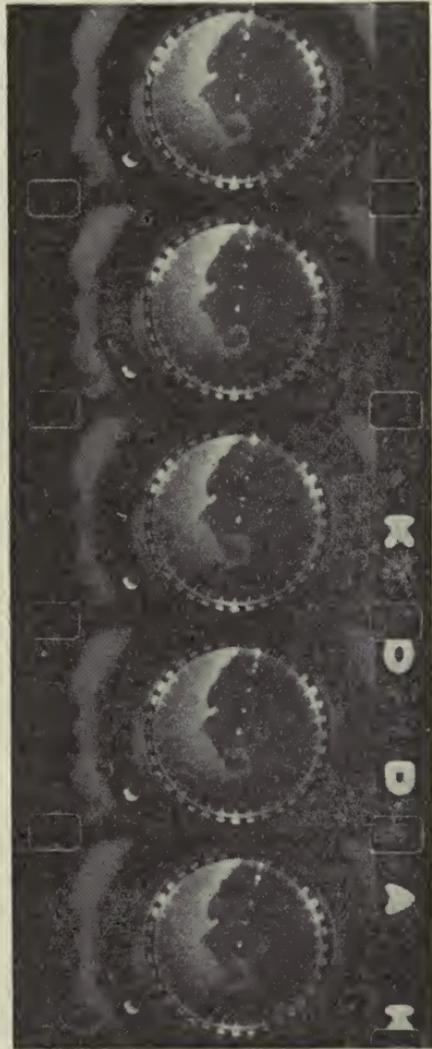


FIG. 15. Strip of motion picture film showing radar map of shoreline of Massachusetts.

meter, it was even possible to measure the brightness of small areas of the radar image. A unique feature of the device is its integrating circuit by means of which low levels of light can be measured by its action over a measured period of time. Direct reading scales are also provided for the higher light levels.

Methods of Photographing Indicators.—At first, a method first published by PSL involving a double exposure was used. The tube face was first covered with black cloth or paper. The console area surrounding the tube was then photographed in subdued light so that the finished print would convey the impression that the tube is in a darkened room. The film was then rewound, the black cloth removed and the radar image and face lighting adjusted to the proper level. A second exposure was then made.

This method was later abandoned since many of our pictures were made under severely adverse conditions when the fairly delicate arrangement of lights, masks and camera was often inadvertently disturbed. A simpler method was devised, enabling the console and radar set to be photographed at the same time.

The problem in single exposure photography was to control two contiguous areas of illuminations, that on the console and that on the tube face itself. Since the illumination on the tube face is relatively low, its boundary did not need to be sharply defined. In our work the scope face is almost always photographed so as to nearly fill the height of the screen, further simplifying the problem.

T. F. Hartley, the cameraman who actually photographed most of the motion pictures of scopes at the Radiation Laboratory, solved the immediate problem by producing a light reflector shaped much like an oversized cake ring. (Fig. 14.) Inside this ring, twelve $7\frac{1}{2}$ -w lamps were arranged symmetrically about an adjustable central cylinder. In use, the reflector is placed close to the tube face and aligned so that the axes of the cylinder and the scope coincide. If the lights are now turned on, the console is uniformly illuminated except for the circle masked by the cylinder. Two other lamps in reflectors are set up behind the reflector so as to direct light into the rear of the cylinder. This light rereflected from the inner wall of the cylinder, provides flat face lighting. Both sets of lamps are provided with independently variable voltage sources for controlling the levels of illumination. The method proved to be simple and yielded results superior to those previously obtained. An enlargement of several frames taken by this method is shown in Fig. 15.

Filters.—A No. 106 Plexiglas filter is used to cut down the blue light appearing in the generating trace, which because of its relatively high intensity causes the trace to photograph as a much broader line. The No. 121 Plexiglas filter usually mounted over the face of the screen should not be used since it is much denser than necessary. (See Figs. 3 and 4.)

Processing.—In processing still pictures which might be considered as integrated exposures of a number of motion picture frames, it was found desirable to develop the negative to a gamma of 0.8. Because the brightness of the radar image fades with time, the image contrast of a single motion picture frame which must record this added effect is greater than that of a still picture. Therefore, it would appear that the motion picture negative should be developed to an even lower gamma. However, since face lighting artificially reduces the contrast of the scope image, best results have been obtained when the negative is developed to a gamma between 0.8 to 0.9. The frames shown in Fig. 15 were developed in this manner. The foregoing statements apply principally to map-type images photographed by the Polaroid $f/0.7$ lens which is capable of giving nearly the proper exposure. When negatives are made with slower lenses forced development is generally necessary to obtain reasonably good results.

In cases where the radar picture is composed principally of lines or spots, forced development can sometimes be used to good advantage to accentuate these simple details even when photographed by the Polaroid lens.

Since the high speed of the Polaroid $f/0.7$ lens and the employment of face lighting techniques yield almost correct exposures, the need for special manipulation of the negative has been reduced. Consequently, the last motion pictures of radar scopes produced at the Radiation Laboratory were given the normal reversal treatment at Rochester yielding superior results.

Color Photography.—Results obtained by the method outlined above were so gratifying that, just prior to the termination of the Radiation Laboratory, an attempt was made to photograph the same radar image shown on Fig. 13 on Kodachrome. Surprisingly enough, the persistent image was recorded through about 90 deg of the tube face. If time had permitted, the faster color films developed for the armed forces and face lighting filtered to match the color of the persistent image, might well have yielded color photographs of

sufficiently good quality to replace the black-and-white scope pictures which have marred the finish of our Kodochrome motion pictures.

Acknowledgment.—Investigation of various phases of this work were carried out under the direction of Carl F. J. Overhage and Charles Newton, Group Leaders at the Radiation Laboratory. Clifton Tuttle, of Eastman Kodak Company, collaborated extensively in investigations of fast lenses and films for motion picture use. Irving Doyle, chief engineer of the Fairchild Camera and Instrument Company and designer of the *O-5-A* camera, supplied the photograph of the *O-5-A* camera and the RCA beam-splitter curves. All photographs except those noted above were obtained from the Radiation Laboratory, Massachusetts Institute of Technology.

A PROPOSED FILM LOCK AND IDENTIFICATION BAND*

GARE SCHWARTZ**

Summary.—Cross-banding of reels between exchange and theater calls for some reform to eliminate the confusion caused by this inefficient method. The paper describes a proposed film lock and immediate identification which becomes an integral part of the film itself.

In handling motion picture film, it has always been a problem to hold the film against unwinding either temporarily or permanently. Various expedients, such as metal clips which scar the film, rubber bands which mark the film upon deterioration, small clamps, and the like, have been used for this purpose.

Release prints are bound with a paper band which is wrapped around the reel and held in place by a string. As the band usually contains the data relative to the film, and as they must be removed each time the film is used or examined, and since each band fits only its particular reel, it must be replaced upon the exact reel or confusion results.

The proposed film lock is an integral part of the film so there is no possibility of misapplying the data relative to the films as the lock becomes a part of its respective reel.

The film lock amounts to forming a tongue on the end of the film with a groove or series of grooves formed in the body of the film adapted to receive the tongue, so that the outer strand of film may be locked on itself by inserting the tongue through one of the grooves. The friction of the tongue between the strands of the roll will prevent the tongue from withdrawing and the normal tendency of the film roll to expand will exert a continuous pressure so that the tongue will be permanently locked in place and the reel will not unwind until the tongue is actually withdrawn. The tongue is forced into the slots merely by a pressure of the thumb around the outside strand of the film until it encounters the slot, whereupon it is worked into the slot and fixed between the two outer strands of the roll. After it is once

* Presented Oct. 25, 1946, at the SMPE Convention in Hollywood.

** Twentieth Century-Fox Film Corporation, Beverly Hills, Calif.

locked, it will remain indefinitely and is easily released merely by withdrawing the tongue.



FIG. 1. Proposed new identification reel band.

The lock may be used repeatedly and will find usefulness not only for temporarily locking rolls against unwinding during handling in the cutting rooms or for inspection, but will serve as a permanent lock for holding rolls of film of either small or large diameter against unwind-



FIG. 2. Cutaway showing tongue and groove of proposed film lock band.

ing when stored permanently. It also provides a means of attaching the data relative to each film permanently to its respective film so that there is no chance of misapplied data caused by separating a roll of film from its respective wrapper.



FIG. 3. Film lock completed.

A simple punch quickly accomplishes the forming of the tongue and groove in a single operation, and in practice, film locks could be made and kept in stock and spliced onto their respective reels, or they could be made an integral part of the film itself.

I wish to extend thanks to the many individuals who have given their co-operation in developing this proposal.

DISCUSSION

DR. C. R. DAILY: I should like to know whether this band has been given an exchange trial yet.

MR. SCHWARTZ: No, but I have given it an exhaustive test at the studio. Various questions were raised as to the possibility of the tongue becoming worn or torn, and the question of the operator tearing off the ends. So far as the operator is concerned, I have no answer. So far as the wear and tear of the film is concerned, I did allow the film to flap on a metal bench 1500 or 2000 times, which was an even more drastic test than the usual flapping of the film in the lower magazine of the projector or in the rewind box in the booth. I cannot give any particular reason why the film stood up to wear and tear, except the fact that there was a lesser film surface concerned in threading and rewinding the film in the tests that I made. I placed the tongue into the slot on the reel as far as it would go, and then by exerting extreme pressure I pulled the film in such a fashion that normally the film would tear. To my surprise, it did not. To make the comparative test, I used the normal full width leader under the same circumstances and after the thirty-fourth time the film did tear.

MR. E. DENNISON: I have done a lot of research on handling film in exchanges for a period of twenty years, and I have also had many ideas as to how to keep the ordinary paper film band from being a nuisance to the operators and inspectors in exchanges. I think your idea of the lock is very good, but I think you are going to have the same human element to contend with as you had with the film. Several things have been evolved in the past years. One was the steel band. Some others had ideas of getting away from the ordinary paper band with the string and the button on it. I think you are going to have to educate every individual projectionist in the United States to use something different.

MR. SCHWARTZ: We know that from time to time we have damaged film come back because the operator just got mad. He could not get the film into the slot, so he tore another piece and another piece, and he had no concern about the film itself. I do think if we help him with the film lock, or some other method that may be adopted, he will feel we are with him and trying to help him in some way. The present method has been a drawback in many, many ways. More often than not the operator will take all the bands off of the reel and stick them down in the side of the container and just forget them. This proposal is an attempt to improve the method of identifying film, and holding the film from unraveling, so perhaps some method can be found whereby we can help to educate the operator to be a little more concerned about the film. If we are helping him, I am sure he will help us.

PRESERVATION AND POSTWAR UTILIZATION OF U. S. NAVY COMBAT FILM*

GERALD L. SARCHET**

Summary.—*The unprecedented volume of Navy combat film photographed during the war presented serious problems of co-ordination, cataloging, and filing. This paper outlines briefly the inception and organization of the U. S. Navy Film Library, the mission of which is the preservation and custody of all Navy Combat Film.*

For the first time in the history of warfare, motion pictures became a universal medium in the field of actual combat. The unprecedented volume of combat film, running into millions of feet, photographed by the Navy during the war years, presented several serious problems of which preservation and future utilization were the most pressing. Anticipating the relative magnitude of this new activity, a Motion Picture Film Library was organized as a unit of the U. S. Naval Photographic Center at Anacostia, D. C., until very recently, known as the Photographic Science Laboratory. The mission of this organization was the custody and preservation of all Navy motion picture combat film as well as its co-ordination for immediate and future reference.

It was evident at the outset that the paramount factor in any system devised to catalog and file this type of material must be its preservation in terms of authentic locale. Since almost every ship in the combat areas carried on some photographic activity, our sources of material ran well into the hundreds. This film represents a documentary record of naval action during this period, and the only means of preserving its authenticity was to assemble each activity's film into separate rolls, and catalog it as such. This method of assembly meant that the combining of like material—that is, grouping all shots of deck crashes, close-ups of gun crews in action, *etc.*—would be impossible, although it would have made future reference and research somewhat easier. Under ordinary circumstances, this could

* Presented Oct. 22, 1946, at the SMPE Convention in Hollywood.

** U. S. Naval Photographic Center, Anacostia, D. C.

have been accomplished; but the tremendous volume and wide variety of subject matter being received each day would have made

DATE OF SCREENING: 5/14/46 Ham.

MOTION PICTURE FILM LIBRARY CONF.

INDEX #: 16820

PRODUCED BY: U. S. NAVY DATE: 3/18/42

NEG: 1-5820 POS: 2-5820 DUPE NEG: _____

MASTER: _____ 16 MM: _____ LENGTH: 462 ft.

SUBJECT: PRESENTATION OF AWARDS, USS TROUT.

- 1) MCU Awards being given to men; men lined up at quarters.
- 2) GV Band playing.
- 3) GV Men lined up topside submarine.
- 4) GV-UA Photographer topside conning tower submarine.
- 5) GV-UA Flag with three stars flying from periscope of submarine.
- 6) MCU Officers in white lined up.
- 7) MCU Officers and men lined up at quarters topside submarine.
- 8) CU Adm. speaking over mike.
- 9) GV-MCU Lt. Comdr. presenting three-star flag to a general.
- 10) GV Officers on dock saluting.
- 11) GV Officers lined up topside submarine, saluting.
- 12) GV Band playing, Adm. FG saluting.
- 13) GV Officer reading over microphone.
- 14) MCU Officers lined up aboard submarine receiving decorations—

SV.

TROUT, USS

SSs, gen.

QUARTERS, MEN AT

AWARDS, presenting

BANDS, USN

PHOTOGRAPHERS, official

FLAGS, gen.

OPTICS, periscope

OFFICERS, USN

COMM. AFLOAT, radio

SALUTING, hand

FIG. 1. Sample review sheet.

it an almost impossible task even for a highly trained and well-staffed organization.

The initial functions under this system were the deletion of evident

"N. G." footage and the assignment of a permanent numerical index number to each roll. The prints were then screened and a scene-by-scene description taken by means of a dictaphone. At the same time the current classification and quality were established. This record was then reduced to a typewritten review sheet, listing the index number assigned that particular roll of film. Copies of this review sheet were immediately made available to all authorized agencies. As a result, within a matter of hours after the film reached the library, selections of material could be made simultaneously by the several groups charged with the compilation of photographic combat reports

INDEX # 14596				U. S. NAVY FILM LIBRARY		CLASSIFICATION RESTRICTED	
PRODUCED BY USS SHANGRI-LA (CV-39)				DATE		8/27/45	
REEL #	POSITIVE	NEGATIVE	DATE	IN mm	LENGTH	35mm	FT.
	4-6218 (S)	1-4034 (N)	4-6217 (S)	Color	16mm	283	ft.
SUBJECT:				TASK FORCE 39 UNDERWAY & IN TOKYO BAY		SHANGRI-LA, USS	
1) AV Task force underway. British DD seen below on surface.				2) AV Many components of the task force underway, DDs, air craft carriers, heavy cruisers seen entering Sagami, Guam Bay, coast of Japan seen in BG.		3) AV British BB, HMS KING GEORGE V, underway.	
4) AV USS MISSOURI underway.				5) AV DD coming alongside the Missouri for transferring personnel at sea.		6) AV DD alongside the USS MISSOURI-SV.	
7) AV-MB British DD underway.				8) AV Yokasuka naval base, Japanese BB Nagato seen anchored in harbor.		9) AV Number of industrial cities in & around Yokanama	
10) AV Yokahama sea plane base, Jap plane seen on field				11) AV POW camp near Yokahama sea plane base		12) AV HMS KING GEORGE V	
13) AV USS MISSOURI, shore line of Yokasuka naval base seen in BG.						SHANGRI-LA, USS FILMS, 16mm color TASK FORCES HARBORS, Tokyo Bay SHIPS, FOR., British DD DESTROYERS, DD, underway AIR CARRIERS, CV, underway CRUISERS, CA, underway HARBORS, Sagami Bay, Guam- KING GEORGE V, HMS MISSOURI, USS BBs, underway TRANS. AT SEA, personnel NAVAL BASES, MOB, Yokasuka SHIPS, FOR., Japanese CITIES, Yokahama PLANES, FOR., Japanese PRISONS, Yokahama AERIAL VIEWS, planes AERIAL VIEWS, ships	
QUALITY: Good.							

Fig. 2. Cross-reference index card.

and the release to the public, through the various news channels. (See Fig. 1.) The task of immediate availability having been accomplished, the review sheet was then edited by means of an alphabetical cross-reference index. This index covers over 500 main headings and approximately 2500 subheadings, which had to be developed before the process of cataloging and filing could be carried through to completion. As an example: "Ships" is a main heading, the first subheading will be types of ships, under this heading will follow others covering the various activities such as *DEs* underway, firing, burning, exploding, sinking, *etc.* All of the cards under each subheading are, in turn, separated as to original type of film, that is, 35-mm black-and-white, or 16-mm black-and-white, or color. (See Fig. 2.)

It will be noted that the index number, the origin (ship or station), the date of action, a title covering the general subject matter, and the vault location of all film both original and duplications under this number appear on the card. The cross-references are listed on the right-hand side, one of which is arrowed. To minimize the reading time in the selection of stock footage, the arrowed items on the left indicate the material covered by the arrowed cross-reference. Thus, as the completed card reaches the alphabetical file, the material it covers becomes immediately available. To augment the alphabetical index and at the same time expedite the initial filing of the film in the vaults and the handling of immediate requests originating from copies of the original screening account, a numerical file was established. This cardex file lists, in numerical order, every roll of film that has been reviewed. A temporary card listing only the type of film and its vault location is used until such time as it can be replaced with the completed card.

To ensure the maximum degree of physical preservation, the U. S. Naval Photographic Center is equipped with 62 modern air-conditioned film vaults. Temperature and relative humidity of 68 and 50 respectively, are maintained 24 hours a day.

In an effort to utilize the maximum vault space available, a system of can numbers was devised whereby a number of small rolls carrying different index numbers were assigned the same can number in a given vault. This meant that a 100-ft roll of film was not occupying the space that could have been utilized by four or five additional rolls of similar size.

As an added precaution original negative and any duplicating material covering it is never filed in the same vault. The Library Annex, only recently completed, now houses the present library staff and 36 of the existing vaults. At present, the Navy has on file approximately twenty-five million feet of combat film and since the Library is the depository for all Navy film having historical value, the files are constantly expanding. While the foregoing has dealt exclusively with motion pictures, there are presently over a million still and aerial negatives and prints covering the various combat activities which have been cataloged and filed in basically the same manner.

The primary function of this film is, of course, its utilization in the Navy's postwar training program. Into almost every training film is incorporated some measure of this material. The interest it

stimulates and the parallel it provides between training and actual combat are invaluable.

Rapid demobilization has delayed, to some degree, the Navy's program of making pictorial material available to the public through educational institutions, research organizations, and the motion picture industry.

This material is being made available to such agencies by authorization of the Office of Public Information, under the supervision of the Secretary of the Navy.

CURRENT LITERATURE OF INTEREST TO THE MOTION PICTURE ENGINEER

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

American Cinematographer

28, 3 (Mar. 1947)

Composition in Motion Pictures (p. 84)	H. T. SOUTHER
The Zoomar Lens (p. 87)	F. G. BACK
"13 Rue Madeleine" (p. 88)	H. A. LIGHTMAN
The Cinema Workshop—9. Color Cinematograph (p. 92)	C. LORING

Communications

26, 12 (Dec. 1946)

Placement and Operation of Microphones in Broadcast Studios (p. 12)	J. B. LEDBETTER
27, 2 (Feb. 1947)	
Lateral Recording (p. 26)	W. H. ROBINSON

Electronics

20, 3 (Mar. 1947)

Experimental C-R Tubes for Television (p. 112)	
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Ideal Kinema

13, 140 (Mar. 13, 1947)

B.T.H.'s New Projector (p. 23)	
--------------------------------	--

International Projectionist

22, 2 (Feb. 1947)

"Quality" versus "Pleasing" Sound Reproduction (p. 5)	J. MOIR
Simultaneous All-Electronic Color Television (p. 8)	
Magnetic Recording, Reproduction Data (p. 14)	G. T. CLEARS
22, 3 (Mar. 1947)	
Studio Super H.I. Carbon Arc Lamps (p. 7)	P. MOLE
Magnetic Recording Symposium by Academy (p. 9)	
Television, Films and the Human Eye (p. 14)	A. ROSE

Radio News

37, 3 (Mar. 1947)	
The Recording and Reproduction of Sound (p. 52)	O. READ
37, 4 (Apr. 1947)	
The Recording and Reproduction of Sound (p. 50)	O. READ
Magnetic Sound for Motion Pictures (p. 12)	M. CAMRAS

SOCIETY ANNOUNCEMENTS
SEMINAR ON OPTICS HELD

An interesting seminar was held by the Midwest Section of the Society in Chicago on May 8, 1947, devoted to "Optical Systems for Motion Pictures". R. E. Lewis, Secretary-Treasurer of the Section, served as moderator. Others who contributed to the session were E. E. Bickel, chief optical engineer, Simpson Optical Manufacturing Co.; R. F. Mitchell, assistant chief engineer, Ampro Corporation; A. M. Smith, assistant optical engineer, Bell and Howell Co.; and R. A. Woodson, assistant chief optical engineer, Bell and Howell Co.

Among the items discussed by the group were limits of lens design usefulness, difficulties with mechanical clearance for optics, movement of the film in the focal plane, as well as various sound reproduction systems and related problems.

A paper by J. A. Maurer, of J. A. Maurer, Inc., entitled "General Principles of Optical Recording on Film" was read by R. T. Van Niman of Motiograph. This was a transcription of a talk which Mr. Maurer gave previously before the Acoustical Society in Chicago.

Active discussion from the floor indicated the popularity and success of the seminar type of meeting, held in the rooms of the Western Society of Engineers.

BACK ISSUES AVAILABLE

Again we have heard of the availability of sets of back issues of the JOURNAL and we are passing this information along to interested members. Many issues are now out of stock and we are glad to co-operate in finding purchasers for the sets listed below. All details concerning price, payment, *etc.*, must be arranged direct with the owners given.

John J. Kuehn, 728 Buckingham Place, Chicago 13, Ill., has a complete set of bound JOURNALS through 1944, and unbound copies for 1945 and 1946.

Philip H. Hiss, "Cedarcrest", New Canaan, Conn., has many of the early *Transactions* which are now out of print, and JOURNALS from 1930 to August 1945.

Both of these sets must be purchased complete, the owners do not wish to sell separate volumes or issues.

We are grieved to announce the death of Ernest S. Lundie, Active member of the Society, on March 11, 1947, in Glenside, Penna.

JOURNAL OF THE SOCIETY OF MOTION PICTURE ENGINEERS

Vol 48

JUNE 1947

No. 6

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Indexes to the semiannual volumes of the JOURNAL are published in the June and December issues. The contents are also indexed in the *Industrial Arts Index* available in public libraries.

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JOURNAL OF THE SOCIETY OF MOTION PICTURE ENGINEERS

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No. 6

PROPOSALS FOR 16-MM AND 8-MM SPROCKET STANDARDS*

J. S. CHANDLER, D. F. LYMAN, AND L. R. MARTIN**

Summary.—On Nov. 8, 1945, the chairman of the SMPE Standards Committee appointed a Subcommittee on 8-Mm and 16-Mm Projector Sprockets with the task of revising the present American Standards for sprockets. The personnel of the subcommittee is Otto Sandvik, chairman; Herbert Barnett, John A. Maurer, Lawrence T. Sachtleben, and Malcolm G. Townsley. This paper, however, is not a report by the members of the subcommittee, but is material prepared for their consideration.

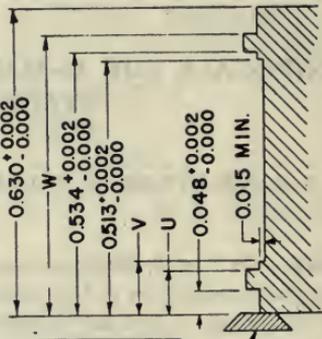
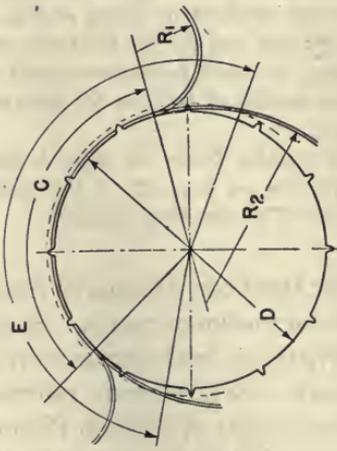
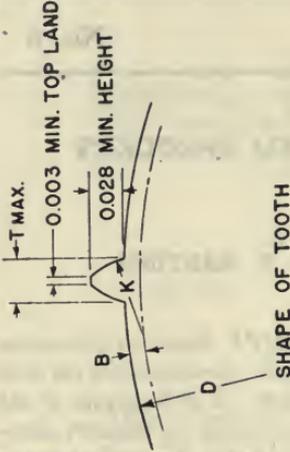
The ASA Sectional Committee on Motion Pictures, Z22, had earlier referred the sprocket standards to the Standards Committee for reconsideration, suggesting that the specifications should be in equation form. In this paper, the authors have followed this procedure and are submitting proposals for a new standard, as shown in Fig. 1. Formulas are given for the root diameter of the sprocket and for the thickness and shape of the tooth. In these formulas due allowances are made for variables such as the pitch of the film, the path of the film, and the number of teeth on the sprocket. Careful consideration is given to lateral dimensions.

Members of the Society and others interested in sprocket design are urged to read this paper and Dr. C. F. Vilbrandt's paper, beginning on page 521 of this issue, and to submit their comments to Boyce Nemeo, SMPE Engineering Secretary.

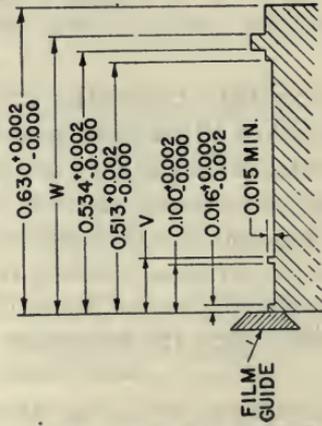
In October 1945, Committee Z22 of the American Standards Association reviewed all the existing standards for motion pictures. Some were accepted, either as they had been written or with minor corrections, and were reissued as 1946 Standards. Several were referred back to the Committee on Standards of the Society of Motion Picture Engineers for revision. Among these were Z22.6-1941 and Z22.18-1941 covering 16-mm and 8-mm film sprockets, respectively. They were returned with the suggestion that the substitution of formulas

* Presented Oct. 25, 1946, at the SMPE Convention in Hollywood and Apr. 25, 1947, at the SMPE Convention in Chicago, Ill.

** Eastman Kodak Company, Rochester, N. Y.



DIMENSION	U	V	W
CAMERA	0.095	0.114	0.574
PROJECTOR	0.094	0.113	0.570
TOLERANCE	+0.000 -0.002	+0.000 -0.002	+0.000 -0.002



NOTE: All dimensions are in inches.

FORMULAS AND EXAMPLES

Formulas for computation of P , D , T , K , and B for drive, holdback, and combination sprockets. The examples are sample computations for a 12-tooth sprocket to accommodate film from 0.2 per cent stretch to 1.5 per cent shrinkage with $H = 3.2$ and $F = 4.5$ pitch lengths.

FORMULAS: All dimensions in inches.

EXAMPLES: All dimensions in inches.

Tolerances

DRIVE SPROCKET

$$P = 0.300(1 - S_{MIN})$$

$$D = \frac{P \times N}{\pi} - 0.006$$

$$T_{MAX} = 0.050 - 0.15(H + F)(S_{MAX} - S_{MIN} + 0.001)$$

$$= 0.300(1 + 0.002)$$

$$D = \frac{0.3006 \times 12}{\pi} - 0.006$$

$$T_{MAX} = 0.050 - 0.15(3.2 + 4.5)(0.015 + 0.002 + 0.001) = 0.029$$

HOLD BACK SPROCKET

$$P = 0.300(1 - S_{MAX})$$

$$D = \frac{P \times N}{\pi} - 0.006$$

$$T_{MAX} = 0.050 - 0.15(H + F)(S_{MAX} - S_{MIN} + 0.001)$$

$$P = 0.300(1 - 0.015)$$

$$D = \frac{0.2955 \times 12}{\pi} - 0.006$$

$$T_{MAX} = 0.050 - 0.15(3.2 + 4.5)(0.015 + 0.002 + 0.001) = 0.029$$

COMBINATION SPROCKET

$$P = 0.300 - 0.2S_{MIN} - 0.1S_{MAX}$$

$$D = \frac{P \times N}{\pi} - 0.006$$

$$T_{MAX} = 0.050 - 0.1(H + F)(S_{MAX} - S_{MIN} + 0.001)$$

$$P = 0.300 + 0.2(0.002) - 0.1(0.015)$$

$$D = \frac{0.2989 \times 12}{\pi} - 0.006$$

$$T_{MAX} = 0.050 - 0.1(3.2 + 4.5)(0.015 + 0.002 + 0.001) = 0.036$$

FOR ALL SPROCKETS

$$K = 0.111 - \frac{0.45}{N} + \frac{1}{N^2}$$

$$B = (0.025 + S_{MAX} - S_{MIN})(0.98 - \frac{4}{N} + \frac{10}{N^2}) - 0.014 - 0.014 - \frac{4}{12} + \frac{10}{144} - 0.014 = 0.016 - 0.0005$$

$$= 0.009 - 0.002$$

$$K = 0.111 - \frac{0.45}{12} + \frac{1}{144}$$

$$= 0.0804 - 0.002$$

After computing T , K , and B , check for minimum height and top land on large scale layout. If necessary, change film path to reduce H and F in order to obtain thicker tooth.

FIG. 1.

NOMENCLATURE

- N = Number of teeth on one end of sprocket.
- H = Number of film pitch lengths in direct contact with root diameter of the sprocket. $H = C \times N/360$ where C is the corresponding angle of contact in degrees.
 H can be obtained by observation, but should be estimated to the nearest quarter of a pitch length.
- F = Number of film pitch lengths between the intersections of the path of the film and the path of the tip of the teeth.
 $F = E \times N/360$ where E is the corresponding angle of engagement in degrees.
 F can be obtained by observation, but should be estimated to the nearest quarter of a pitch length.
- $S_{\max.}$ = Per cent maximum film shrinkage to be accommodated. (Express as a decimal in the formulas.)
- $S_{\min.}$ = Per cent minimum film shrinkage to be accommodated. (Express as a decimal in the formulas.) If stretch is to be considered, treat it as negative shrinkage.
- $T_{\max.}$ = Maximum thickness of tooth in inches at root diameter.
 Minimum permissible tooth thickness is controlled by minimum height (0.028 in.) and minimum top land (0.003 in.).
- P = Pitch of teeth in inches on the pitch circle at the center of the film thickness.
- D = Diameter in inches of the surface on which the film lies. (This may be a part of the sprocket or a separate guiding surface.) The tolerance for D equals the tolerance for P times N/π .
- R_1 = Minimum radius of film path entering or leaving the sprocket if path is curved away from the sprocket. Minimum $R_1 = 1/4$ inch.
- R_2 = Minimum radius of film path entering or leaving the sprocket if path is curved toward the sprocket. Minimum $R_2 = 0.7 D$.
- K = Radius of tooth.
- B = Distance from root diameter (D) to center for radius of tooth.

APPENDIX

This standard for 16-mm film sprockets has been developed to give the design engineer an opportunity to specify sprocket dimensions for particular applications and conditions. The standard consists of a number of formulas for the computation of tooth thickness, tooth shape, and circular pitch based upon the range of film shrinkage to be accommodated and the amount of contact between film and sprocket. The root diameter on which the film will run is computed from the circular pitch and the number of teeth on one end of the sprocket.

In cases where the film pitch does not match the sprocket pitch, the formulas for the sprocket pitch are such that the slippage of the film will be in the direction of external tension on the film, backward on feed or drive sprockets and forward on hold back sprockets.

The optimum pitch of the combination sprocket has been established to specify a sprocket that meshes perfectly with film having a shrinkage of the minimum shrinkage plus one third of the shrinkage range. Film of less shrinkage is forced against the direction of the external tension when this sprocket is operating as a drive sprocket. Film of greater shrinkage is forced against the direction of external tension when this sprocket is operating as a holdback sprocket. Combination sprockets should be avoided wherever possible.

It will be noted that formulas for the maximum permissible tooth thickness involve the use of fractions of a film pitch length. (See definitions for H and F .) This provides clearance for the teeth in partial engagement with the film.

The tooth shape, determined by dimensions K and B , provides clearance for the entering tooth for film paths be-

tween R_1 and R_2 . For sound and printing sprockets optimum conditions of flutter are obtained when the film path curves toward the sprocket and approaches the limit defined by R_2 . A more precise formula for R_2 for sound and printing sprockets is $1/R_2 = 19/N - 26/N^2 - 0.060$. The sprocket in this case should be designed and used as a drive sprocket. If it is necessary to use a sound sprocket as a holdback sprocket, it should be designed as a drive sprocket, and film guides must be provided to force the film onto the teeth.

The dimensions shown in the lateral profile views provide clearance for film with lateral shrinkage from 0 to 1.0 per cent for cameras and from 0 to 1.8 per cent for projectors. Film of greater shrinkage can be used on these sprockets, but either the film will pull away from the guide or the fillet of the perforation will engage with the tooth. These lateral dimensions are applicable also to film gates, guides, and pull-down claws.

The choice by the engineer of the range of film shrinkage to be accommodated must depend upon the experience of the manufacturer and the type of equipment being designed. Based on current film conditions, suggested ranges would be from 0 to 1 per cent shrinkage for equipment using unexposed film and from 0 to 1.5 per cent shrinkage for equipment using processed film.

In most cases, particularly when tensions greater than 2 oz must be overcome, it is desirable to make H at least two film pitch lengths. An exception to this occurs when the film is positively guided through a path curving toward the sprocket. In this case, if the value of F is high—at least 4—the value of H may be zero.

FIG. 1 (Continued).

for the specific dimensions given in the original standards might afford the designer a more flexible means of meeting the requirements of each particular application. The Chairman of the Committee on Standards appointed a subcommittee to prepare new standards. It is at the instigation of that subcommittee that these proposals are being submitted to the Society for comment and criticism.

Much of the delay in presenting this paper and the standards to the Society has been caused by investigation of several new and interesting aspects of the operation and design of sprockets. These have been examined by members of several departments of the Eastman Kodak Company, and the results are reflected in this paper. We hope that presentation of these aspects will result in the preparation of additional papers in the future.

Fig. 1 is the proposed standard for 16-mm sprockets. It is divided into four sections: illustrations, formulas and examples, nomenclature, and appendix. As explained above and in the Appendix, the standard was developed to give the designing engineer an opportunity to specify sprocket dimensions for specific applications and conditions.

Provision has been made for camera, printer, and projector sprockets having any practicable number of teeth. Particular attention has been given to the shape of the film path and to the lateral profile of the sprocket itself and also of guides, rollers, and film gates.

Variations of Film.—The one element in motion picture equipment to which practically all other elements must be referred dimensionally is the film. Unfortunately, because of requirements of thickness, flexibility, and transparency, this is made of materials which are subject to dimensional variation. Improvements in film bases during recent years have increased the stability of the film appreciably, but some variation will probably exist as long as the use of transparent film continues.

Because of the variation of the film, the sprocket, which has the most involved contact with the film of any of the mechanical elements, has been the subject of more attempts at standardization than any other part. This present analysis of the film-to-sprocket function may not be the end-all or the cure-all, but it introduces some factors that are new or are at least treated differently than in previous presentations.

Of the several kinds of variation of the film, shrinkage has the most effect on the rest of the system. Raw film is slit and perforated with

extreme accuracy, but under various conditions of treatment, aging, and humidity, shrinkage up to one per cent, or sometimes more, may occur. The processing of exposed film may cause variation, and conditions of storage make the dimensions that apply when the strip is run through the apparatus most unpredictable.

Accommodation for these changes in film caused by shrinkage is the principal factor in the design of sprockets. There are two reasons, varying in relative importance according to the function of the machine of which the sprocket is a part, why this accommodation is necessary. The first is the wear of the film by the sprocket, which is important in projection equipment in which the same film may be run

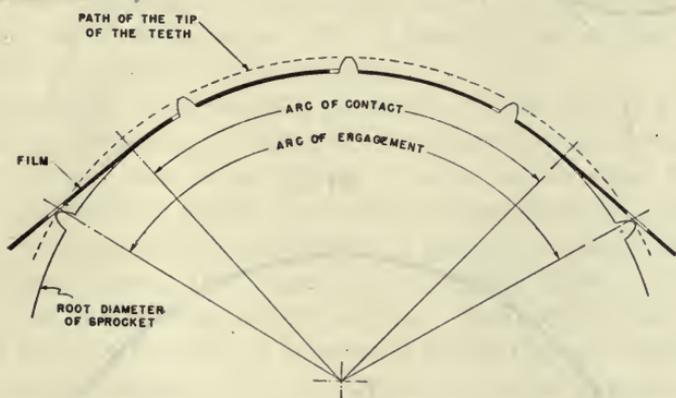


FIG. 2.

many times. Continued satisfactory operation depends as much or more upon the maintenance of accurate, undamaged perforations as upon the condition of the elements in contact with or adjacent to the sound and picture areas. The second reason for specifying the optimum relation between the film and the sprocket applies to sound and printing sprockets. Here the primary requisite is to run the film at a relatively constant velocity in order to ensure freedom from flutter. Fortunately, these two conditions, freedom from wear and freedom from flutter, are not in opposition to each other, and it is possible to design for usable results in both respects.

There are three aspects of sprocket design for which the potential shrinkage of the film must be taken into account. They are determination of (1) the circular pitch of the teeth, (2) the shape and thickness of the teeth, and (3) the lateral profile of the sprocket. They

are considered separately in the three sections of this report that follow, but ultimately they are interrelated.

SECTION 1—CIRCULAR PITCH OF THE TEETH

Function of Sprockets.—Let us consider first the conditions under which sprockets in motion picture equipment operate. Essentially their purpose is to co-ordinate the movement of film through the

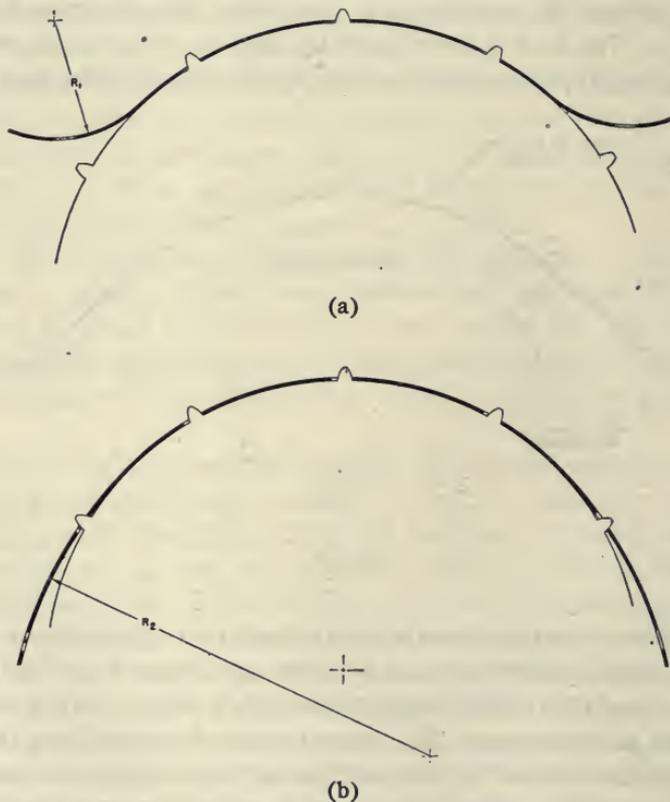


FIG. 3.

equipment so that all functions are kept in their proper relation. Usually they act as a buffer between film under tension on one side of the sprocket and film in a free condition on the other. Occasionally the film is under tension on both sides, but even in this case the tension on one side is almost always greater than that on the other. Thus, the effective condition is the same.

Path of the Film.—The path of the film as it passes over the sprocket is governed by the relative positions of the adjacent elements in the system, such as the supply reel and the gate. This path, however, is usually modified by rollers or guides near the sprocket. From the point where this film path intersects the path of the tip of the sprocket teeth until it passes beyond the similar intersection on the other side of the sprocket there is a zone of action on which the design of the sprocket is based. This zone of action, which can be measured and called the "arc of engagement," Fig. 2, contains a smaller "arc of contact" through which the film is in contact with the root diameter of the sprocket. This is usually a part of the sprocket, but it may be a separate guiding surface.

For simplicity of illustration, the film is shown in Fig. 2 entering and leaving the sprocket in straight lines tangent to the root diameter, but by far the more usual path is a curve, either away from the sprocket as shown in Fig. 3(a) or toward the sprocket as in 3(b). Or, the film can approach the sprocket in a path of one shape and leave in a different curve. It is necessary to establish limits for the minimum radius of curvature toward and away from the sprocket. This must be done on the basis of experience rather than on definite engineering considerations. Film curving away from the sprocket makes a reverse bend, which shortens the life of splices. Also, film left threaded in a camera, particularly during changes in climatic conditions, may take a set which will disturb its proper movement through the rest of the system. In view of these factors, a minimum radius of one-quarter inch is proposed for R_1 , the radius of the path that curves away from the sprocket.

The minimum radius of curvature toward the sprocket is governed by more definite factors. Obviously it cannot be less than the radius of the sprocket. A sprocket of one-quarter-inch radius, the smallest radius advisable for any point in the path, would have only five teeth and is too small to be recommended. Curvature of the film toward the sprocket does not involve reverse curvature of the film and therefore does not affect the life of splices. But film curvature in this direction that too closely approaches the radius of the sprocket increases the arc of engagement so much that the tooth becomes very thin and its shape is affected adversely. The proposed value of $0.7D$ for R_2 , the minimum radius when the film is curved toward the sprocket, is derived analytically in Section 2 of this paper.

Types of Sprockets.—In motion picture equipment there are two

basic types of sprockets, differing in the relation between the direction of the external tension on the film and the direction of the motion. In the first case these directions are opposed, and the sprocket is a drive sprocket. Examples are the feed sprocket, which pulls the film from the supply reel, the intermittent sprocket, which pulls the film through the gate, and the sound sprocket, which pulls the film past the recording or reproducing aperture. The second case is the take-up or holdback sprocket. Here the external tension is in the direction of the motion, and the film is held back by the sprocket.

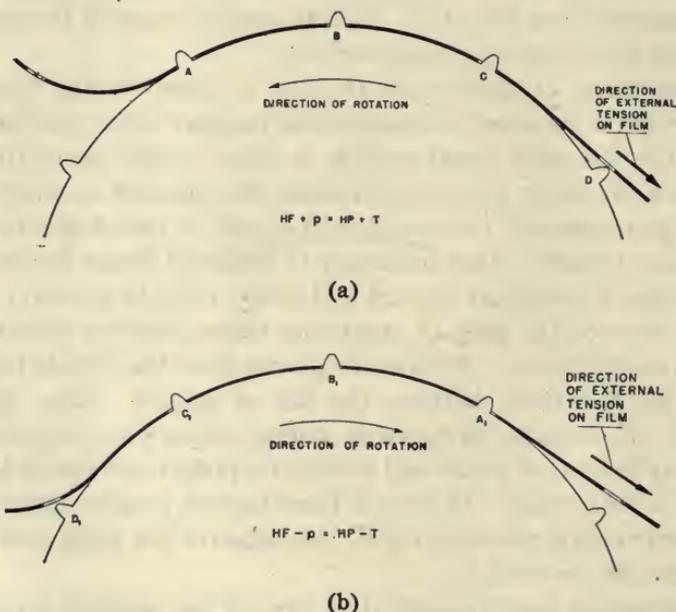


FIG. 4. Drive sprocket (a); holdback sprocket (b).

In addition, there is the combination sprocket. This is used in reversible apparatus where the function of the sprocket changes as the direction of motion changes, while the direction of film tension remains the same. Also, in many cameras and in some projectors, one section of a single sprocket serves as a drive sprocket and another section as a holdback sprocket. Combination sprockets are not recommended for highly accurate apparatus such as printers or other professional equipment.

Figs. 4(a) and 4(b) illustrate the two basic sprocket conditions, drive and holdback.

The sprocket in Fig. 4(a) is driving the film by the front or left-hand face of tooth *A*. As the sprocket rotates, tooth *A* leaves the film, which then slips backward so that the load is transferred to the front face of tooth *B*. Meanwhile, tooth *D* enters the perforation without touching the film, as it should if wear is to be kept to a minimum.

Fig. 4(b) shows a properly designed sprocket for the holdback condition. In this case, the film is held back by the rear or left-hand face of tooth *A*₁. As the tooth leaves, the film slips forward, the load is transferred from tooth *A*₁ to tooth *B*₁, and tooth *D*₁ freely enters the perforation that is coming into engagement.

Examination shows that in Fig. 4(a) the circular pitch of the sprocket teeth is greater than the pitch of the film, while in Fig. 4(b) the pitch of the sprocket teeth is less than the pitch of the film. From observation of the action under these two conditions, we can conclude that:

- (1) A properly designed drive sprocket should have a circular pitch equal to or greater than the pitch of the film; and
- (2) A properly designed holdback sprocket should have a circular pitch equal to or less than the pitch of the film.

These conclusions are not novel but were evident in Jones' paper on Film Sprocket Design.¹

Experimental Confirmation of Above Rules.—There is some recent experimental evidence to support the statements made above. Films of three different shrinkages were run in succession on three sprockets having different pitches. Each of the nine combinations of film and sprocket was observed and photographed, under both drive and holdback conditions, with external tensions of 4, 6, 8, and 10 oz applied to the film.

Fig. 5 illustrates qualitatively the results of these tests. It shows, for both drive and holdback conditions, that when the shrinkage of the film and that of the sprocket differ in the theoretically correct direction, the operation is satisfactory. But when the shrinkage difference is in the other direction, there is trouble. In the case of drive sprockets, no actual loss of loop occurred, but it is apparent in the pictures that violation of the theory results in a disturbance caused by contact between the entering tooth and the edge of the perforation. On holdback sprockets, since there was no sprocket clamp to prevent it, the film rose to the tops of the teeth, and the take-up device pulled the film ahead so that the loop at the other side of the sprocket was

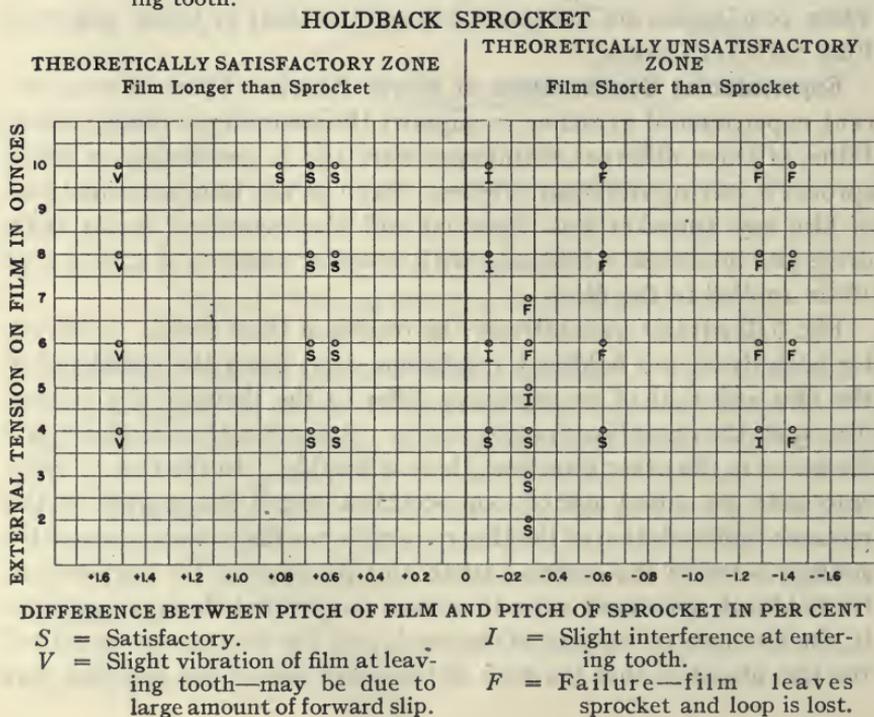
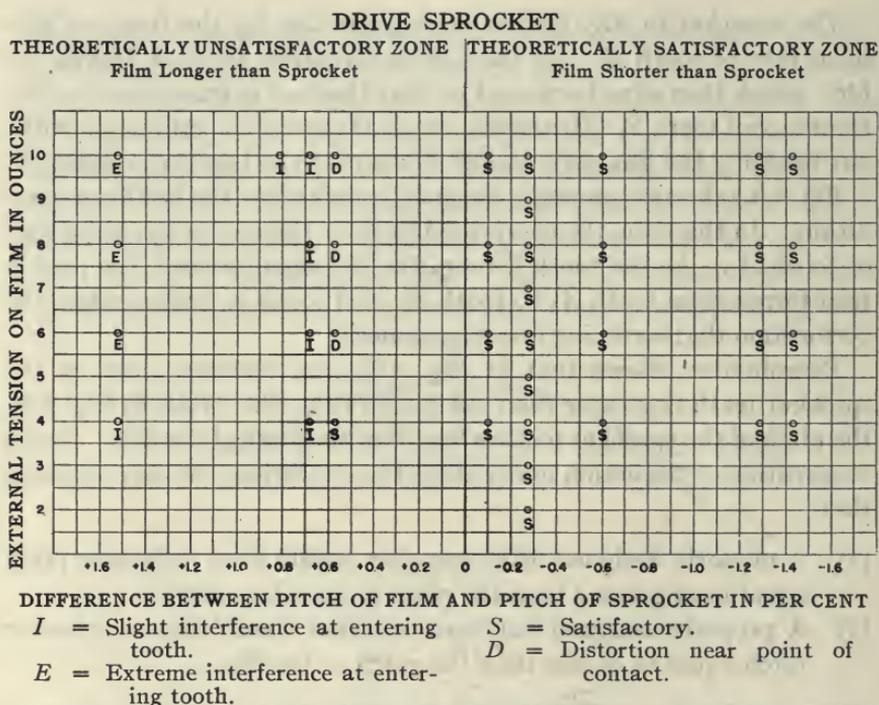


FIG. 5.

lost. Increased tension aggravated these disturbances, but when the pitch differential was in the correct direction, an increase of tension made no perceptible difference. These are merely observations of the functioning of the sprocket, not wear tests of the type described by Vilbrandt.² In his test, he shows that the running life of the film is reduced when the external tension applied to the film is increased.

Pitch of Sprocket in Relation to Thickness of Tooth.—Interference of the film with the sprocket exists when there is so much difference between the pitch of the film and the pitch of the sprocket that there is contact between the sprocket teeth and the perforations at both ends of the arc of contact. Interference can occur at the outer edges of the teeth, as would happen if the film in Fig. 4(a) were shorter, or at the inner edges, as would result with longer film in Fig. 4(b). From the limiting conditions shown in Figs. 4(a) and 4(b) can be derived primary equations for freedom from interference of this type.

$$\begin{array}{ll} \text{Drive sprocket} & HF + p = HP + T \\ \text{Holdback sprocket} & HF - p = HP - T \end{array}$$

H = integral number of film pitch lengths in the arc of contact

F = length of one film pitch, in inches

p = height of the perforations, in inches

P = pitch of sprocket teeth on the pitch circle at the center of the film, in inches

T = maximum thickness of the tooth at the root diameter, in inches.

These formulas in approximately the same form were shown by Jones¹ as well as by Hill and Schaefer.³

It is evident from consideration of these equations that with F and p established for a given shrinkage of film, P can vary through a wide range if corresponding changes are made in T . The limit of this variation is controlled by the limits for T , which cannot be greater than p nor less than zero.

But there are conditions other than interference to consider. Figs. 4(a) and 4(b) illustrate that the *direction* of the slippage is governed by which pitch is larger, that of the sprocket or the film, while the *amount* of the slippage depends upon the difference between the two pitches. For minimum slippage, the pitch of a drive sprocket should be equal to the pitch of the longest film that will be run on the equipment, and the pitch of a holdback sprocket should be equal to the pitch of the shortest film likely to be encountered. Logically, the tolerances for the nominal dimensions for the pitch of the sprockets

should be positive in the first case and negative in the second. The formulas given in this proposed standard are:

$$P = 0.300 (1 - S_{\min.}) \text{ for drive sprockets; and}$$

$$P = 0.300 (1 - S_{\max.}) \text{ for holdback sprockets.}$$

In these formulas $S_{\max.}$ and $S_{\min.}$ are the per cent maximum and minimum film shrinkage likely to be encountered in the use of the

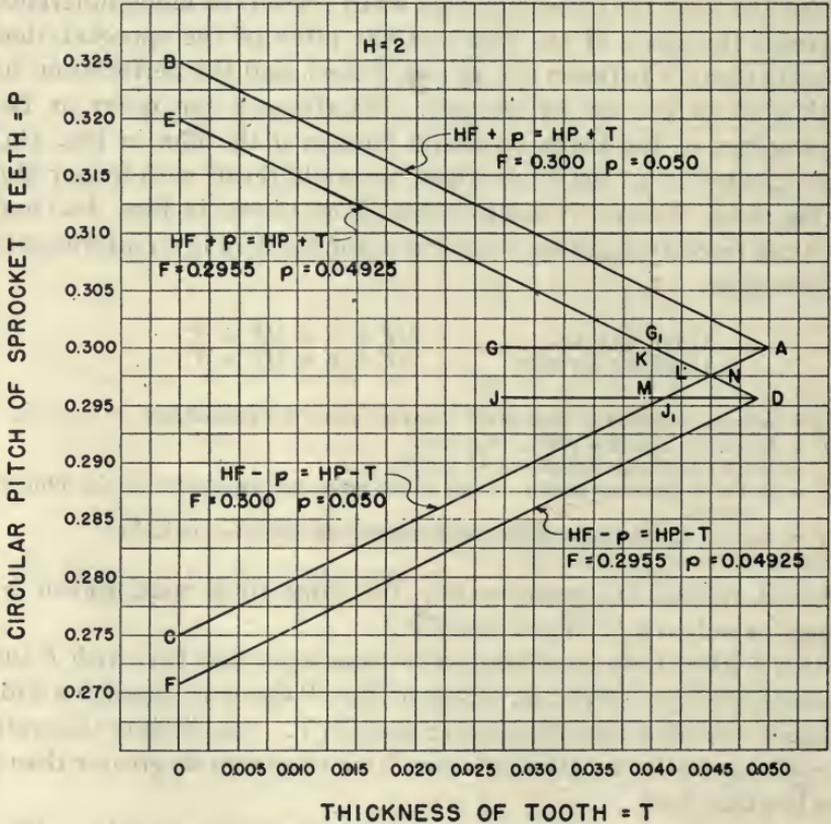


FIG. 6.

equipment being designed. They should be expressed as decimals, and if stretch is to be considered, it should be treated as negative shrinkage.

Graphical Analysis.—If, for a given value of H , such as 2, and for a definite condition of film, such as zero shrinkage, in which case $F = 0.300$ and $p = 0.050$, we plot the pitch of the sprocket teeth versus the thickness of the tooth for the two formulas derived from

Figs. 4(a) and 4(b), we obtain the curves AB and AC in Fig. 6. If the formulas are replotted for the same value of H but for a different shrinkage of film, such as 1.5 per cent ($F = 0.2955$, $p = 0.04925$), we obtain curves DE and DF in the same figure.

Examination of Fig. 6 indicates a number of interesting facts. The co-ordinates of point A at the intersection of the drive and holdback curves for film of zero shrinkage correspond to the values of F and p for such film. Similarly, the co-ordinates of point D correspond to the F and p values for which ED and FD are drawn.

Conditions of pitch of the sprocket and corresponding thickness of tooth below AB and above AC will permit operation of unshrunk film without interference. Pitch-of-sprocket and thickness-of-tooth conditions below DE and above DF will permit operation, without interference, of film shrunk 1.5 per cent. Conditions that are common to these two areas are within the triangle ENC , which indicates the pitches and tooth thicknesses of sprockets that will preclude interference for film in the range of shrinkage from zero to 1.5 per cent. A similar analysis can be made for any set of design conditions.

Inasmuch as the pitch at point A corresponds to the pitch of the longest film that would be run under these hypothetical conditions, this value should be used for the pitch of the drive sprocket, and on a like basis the pitch of a holdback sprocket should be equal to the pitch at point D .

The design co-ordinates of a drive sprocket will be on line GA , with a thickness of tooth less than that for point G_1 . The formulas for tooth thickness proposed for the new standard, Fig. 1, and derived in Section 2, of this paper indicate the optimum value at point K , which is far enough within the triangle of safe operating conditions to permit manufacturing tolerances for both the pitch and the thickness, as well as to accommodate for the teeth in partial engagement with the film. The proper holdback sprocket for the same set of conditions of film shrinkage and engagement will be on line JD , with a tooth thickness less than that for point J_1 . The formula derived in Section 2 and shown in Fig. 1 places the holdback sprocket at point M .

Combination Sprocket.—From the standpoint of graphical analysis, point N appears to be the logical choice for a combination sprocket. The optimum pitch for a combination sprocket is a compromise at best. If a properly designed drive sprocket is used as a combination sprocket, all film operating under holdback conditions is forced against the direction of external tension by each tooth

as it enters the perforation. The same is true if a holdback sprocket, used as a combination sprocket, operates under drive conditions. This indicates that the best possible combination sprocket has a circular pitch somewhere between the drive and the holdback pitches. The co-ordinates of point *N* can be determined mathematically by solving the simultaneous equations

$$\begin{aligned} HF + p &= HP + T \text{ for maximum shrinkage (line } ED) \text{ and} \\ HF - p &= HP - T \text{ for minimum shrinkage (line } CA). \end{aligned}$$

This solution yields a value of

$$P = 0.300 - 0.15 S_{\max.} - 0.15 S_{\min.} + \frac{0.025}{H} S_{\min.} - \frac{0.025}{H} S_{\max.}$$

A sprocket with this pitch will mesh perfectly with film having a shrinkage equal to the minimum shrinkage plus 53 per cent of the shrinkage range for which the design is being made. But because of other factors, it does not prove to be the optimum pitch for a combination sprocket. Any sprocket pitch between maximum and minimum film pitch will operate satisfactorily with some films and unsatisfactorily with others. The optimum pitch occurs at a point where the degree of unsatisfactory operation is reduced to a minimum. It has been found that drive-sprocket conditions are more severe than holdback sprocket conditions, as shown by Vilbrandt.² A second factor is the shape of the distribution curve showing the frequency with which various shrinkages are encountered. This tends to come to a peak nearer the minimum than the maximum end of the shrinkage range. Therefore, the combination sprocket has been designed to mesh perfectly with film having a shrinkage equal to the minimum shrinkage plus one third the shrinkage range. Its pitch is determined by the formula

$$P = 0.300 - 0.2 S_{\min.} - 0.1 S_{\max.}$$

Because this is in the drive-sprocket range, the tolerance is in the plus direction. Point *L*, Fig. 6, designates the pitch of the sprocket and the thickness of the tooth proposed for the combination sprocket.

Maximum Pitch of Film.—For selection of the value of the maximum pitch of the film, several factors must be studied. The standards that specify the pitch of the film permit a plus or minus tolerance of 0.0005 inch at the time of perforating.

Film will expand if it is subjected to high humidity, although the

amount of this change is slight. On any but very freshly perforated film, it only counteracts some of the normal shrinkage that occurs with aging. For projectors and most cameras and printers, pitches longer than permitted by the standard need not be considered. However, film, like all materials, has a modulus of elasticity governing its elongation under tension. The elongation is negligible for the forces applied in ordinary cinematographic apparatus. But there is an apparent elongation that is particularly evident when 16-mm film is run on a sprocket with a single row of teeth. This effect is caused both by the local distortion of the film at the perforation that carries the load and by the elongation of the film between perforations. The extent of the distortion depends upon the amount of tension on the film. Tension at a drive sprocket causes appreciable trouble and should be kept to a minimum. It is probably not necessary to take this distortion into consideration in the initial design, but it is well to keep it in mind so that if difficulty occurs when the sprocket is driving fresh film, the effect of the film tension on its pitch can be properly evaluated, and the circular pitch of the sprocket can be increased accordingly.

Minimum Pitch of Film.—The major factor to be considered in determining the minimum film pitch is simply the maximum shrinkage that is likely to be encountered. The permissible error in perforating is minus 0.0005 inch, which corresponds to 0.17 per cent shrinkage. Unprocessed film used in a camera or printer rarely exceeds 1.0 per cent shrinkage, and this is a satisfactory figure for S_{\max} for most equipment using unprocessed film. In projectors and other equipment using processed film, a shrinkage of 1.5 per cent should be accommodated. The greater average age of such film and varying conditions of storage account for the increase.

Summary.—The above derivation applies to 16-mm film, but the principles involved are applicable to 8-mm film.

The formulas listed below show the basis of computation for 8-mm and 16-mm sprockets. The root diameter D , in inches, of the surface on which the film lies, is

$$D = \frac{P \times N}{\pi} - 0.006$$

in each case, where N is the number of teeth. This diameter may be a part of the sprocket or a fixed guiding surface.

	Drive Sprocket	Holdback Sprocket
8-mm	$P = 0.150 (1 - S_{\min.})$	$P = 0.150 (1 - S_{\max.})$
16-mm	$P = 0.300 (1 - S_{\min.})$	$P = 0.300 (1 - S_{\max.})$
Combination Sprocket		
8-mm	$P = 0.150 - 0.1 S_{\min.} - 0.05 S_{\max.}$	
16-mm	$P = 0.300 - 0.2 S_{\min.} - 0.1 S_{\max.}$	

SECTION 2—SHAPE AND THICKNESS OF SPROCKET TEETH

Importance of Shape of Tooth.—In all cases except that of perfect mesh there must be some sliding of the edge of the perforation up or down the face of the tooth. The shape of the tooth is important not only from the standpoint of wear of the film at the point of contact, but also as it relates to the sliding of the film along the root circle of the sprocket and to the manner of transfer of the load from one tooth to the next. In the worst case, all the shrinkage differential is absorbed by a sudden jump of the film as it leaves the tip of one tooth and comes into contact with the next tooth.

It will be obvious from a study of the nature of the action of the tooth that the drive sprocket is the most critical with respect to the shape of the tooth. Therefore, most of the following derivations apply specifically to drive sprockets, and it is shown that the resulting shape and thickness of the tooth are entirely adequate for holdback and combination sprockets.

Epicycloid Curve.—It was pointed out in Section 1 of this paper that the path of the film as it enters and leaves the arc of engagement may be the arc of a circle (tangent to the root circle of the sprocket) curving either away from the sprocket, Fig. 3(a) or toward the sprocket, Fig. 3(b), or the path may be a straight line tangent to the root circle, Fig. 2. Actually, it is not necessary to assume that all possible film paths are circular arcs, but for convenience of specification and analysis, the limiting paths can be considered arcs of circles.

The most logical starting place for the analysis of the shape of the tooth is the curve generated by a point on the film relative to the sprocket when the film moves along its path without slipping on the root circle of the sprocket. Since we have assumed that the path is an arc of a circle, the curve so generated is an epicycloid. In the case of a straight path, the resulting curve is an involute and can be treated as a special case of the epicycloid in which the generating circle has an infinite radius. The generated curve is an epicycloid

whether the generating circle curves away from the sprocket or curves toward the sprocket and actually encloses it. Fig. 7 shows an epicycloid generated by a circle curving away from the root circle (curve 1), another generated by a circle curving toward the root circle (curve 2), and an involute (curve 3). The involute is the most erect

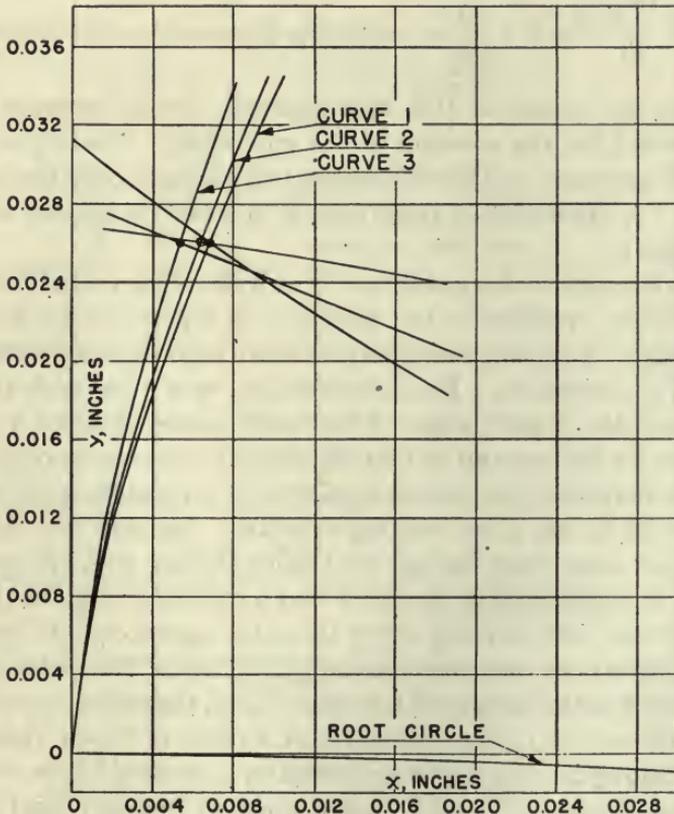


FIG. 7.

of the three. Curves 1 and 2 can be made to coincide, but the length of the arc of engagement differs greatly in the two cases.

The equation, in parametric form, for the epicycloid generated by a circle curving away from the root circle can be expressed as follows:

$$\begin{aligned} y &= R_1[(1 - \cos \alpha) - \rho(1 + \cos \theta)] \\ x &= R_1[\rho \sin \theta - \sin \alpha], \end{aligned}$$

where x and y are the rectangular co-ordinates of the epicycloid with

the origin at the base of the epicycloid (also the base of the tooth); the x axis being tangent to the root circle at the origin.

R_1 = the radius of the generating circle

D = the root diameter of the sprocket

θ = the angle through which the sprocket turns in generating the curve up to the point (x, y)

$\alpha = \rho\theta$ = the angle which the film makes with the x axis at point (x, y) , (see Fig. 9)

$$\rho = \frac{R_1 + D/2}{R_1} = 1 + \frac{D}{2R_1} \text{ (a relationship introduced for convenience).}$$

During the course of this investigation, several universal charts were devised for the solution of the epicycloid. These give a high degree of accuracy and have numerous advantages over the equation method. A discussion of these charts, however, is beyond the scope of this paper.

Since the epicycloid is generated by a circle rolling on the root circle, it is the locus—relative to the sprocket—of a point on the film, such as the edge of a perforation, provided there is no slippage between the film and the sprocket. The epicycloid curve is a valuable reference from which the desired shape of the tooth can be deduced by proper allowance for the amount of film shrinkage to be accommodated.

It is obvious that the reference epicycloid to consider is the one that corresponds to the most limiting condition—namely, the film path that curves away from the sprocket along the arc with the minimum radius. It is proposed in Section 1 that a radius of $1/4$ in. be the minimum for the path curving away from the sprocket. To provide a factor of safety for occasional greater shrinkage of film or for inadvertent cases of paths with radii less than $1/4$ in., the reference epicycloid for this derivation is that generated by a circle of $3/16$ -in. radius.

Fig. 8 shows the epicycloid generated by a circle of $3/16$ -in. radius on the root circle of a 12-tooth, 16-mm sprocket (curve 1) and also the epicycloid generated by a circle of $1/4$ -in. radius on the same root circle (curve 2). The difference is such as to accommodate approximately 0.12 per cent additional shrinkage.

Allowance for Shrinkage at Tip of Tooth.—Now it is necessary to consider the action of the tooth. Fig. 9 shows on a large scale the film and one tooth of a 12-tooth sprocket. If the tooth is moving to the left and the film tension is to the right, we have a drive sprocket. The circular pitch of the sprocket is greater than the pitch of the film. The action, therefore, takes place as the film slides up the tooth and leaves the sprocket.

The radius of the film path is $\frac{3}{16}$ in., and the corresponding epicycloid (curve 1, Fig. 8) is shown again, as curve 1 on Fig. 9. If the shape of the tooth is such as to guide the film along this epicycloid, the film will not slip on the sprocket until after it leaves the tip of the tooth, whereupon it will jump to the right and will stop suddenly

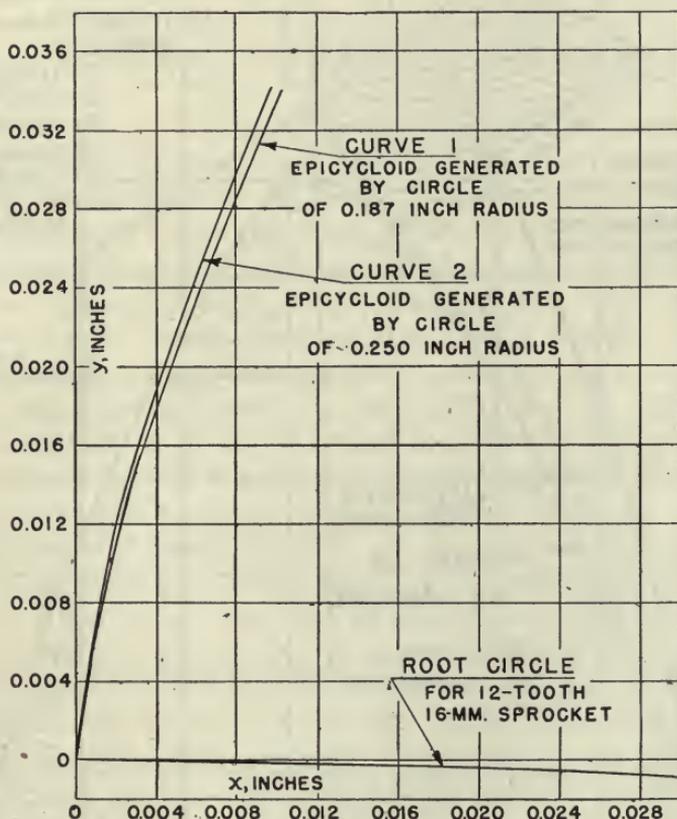


FIG. 8.

when the next perforation engages the next tooth to the right. Any tooth shape falling to the left of the epicycloid will first slide the film to the left on the sprocket and then allow a greater amount of jump to the next tooth. A tooth shape falling to the right of the epicycloid will let the film slip back gradually and thus accommodate part or all of the shrinkage differential before the film reaches the tip of the tooth. The optimum condition is reached when the tooth just allows accommodation of the maximum shrinkage differential when the film is

ready to leave the tip of the tooth. If the film is shrunk less or the path has a larger radius, there will be full accommodation earlier and the film will leave the tooth before it reaches the top.

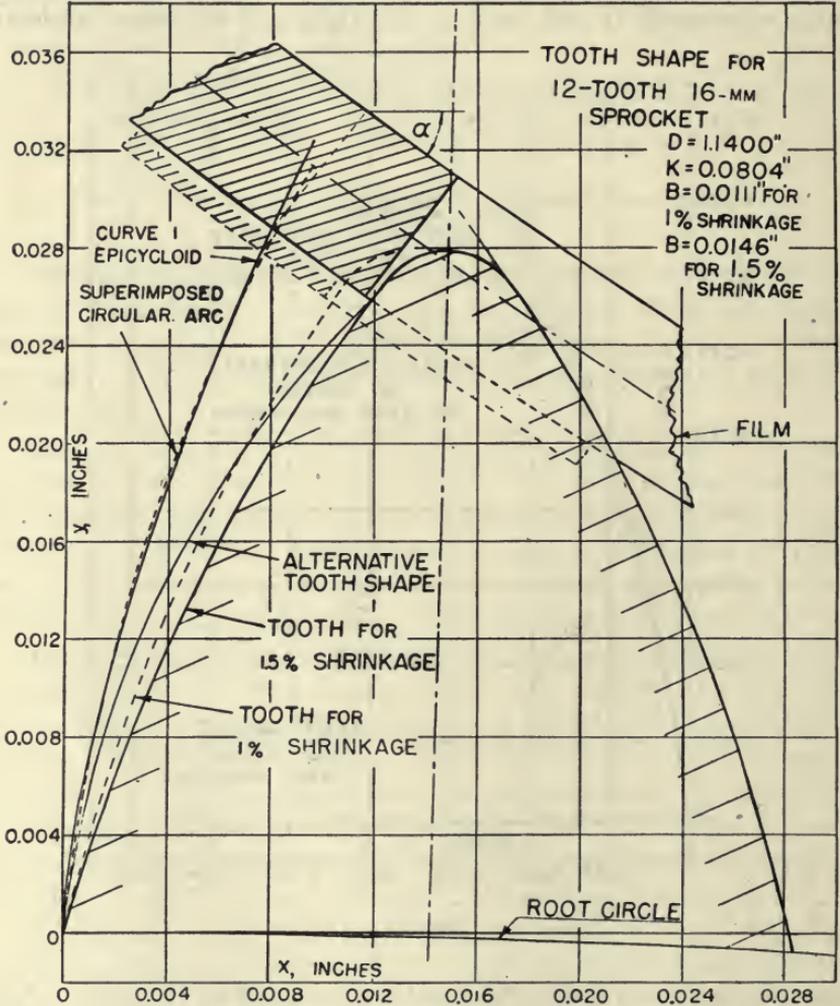


FIG. 9.

With a film path of $\frac{3}{16}$ -in. radius, one tooth is always fully disengaged before the film starts to move up from the base of the succeeding tooth. (This is true even for an 8-mm sprocket with an infinite number of teeth.) Therefore, the shrinkage differential with which we are concerned is that for one pitch length of film. For example,

if the shrinkage range is from 0 to 1.5 per cent, the circular pitch of the sprocket is chosen to match unshrunk film (0.300 in.) and the maximum pitch differential is 1.5 per cent of 0.300 in. or 0.0045 in. The proposed tolerances for the pitch of the drive sprocket are plus 0.0003 in., minus 0.0000. Therefore, an additional allowance of approximately 0.0003 in. is made in establishing the location of the tip of the tooth.

The maximum permissible thickness of the tooth for a given path of film engagement and the required shape of the tooth automatically fix the maximum height of the tooth. It is necessary to establish a minimum height of tooth upon which to base the analysis of the shape. The minimum height of 0.028 in. has been found practical, and a minimum top land of 0.003 in. is considered good design practice. In order to permit some rounding of the tip, a working height of 0.026 in. has been used in this analysis.

Fig. 9 shows two film positions, one in solid lines for a shrinkage of 1.5 per cent and one shown by broken lines for a shrinkage of 1 per cent. In each case the lower edge of the perforation is 0.026 in. above the root circle, and the film is just ready to leave the tooth.

Specification of Shape of Tooth.—So far, only two points on the profile of the tooth have been located, one at the maximum working height of 0.026 in. and the other at the intersection with the root circle. Obviously, the manner in which the film is allowed to slip to take care of the shrinkage differential is controlled by the shape of the tooth between these two points. Here, again, the epicycloid curve serves as a valuable reference. However, the relationship between the way the film slips and the running life of the film is not directly evident. The ultimate solution lies in exhaustive wear tests, with due consideration to all the other factors involved. A convenient method of specifying the shape of the tooth is to state the radius K of a circular arc and the distance B from the root circle to the center for the arc. (When B is positive, the center is inside the root circle.) This method is justified not only for its convenience but for practical considerations of manufacture. That the circular arc is adequate can be seen in Fig. 9 from the close agreement of the circular arc with the epicycloid. One logical procedure for defining the shape of the tooth has been completely worked out and is described here, followed by a brief discussion of an alternative procedure.

The first method is based on the circular arc that best approximates the epicycloid. As the shrinkage differential increases, the radius K

of the tooth (Fig. 1) remains constant, but B , the distance from the root circle to the center of the radius, is increased. This brings the upper end of the tooth to the proper terminal point and provides a uniform shrinkage adjustment as the film moves up the face of the tooth.

If the radius K is determined for sprockets having different numbers of teeth, it is possible to plot a curve of K versus $1/N$, where N is the number of teeth. The use of $1/N$ as the independent variable permits plotting values of N up to infinity on a single curve. The curvature of the root circle is a direct function of $1/N$, and it is logical that other variables are related more directly to $1/N$ than to N . The following equation for K was found to fit the curve of K versus $1/N$ satisfactorily.

$$K = 0.111 - 0.45/N + 1/N^2.$$

This illustrates the value of equations in the proposed standards.

By a similar process, curves for the value of B were determined. Here there are two variables, the number of teeth and the shrinkage of the film. To allow the engineer full scope in design, the shrinkage has been included as a variable in the proposed equation for B . (For a discussion of shrinkage, see Section 1, Maximum Pitch of Film and Minimum Pitch of Film.)

$$B = (0.025 + S_{\max.} - S_{\min.}) \left(0.98 - \frac{4}{N} + \frac{10}{N^2} \right) - 0.0140.$$

Where practicable, the above derivations were obtained mathematically. All graphical analysis was done at a scale of approximately $250\times$, so that a high degree of accuracy resulted. The proposed tolerances for K and B (Fig. 1) provide approximately the same accuracy at the tip of the tooth as that for pitch, and they are in the direction to allow additional clearance. It will be noted that for the case of zero range of shrinkage, the value for B given by the above equation specifies a curve falling a little to the right of the epicycloid. This deviation is provided because the film, as shown by Fig. 9, makes contact at the upper edge of the perforation rather than at the lower edge, the edge that generated the epicycloid.

It may be argued that the above procedure will result in a tooth that slants too much at its base for good driving action, particularly when the tension on the film is high. The alternative procedure for determining the shape of the tooth overcomes this objection. By this method the value of B is made independent of the range of

shrinkage and approximates the value given by the above equation for zero range of shrinkage. The value of K must then vary with the range of shrinkage, from about the value given above to lower values as more shrinkage is accommodated. The resulting tooth is very nearly tangent to the epicycloid at its base but never crosses to the left of the epicycloid. This gives the steepest permissible tooth at the base. Equations for this procedure have not been completely derived, but the shape for 1.5 per cent shrinkage on a 12-tooth sprocket is shown by a light line on Fig. 9. Also, 8-tooth sprockets have been constructed in accordance with both the above procedures for comparative tests. The running life of the film should be considered the most important criterion for the final choice of the pro-

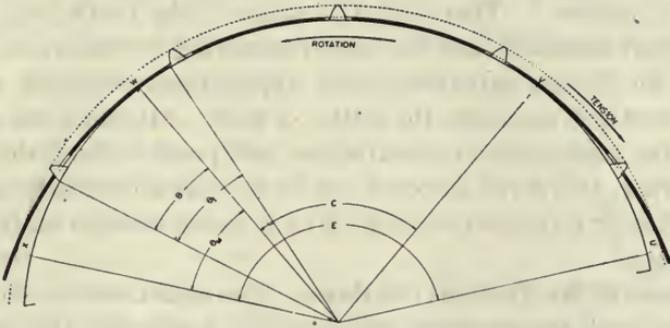


FIG. 10. Twelve-tooth sprocket for 16-mm film; 1.5 per cent shrinkage.

cedure to standardize. There appears to be an advantage in the first procedure from the standpoint of flutter, and it is possible that at moderate film tensions the slant of the tooth at its base will prove beneficial in helping to strip the film from the sprocket.

It is also possible to specify an involute with a given pressure angle for the shape of the tooth. This is not being recommended for the standard, as it results in a tooth which is even more slanting at its base than the tooth obtained by the first procedure.

Minimum Radius of Path Curving Toward Sprocket.—If the radius, R_2 (Fig. 3(b)), of the path curving toward the sprocket is equal to the radius of the root circle plus $\frac{3}{16}$ in., the epicycloid generated is identical with the reference epicycloid used in establishing the shape of the tooth. This cannot be specified as the value of R_2 , however, because usually more than one pitch length is involved in the path of disengagement (W to X in Fig. 10). For this reason the

accommodation required for shrinkage may be greater than in the first case. Also, the slope of the film is less than before. By trial and error, a value of R_2 can be found for any specific case. The simple equation, $R_2 = 0.7 D$, given in the proposed standard (Fig. 1) is conservative for values of N from 8 to 55. The more precise equation,

$$1/R_2 = 19/N - 26/N^2 - 0.060,$$

applies to all values of N . Both equations are limited to the first procedure for specifying the shape of the tooth. It may be necessary to revise them if the second procedure is adopted.

The shape of the path defined by the precise equation for R_2 and the values of K and B determined by the first procedure approach very closely the solution previously developed for considerations of flutter alone by Chandler.⁴ Therefore, the shape of the tooth specified by the proposed standard and the path designated by the more precise equation for R_2 are satisfactory for applications requiring a drive sprocket that will minimize the flutter of film. Although less advisable from the standpoint of construction and possibly from the standpoint of wear, this drive sprocket can be used as a holdback sprocket with low flutter if precautions are taken to guide the film on the teeth as it engages.

Thickness of the Tooth at the Base.—The equations for the thickness of the tooth require some explanation. As given in the proposed standard, these equations apply to the first procedure for determining the shape. Instead of a detailed mathematical treatment of this point, only the steps involved are discussed.

Fig. 10 shows a section of a 12-tooth sprocket with allowance for shrinkage of 1.5 per cent. The most critical condition for interference caused by the thickness of the tooth is when the engaging and disengaging paths of the film are of minimum radius R_2 . A tooth in any position in the path from U to V must be free to enter the perforation without touching the film.

The thickness of the tooth must be reduced from the maximum value of 0.050 in. by the shrinkage of the film in the arc of contact from V to W . Additional allowance must be made for the film in partial engagement, between U and V and between W and X .

The angle θ is the angle subtended by the path of disengagement from the point of tangency W to the base of the tooth under consideration. It varies from zero to θ_M (Fig. 10). Let D be the amount that the tooth has been modified from the epicycloid. This is very nearly

proportional to θ^2 and is plotted as the solid line of Fig. 11. If the plot of D versus θ fell along the straight broken line, the shape of the tooth would be such that no additional reduction in thickness would be required for the regions of partial engagement. The slope of this broken line is D_I/θ_I , where D_I is the shrinkage differential for one pitch length, which corresponds to the index angle of the sprocket θ_I . The value of ΔD_M , or the maximum difference between the curves of Fig. 11, is the additional allowance needed to avoid interference because of the action of the tooth along the path W to X (Fig. 10). However, an equal amount of interference will occur, if the tooth is symmetrical, along the path U to V . The formula for the thickness of the tooth of a drive sprocket,

$$T_{\max.} = 0.50 - 0.15 (H + F) (S_{\max.} - S_{\min.} + 0.001),$$

includes the following reductions: one for the shrinkage of the film in the arc of contact; a second, $2\Delta D_M$, for the reasons indicated above; a third for the pitch tolerance allowed for the sprocket; and a fourth, $\frac{1}{2}D_I$, for positive clearance. In the formula, H is the number of pitch lengths in the arc of contact, C (Fig. 10), and F is the total number of pitch lengths in the arc of engagement E .

Holdback and Combination

Sprockets.—The action of drive and holdback sprockets has been discussed in Section 1 of this paper. Let us consider the faces of the teeth toward the region of full engagement as "inside" faces, and those away from the region of full engagement as "outside" faces. On the normal drive sprocket the film makes contact with the outside face of the tooth; on the normal holdback sprocket the film makes contact with the inside face of the tooth. Thus the reference epicycloid for a holdback sprocket curves away from the tooth, rather than along the tooth as it does for a drive sprocket, and much more accommodation for shrinkage is available than is needed. As a result, the shape of the tooth is not critical unless the steepness at the base becomes an important factor. For the sake of uniformity, the same shape of tooth has been

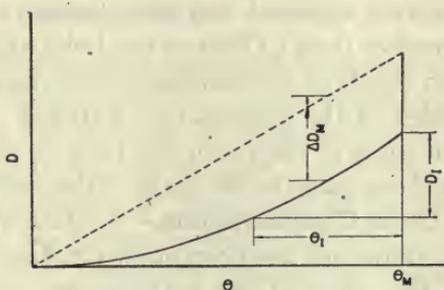


FIG. 11. Tooth modification versus angle of rotation.

recommended for all three types of sprocket. The formulas for R^2 and T_{\max} are likewise conservative for the holdback sprocket.

If a holdback sprocket with a pitch equal to that of the shortest film is rotated in the opposite direction (*i. e.*, made to operate as a drive sprocket), the film still bears against the inside face of the tooth. The film, however, strikes the inside face of the tooth at an unfavorable angle, and only a small portion of the height of the tooth acts to force the film forward to make the shrinkage accommodation. If a drive sprocket is operated as a holdback sprocket, the action remains on the outside face of the tooth. With proper design all or most of the height of the tooth is available for the shrinkage adjustment. Guides may be needed to ensure engagement of the film; any friction caused by the guides will assist in holding the film back, thus decreasing the load on the tooth. This arrangement has been recommended for holdback sprockets when low flutter is required.

It is for these reasons, as well as others, that the pitch of the combination sprocket has been located closer to the pitch of the drive sprocket than to that of the holdback sprocket. Theoretically, only two thirds of the shrinkage differential need be accommodated in the design of the combination sprocket. Therefore, the formula for the thickness of the tooth has been changed accordingly, but no change has been made in the shape of the tooth.

Other Considerations.—In the derivation of the formulas of Fig. 1 no allowance has been made for stretch of the film or for deformation at the edges of the perforations under normal operating tensions. High-speed motion pictures and wear tests made by Dr. C. F. Vilbrandt under Dr. E. K. Carver, head of the Department of Manufacturing Experiments, Eastman Kodak Company, have shown that these factors are of more importance than originally supposed. On the drive sprocket, distortion of the perforation gives the film an effectively longer pitch. This adversely affects the action of the teeth. In many cases severe flexing of the film may result, causing early failure from fatigue. On the holdback sprocket, any distortion of the leaving perforation in effect reduces the pitch of the film, which again degrades rather than improves the action. It has been observed that the film-flexing condition is less severe in the case of the holdback sprocket.

One advantage of the equation form of the proposed standard is its great flexibility. Suitable changes can readily be introduced to allow for the effects of stretch and distortion of the film. No attempt has

been made in the present analysis to incorporate these alterations. It is felt that more precise quantitative information is needed and that any such proposed changes should be backed by thorough testing before their presentation. On the basis of test observations, for sprockets made according to the formulas of Fig. 1 it is recommended that the tension not exceed 4 oz for drive sprockets nor 8 oz for holdback sprockets.

The number of film pitch lengths in the arc of contact and in the arc of engagement has a bearing upon the operation of the sprocket, especially if appreciable amounts of distortion are present. For practical reasons the minimum recommended value of H has, therefore, been set at 2, except for the special conditions noted in the Appendix of Fig. 1.

SECTION 3—LATERAL PROFILE

Need of Specifying Lateral Profile.—It is necessary to pay special attention to the lateral profile of sprockets for motion picture film in order to provide protection for the film in three ways. The first of these is protection against physical damage to the fillet of the perforation by the corner of the tooth. Inasmuch as the base of the tooth is formed by two machining operations, there is an unavoidable sharp corner which is extremely difficult to remove without damage to the tooth. In addition to potential damage to the film, the action between the film and the sprocket is erratic and unsatisfactory if the tooth rides on the fillet rather than on the flat of the perforation.

The second and third zones to protect are the picture area and the sound-track area. As described in the section on pitch, except in the rare case of perfect mesh there will be slippage between sprocket and film as each tooth leaves a perforation. Although in many designs the emulsion surface of the film does not come into contact with the sprocket, abrasion marks on the support can affect picture or sound quality quite objectionably. The purpose, therefore, of specifying lateral profile is to ensure both the proper location and the size of the tooth in relation to the guide for the edge of the film. Moreover, it is necessary to locate the zones that are recessed or undercut below the root diameter so that there will be no contacting surface between the picture or sound-track area and the sprocket.

Edge to Be Guided.—Several conditions must be established before the dimensions can be determined. The first of these is the

choice of the edge of the film that will be guided. In sound equipment the film should be positioned by a fixed guide at the sound-track edge (*Z22.16-1941* and *Z22.15-1946*). Moreover, Specification *Z22.14-1941* specifies location from this side at the picture aperture. Thus the standards indicate that the location should be from the sound-track edge of the film on *all* sprockets in sound equipment and in any other apparatus through which sound film may be run. These proposed specifications for sprockets recommend that all 16-mm equipment be designed to take sound film without damage. If, however, the basic design requires sprockets with two rows of teeth it makes little difference which side of the film is guided, as long as the dimensions and location of the teeth are specified in relation to that guiding edge according to the principles described in this analysis.

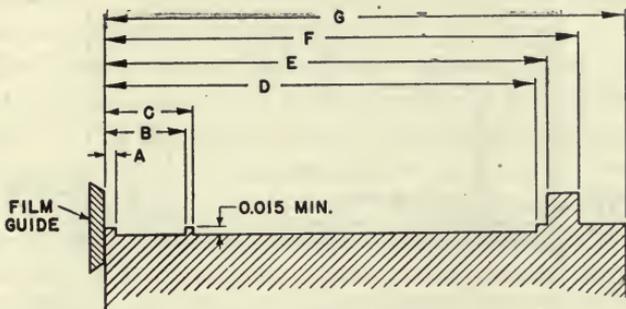
Shrinkage of the Film.—The second condition to be considered is the inevitable effect of film shrinkage. Measurements indicate that the lateral shrinkage of film is usually greater than the linear shrinkage. In some cases the difference is as much as 50 per cent, but the average is approximately 20 per cent. Based upon current experience, we shall consider lateral shrinkages of 1 per cent and 1.8 per cent as the highest to be encountered in equipment using unexposed film and processed film, respectively. Statistics regarding the actual amounts of linear and lateral shrinkage that equipment in the field may be required to accommodate are beyond the scope of this report. A valuable contribution to the field of motion picture engineering would be made by an extension of the work described by Maurer and Bach.⁵

Applicable Specifications.—For an analysis of the lateral profile it is necessary to consider the applicable specifications, which are listed below, as well as the shrinkage characteristics of the film itself.

- Z22.12-1941* Cutting and Perforating Negative and Positive Raw Stock
- Z22.13-1941* Camera Aperture
- Z22.14-1941* Projector Aperture
- Z22.15-1946* Emulsion and Sound Record Positions in Camera
- Z22.16-1941* Emulsion and Sound Record Positions in Projector
- Z22.41-1946* Sound Records and Scanning Area

Many of these standards have been revised since 1941 as temporary War Standards (*Z52*), and practically all are now being considered for revision and reissue. As far as possible, this paper is based on

the latest information available in each case. At each point the worst condition imposed by tolerances should be provided for, and if at all practicable, the profile should ensure protection of the entire



Dimension	Column I	Column II	Column III	Column IV	Column V	Tolerance
Range of film shrinkage, per cent	0	0 to 1.0	0 to 1.8	0 to 1.0	0 to 1.8	
Width of protected picture area	0.404	0.404	0.404	0.392	0.392	
A	0.016	0.016	0.016	0.016	0.016	+0.000 -0.002
B	0.100	0.100	0.100	0.100	0.100	+0.002 -0.000
C	0.109	0.108	0.107	0.114	0.113	+0.000 -0.002
D	0.519	0.519	0.519	0.513	0.513	+0.002 -0.000
E	0.534	0.534	0.534	0.534	0.534	+0.002 -0.000
F	0.580	0.574	0.570	0.574	0.570	+0.000 -0.002
G	0.630	0.630	0.630	0.630	0.630	+0.002 -0.000
Width of rail (C-B)	0.009	0.008	0.007	0.014	0.013	+0.000 -0.004
Width of tooth (F-E)	0.046	0.040	0.036	0.040	0.036	+0.000 -0.004

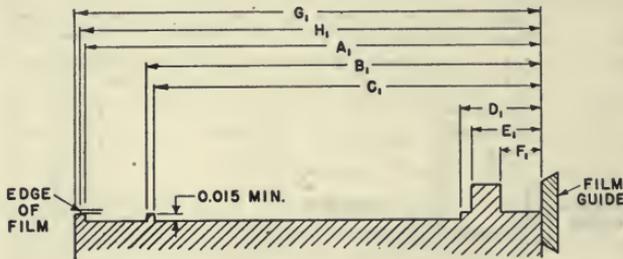
NOTE: All dimensions are in inches.

FIG. 12.

picture area photographed in the camera and the entire recorded sound track.

Guide at the Sound-Track Edge.—Fig. 12 shows in tabular form the lateral dimensions for a sprocket accommodating film that is guided at the sound-track edge. The nominal dimension for each point is derived from the most unfavorable tolerance of the

applicable specification. The tolerances are unilateral in the direction to give increased protection to the film. The value of 0.002 in. is considered a practical manufacturing tolerance, but smaller



Dimension	Column I	Column II	Column III	Column IV	Column V	Tolerance
Range of film shrinkage, per cent	0	0 to 1.0	0 to 1.8	0 to 1.0	0 to 1.8	
Width of protected picture area						
A_1	0.404	0.404	0.404	0.392	0.392	
B_1	0.614	0.614	0.614	0.614	0.614	+0.002 -0.000
C_1	0.528	0.523	0.518	0.523	0.518	+0.000 -0.002
D_1	0.521	0.521	0.521	0.515	0.515	+0.002 -0.000
E_1	0.109	0.108	0.107	0.114	0.113	+0.000 -0.002
F_1	0.096	0.095	0.094	0.095	0.094	+0.000 -0.002
G_1	0.048	0.048	0.048	0.048	0.048	+0.002 -0.000
H_1	0.630	0.630	0.630	0.630	0.630	+0.002 -0.000
Width of rail (B_1-C_1)	0.628	0.622	0.617	0.622	0.617	+0.002 -0.000
Width of tooth (E_1-F_1)	0.007	0.002	No rail	0.008	0.003	+0.000 -0.004
Support for film (H_1-A_1)	0.048	0.047	0.046	0.047	0.046	+0.000 -0.004
	0.014	0.008	0.003	0.008	0.003	+0.002 -0.002

NOTE: All dimensions are in inches.

FIG. 13.

tolerances may be specified by the engineer if conditions permit. No taper is shown on the sides of the tooth because it is so narrow. If desired, a taper of 0.002 in. per side may be specified.

Column I is for unshrunk film and protection of the full 0.404-in. width of the camera aperture. Because of permissible variations in

the location of the perforation and in the width of the film, the maximum width of the tooth has been reduced from the 0.052-in. width of the straight section of the perforation to 0.046 in., with a minimum width of 0.042 in. The rail between the sound record and the picture area varies from 0.009 in. to 0.005 in.

If the film were to shrink laterally and still be guided at the same edge, scratching or interference would develop at points dimensioned by *A*, *C*, and *F*. In Columns *II* and *III* are tabulated the dimensions for the same full-aperture protection as in Column *I*, but for film shrinkage ranges of 0 per cent to 1 per cent and 0 per cent to 1.8 per cent, respectively. Even in the case of lateral shrinkage of 1.8 per cent, dimension *A* will change less than 0.0005 in. and can be left at 0.016 in. Shrinkages of 1 per cent and 1.8 per cent reduce the dimension *C* to 0.108 in. and 0.107 in., respectively, and make corresponding reductions in the maximum width of the rail to 0.008 in. and 0.007 in.

Shrinkage of the width of film corresponding to dimension *F* is of greater importance. For the two amounts of shrinkage under consideration, the 0.580-in. dimension is reduced to 0.574 in. and 0.570 in., and the maximum width of the tooth becomes 0.040 in. and 0.036 in., with minimum widths of 0.036 in. and 0.032 in. Because the tooth is in operating engagement with the film, a natural reaction at this point in the analysis is to change the edge guide to the perforated edge of the film.

Guide at the Perforated Edge.—Fig. 13 shows in tabular form the lateral profile of a sprocket based upon the same ASA specifications used for Fig. 12 except that the guide is at the perforated edge. Under this condition one additional point must be considered, the sound-track edge of the film, to which the dimension H_1 has been applied on the sketch. Nomenclature is the same as on Fig. 12, but the subscript₁ indicates that the film is being guided at the perforated edge. As in Fig. 12, Column *I* shows the dimensions for unshrunk film and protection of the full 0.404-in. width of the camera aperture. Columns *II* and *III* show the same dimensions for film-shrinkage ranges of 0 per cent to 1 per cent and 0 per cent to 1.8 per cent, respectively. Because variations in the slit width of the film have no effect here, the maximum width of the tooth has been increased to 0.048 in. Dimensions E_1 , D_1 , B_1 , and H_1 will be affected by lateral shrinkage. Shrinkage of 1.8 per cent will reduce dimension E_1 only 0.002 in., to 0.094 in., which makes the width of the tooth 0.046 in.

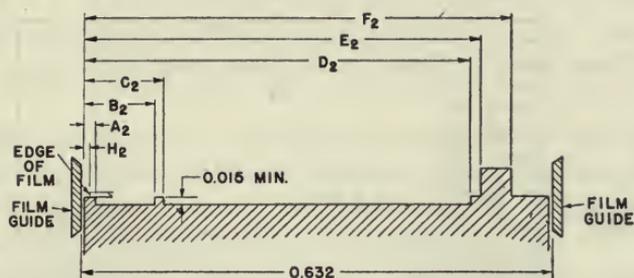
with a minimum of 0.042 in. From the standpoint of the manufacture of the sprocket and wear of the film, this is highly desirable, but there is an undesirable effect at the other edge of the film. The B_1 dimension, 0.528 in., must be corrected for shrinkage, reduced 0.005 in. to 0.523 in. for a shrinkage of 1 per cent and reduced 0.010 in. to 0.518 in. for a shrinkage of 1.8 per cent. These changes in B_1 cause the width of the rail between the sound-track area and the picture area to be reduced in the case of a shrinkage of 1 per cent to a maximum of 0.002 in., and in the case of 1.8 per cent there is no rail at all. For dimension D_1 , shrinkages of 1 per cent and 1.8 per cent reduce the dimension from 0.109 in. to 0.108 in. and 0.107 in., respectively.

A much more serious problem, however, is caused by the change in the dimension H_1 . Shrinkage of 1.8 per cent will reduce this from a minimum of 0.628 in. to 0.617 in. This leaves only 0.001 in. to 0.005 in. of support for the outer edge of the film.

Reduction of Protected Width.—Even in the case of guiding at the sound-track edge of the film, the rail between the sound-track area and the picture area is impracticably small. This indicates that it is not advisable to protect the full width of the picture area. With a 0.404-in. camera aperture and a 0.380-in. projector aperture, there is a margin of 0.012 in. for misalignment in either direction. Because of questions of alignment and tolerances for other parts of the equipment, it is inadvisable to utilize this full value for additional support, but part of it can be considered more useful for support than for margin. This part should not exceed 50 per cent or 0.006 in. on each side.

If the support between the sound track and the picture area is increased by the 0.006 in. mentioned above, increasing C in Fig. 12 or decreasing C_1 in Fig. 13, the width of the rail is increased for unshrunk film from a maximum of 0.009 in. to 0.015 in. in the first case and from a maximum of 0.007 in. to 0.013 in. in the second case. For film with 1.8 per cent shrinkage, however, the maximum width of the rail becomes 0.013 in. for guiding at the sound-track edge and is still only 0.003 in. for guiding at the perforation edge. Columns *IV* and *V* in Fig. 12 and 13 show the dimensions for the two shrinkage ranges and the narrower protected picture area. Inasmuch as manufacturing tolerances reduce the last dimension to zero (physically), it appears advisable to retain as a standard the guide at the sound-track edge, Columns *IV* and *V*, Fig. 12.

Channel Guide.—An alternate method of film guiding utilizes a channel or two fixed guides between which the film can wander from side to side. Fig. 14 shows such a system. The separation between the guides should be not less than 0.632 in. to accommodate film



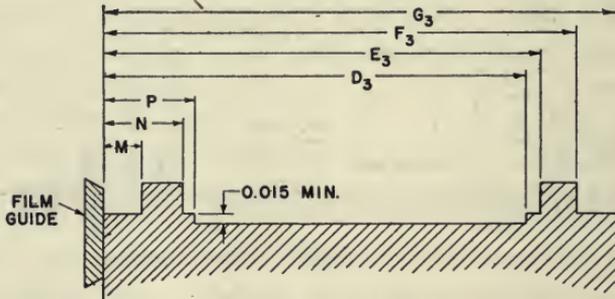
Dimension	Column I	Column II	Column III	Column IV	Column V	Tolerance
Range of film shrinkage, per cent	0	0 to 1.0	0 to 1.8	0 to 1.0	0 to 1.8	
Width of protected picture area	0.404	0.404	0.404	0.392	0.392	
A_2	0.016	0.016	0.016	0.016	0.016	+0.000 -0.002
B_2	0.104	0.109	0.114	0.109	0.114	+0.002 -0.000
C_2	0.109	0.108	0.107	0.114	0.113	+0.000 -0.002
D_2	0.523	0.524	0.525	0.518	0.519	+0.002 -0.000
E_2	0.536	0.537	0.538	0.537	0.538	+0.002 -0.000
F_2	0.580	0.574	0.570	0.574	0.570	+0.000 -0.002
H_2	0.004	0.010	0.015	0.010	0.015	+0.000 -0.002
Width of rail ($C_2 - B_2$)	0.005	No rail	No rail	0.005	No rail	+0.000 -0.004
Width of tooth ($F_2 - E_2$)	0.044	0.037	0.032	0.037	0.032	+0.000 -0.004
Support for film ($A_2 - H_2$)	0.012	0.006	0.001	0.006	0.001	+0.002 -0.002

NOTE: All dimensions are in inches.

FIG. 14.

0.630 in. wide. Points A_2 , C_2 , and F_2 are governed by the potential contact of the film with the left-hand guide and are dimensioned as in Fig. 12. Points H_2 , B_2 , D_2 , and E_2 , must accommodate film in contact with the right-hand guide and can be dimensioned from the left-hand guide as 0.632 in. minus the corresponding dimensions on

Fig. 13. Examination of the dimensions in Column V, Fig. 14, shows that for film shrunk 1.8 per cent the support for the left edge of the film may vary from 0.003 inch to a negative value of 0.001 inch. There is no rail between the sound track and the picture area, and the



Dimension	Column I	Column II	Column III	Column IV	Column V	Tolerance
Range of film shrinkage, per cent	0	0 to 1.0	0 to 1.8	0 to 1.0	0 to 1.8	
Width of protected picture area	0.404	0.404	0.404	0.392	0.392	
<i>M</i>	0.048	0.048	0.048	0.048	0.048	+0.002 -0.000
<i>N</i>	0.096	0.095	0.094	0.095	0.094	+0.000 -0.002
<i>P</i>	0.109	0.108	0.107	0.114	0.113	+0.000 -0.002
<i>D</i> ₃	0.519	0.519	0.519	0.513	0.513	+0.002 -0.000
<i>E</i> ₃	0.534	0.534	0.534	0.534	0.534	+0.002 -0.000
<i>F</i> ₃	0.580	0.574	0.570	0.574	0.570	+0.000 -0.002
<i>G</i> ₃	0.630	0.630	0.630	0.630	0.630	+0.002 -0.000
Width of tooth <i>LH</i> (<i>N-M</i>)	0.048	0.047	0.046	0.047	0.046	+0.000 -0.004
Width of tooth <i>RH</i> (<i>F</i> ₃ - <i>E</i> ₃)	0.046	0.040	0.036	0.040	0.036	+0.000 -0.004

NOTE: All dimensions are in inches.

FIG. 15.

tooth is narrower than in either of the other two cases. Again it seems best to return to Columns IV and V of Fig. 12 for the standard.

Sprockets with Two Rows of Teeth.—Fig. 15 shows the lateral dimensions of a sprocket with two rows of teeth. The tooth adjacent to the edge guide corresponds in size and location to the tooth in Fig. 13. Similarly, the tooth on the opposite side corresponds

to Fig. 12 and is narrower. It is essential to use edge guiding in this case also in order to avoid potential damage to the film by the tooth. If channel guiding were used, the teeth would be of equal width, but both would be narrower than either of those shown in Fig. 15. Column *IV* and *V* are included in the proposed standard. This construction is shown for apparatus limited to silent film. But it is not recommended because of the increasing prevalence of sound film.

Summary.—The teeth, themselves, should not be used as lateral guides, since they may cause destructive action between the corner of the tooth and the fillet of the perforation, with attendant erratic performance.

For each particular application the design engineer must decide which edge to guide. In the case of silent equipment, in which provision is to be made for running single-perforated film, possibly it is advisable to guide at the perforated edge with some encroachment on the sound-track area under extreme conditions. In the case of sound equipment and for a standard, it appears best to specify guiding at the unperforated edge of the film. Based on this thought, Columns *IV* and *V* of Fig. 12 are proposed for the standard.

CONCLUSION

In the preceding sections of this paper we have described several of the variables that affect the interaction of the film and the sprocket. The proposed standard is designed to bring them to the attention of the engineer. It provides means whereby he can accommodate for these variables as they apply to his particular problem.

The principal advantages of the proposal are its adaptability and its flexibility. It is adaptable to any application regardless of the size and the function of the sprocket and also of the path and the shrinkage of the film. It is flexible because it is presented in such a form that if changes are made in the physical properties of film or if research discovers new conditions of improved operation, the formulas can be adjusted to keep the standard up to date.

We believe that the method of approach, analysis, and presentation used in the derivation of this proposal can be applied with beneficial effects to other standardized elements of cinematographic apparatus.

[*Ed. Note.*—Dr. E. W. Kellogg has forwarded a "Discussion by Letter" in which he raises a pertinent question as to whether the

Society should "standardize" certain dimensions of sprockets at all. It was received too late to obtain comments from the authors and include them in this issue of the JOURNAL. The letter, together with other discussion of the paper, will be published with the authors' views in a later issue.]

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THE PROJECTION LIFE OF 16-MM FILM*

C. F. VILBRANDT**

Summary.—With the advent of 16-mm motion picture film into the educational and commercial fields has come the demand for increased projection film life. At the same time, to avoid loose, unsatisfactory winding of the large projection rolls in use today, higher windup tensions are required. In this paper the effect of windup tension on projection life of the film is described and compared with the effect of feed tension. The importance of the relationship between sprocket pitch, film pitch, and film wear is discussed.

Introduction.—Until comparatively recently the use of 16-mm film was limited to amateurs for home movies. Seldom were such pictures projected more than one hundred times. Thus the problem of projection life was not an acute one. However, as the advantages of 16-mm films for advertising, educational, and entertainment purposes became apparent, the number of projections required of a print or reversal film sharply increased. At the same time, larger rolls up to 2000 ft in length were desired by the trade.

Increasing the size of the roll requires greater take-up tension to avoid loose winding. Loosely wound rolls are awkward to handle and are subject to certain defects which tend to decrease the number of satisfactory projections obtained from a print. On the other hand, an increase of winding tension increases the wear on the perforations by the sprocket teeth. The designer and manufacturer of projectors must seek a compromise to ensure the maximum number of projections from a print.

This paper deals with the effects of certain variables on the projection life of 16-mm film. For the purpose of the studies reported here, the projection life is defined as the number of passages over a sprocket required to produce complete breakdown of the film. It should be emphasized that these are laboratory results, and they should be evaluated on that basis.

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** Eastman Kodak Company, Kodak Park Works, Rochester 4, N. Y.

Relationship between Tension on the Film at the Sprockets and Wear of the Film.—On any projector there are essentially two types of sprockets:

- (1) Drive sprockets, which pull the film forward against some restraining force or friction. Thus, in effect, the film pulls against

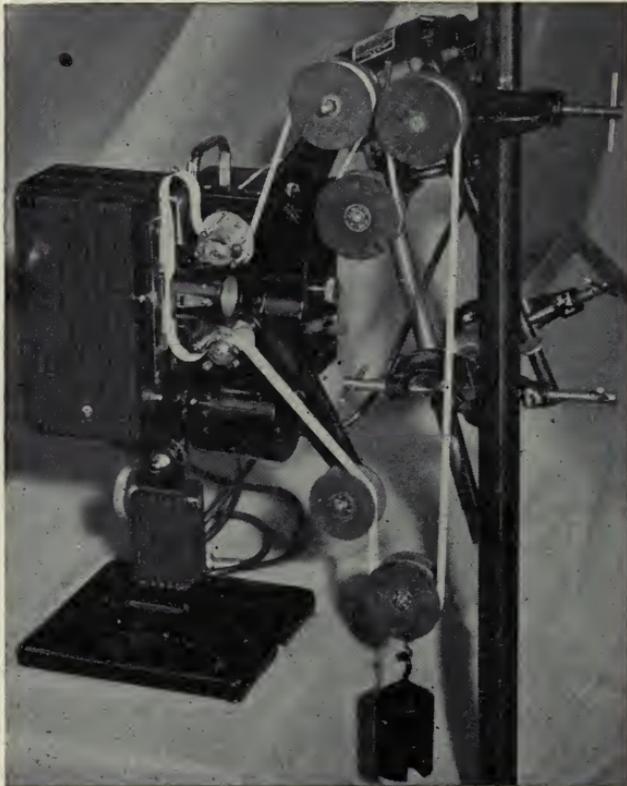


FIG. 1. Apparatus for testing number of passages required to cause complete breakdown of film.

these sprockets in the direction opposite to that of the movement of the film.

- (2) Holdback sprockets, which prevent the film from being pulled ahead by the take-up mechanism or some other device. Here the film pulls against the sprocket in the direction of the movement of the film.

To test the effect of tension on the wear of film engaging both types of sprockets, the apparatus shown in Fig. 1 was used. The projector

was a Model "G" Series II Kodascope, through which a 5-ft loop of processed Kodachrome film was run. Tension was applied by a weighted roller hung in the loop. The gate assembly and pull-down claw were removed from the projector, and the loop was run without tension between the drive sprocket and the holdback sprocket. The angle of approach to the drive sprocket and the exit angle at

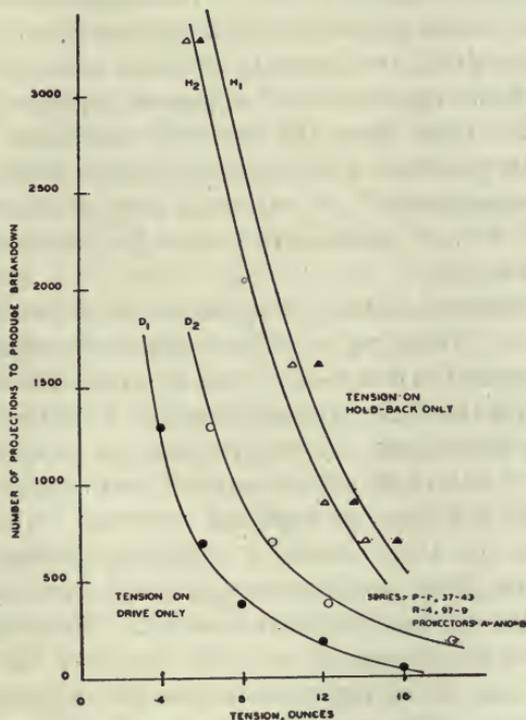


FIG. 2. Relationship between tension on drive and holdback sprockets and number of projections that produce film breakdown. (H_2 and D_2 are curves corrected for snubbing effect of guiding elements.)

the holdback sprocket were held constant by idler rollers placed on the supply and take-up arms.

When it was desired to eliminate the wearing action of the drive sprocket, the tension was removed from it by a tendency drive inserted between the drive sprocket and the weighted roller, as is shown in Fig. 1. This drive consisted of a rubber roller driven by an adjustable-speed electric motor. By proper adjustment of the speed of the roller and the angle of wrap of the film around it, the friction

between the surface of the film and the roller was made just sufficient to drive the film against the applied tension. Thus, the film engaged the drive sprocket without tension. To remove tension from the holdback sprocket, the same drive was inserted between the holdback sprocket and the weighted roller.

Fig. 2 compares the drive and holdback sprockets in relation to the effect of tension on the life of the film. The experimental points from which these curves are drawn represent the averages of two or more separate runs involving two separate projector setups, thus reducing the influence of any peculiarities of alignment, sprocket surface conditions, *etc.* For these tests, the sprockets and films were of such pitch that both sprockets were operating under correct theoretical conditions of engagement.* As expected, increased tension at either the drive or holdback sprocket decreases the number of passages which can be obtained.

The results obtained on the test apparatus are shown by curves H_1 and D_1 in Fig. 2. These curves indicate that the damage to the film at the drive sprocket is five to ten times as great as that at the holdback sprocket for the same *applied* tensions. However, on the apparatus used, the film is partially wrapped around a cylindrical section of the shoe as it enters the drive sprocket, and around a stationary stripper post as it leaves the holdback sprocket. The friction between the film and these snubbing elements increases the tension against which the drive sprocket must pull, and decreases the tension against which the holdback sprocket must act. The magnitude of the snubbing action was measured, and the corrected "life" curves are H_2 and D_2 . These curves represent the number of passages obtained on each sprocket for the actual tensions at which the sprockets and films engage.

A comparison of curves D_1 and D_2 (drive sprocket) shows that the effect of this snubbing on the life of the film is rather large. For these experiments, the film was fed from the back side of the roller on the supply arm, giving a greater wrap around the snubbing element of the shoe, and, consequently, higher friction than when the film feeds from the front and bottom of the supply reel, as in normal projection. Thus, the number of passages obtained on the apparatus used for these

* The pitch of the holdback sprocket should be shorter than that of the film, and the pitch of the drive sprocket should be longer than that of the film. The theoretical considerations involved and the experimental verification of this principle are discussed in the following section of this paper.

experiments is somewhat lower than that which should be obtained with the film feeding normally into the drive-sprocket assembly.

These data indicate that any elements which cause added resistance to movement of the film by the drive sprocket should be avoided. In general, it is better to provide rollers instead of stationary surfaces where the film enters the sprocket assembly. Snubbing could be eliminated by arranging the film path from the supply roll to the free loop so that no guiding elements are required. Although these methods would eliminate the undesirable snubbing action, other factors causing increased damage to the film might be introduced. Experiments to determine the effect of these changes are indicated.

At the holdback sprocket, the snubbing action of the stripper post absorbs part of the applied tension. This friction decreases the strain on the perforations and results in longer film life.

A comparison of the corrected curves, H_2 and D_2 , shows that, even when the influence of the "snubbers" is eliminated, the life of film running on a drive sprocket is significantly less than the life of film running on a holdback sprocket. These data indicate that the action of a drive sprocket is more damaging than that of a holdback sprocket. The relationship of the face of the tooth to the edge of the perforation during their disengagement may account for this difference. This relationship is not the same for the two sprockets, as is shown in a later section of this paper.

Since a drive sprocket is more damaging to film than a holdback sprocket, a special effort must be made to keep the tension on a drive sprocket as low as is consistent with good projector performance. This is particularly true since on every projector there are two, and sometimes three, drive mechanisms that wear the same edge of each perforation:

- (1) A supply sprocket, which pulls the film from the supply reel into the free loop. Tension is present here because there must be a restraining torque on the supply spindle in order to prevent excessive overrunning of the supply reel when the projector is stopped.
- (2) An intermittent device, which pulls the film through the gate. Tension here arises from the friction that is necessary for steadiness of the projected image, and from the acceleration of the film during the pull-down cycle.
- (3) A sound sprocket, which governs the movement of the film through the sound-reproducing mechanism. This sprocket acts

as a drive sprocket with respect to the sound drum, but in some projectors it may also act as a holdback sprocket with respect to the take-up reel.

Both the drive sprocket and intermittent device always engage the forward edge of the perforation, and both pull against an appreciable tension. Thus, for every passage of the film through a projector, the leading edge of each perforation is strained at least twice. On the other hand, because there is only one holdback sprocket, the back edge of each perforation is strained only once during every passage of the film. According to the data of Fig. 2, the action of the drive sprocket is considerably more damaging than that of the holdback sprocket. Thus, when the take-up tension is only slightly higher than the supply tension, the breakdown of the film probably is caused almost entirely by the damage to the forward edge of the perforation. Comparison of curves H_2 and D_2 in Fig. 2 indicates that the tension on the holdback sprocket must be at least two to three times as great as that on the drive sprocket for the breakdown of the film to be caused equally by the drive and holdback sprockets. These curves do not include the damage of the intermittent device, which would be added to that of the drive sprocket. These considerations give rise to the speculation that higher take-up tensions than those now in use on projectors could be employed without an appreciable increase in damage to the perforations.

Relationship between Take-up Tension and Cinching.—With higher take-up tension and consequently tighter winding, the increased damage to the perforations may be more than compensated for by the elimination of the damage caused by winding that is too loose. The useful life of the film may be ended by abrasion of its surfaces and distortion of the film, as well as by breakdown of perforations. At least some of the abrasion of the surfaces of the film is caused by loose winding. During loose winding, the film layers slide on one another, and any dirt particles between the layers may abrade the surfaces of the film. When the finished roll is loosely wound, there is a great temptation to tighten the roll by pulling on the loose end of the film. Here, again, any dirt particles may abrade the film as the layers slide on one another. When a loose roll is re-wound, the application of a brake on the reel instead of on the film will cause sliding and cinching until the roll is tight. How much abrasion is due to these effects and how much is caused by contact

between the film and parts of the projector is open to question. In addition to these defects, the permanent distortion of the film arising from the setting of spoky rolls¹ is caused by storing rolls that are wound too loosely. All these defects can be avoided or at least greatly reduced if a sufficiently high winding tension is used.

What winding tension, then, is required to give satisfactory winding? Preliminary experiments with Kodachrome rolls up to 1600 ft and 2000 ft in length have shown that for satisfactory winding a minimum tension of five ounces is required when constant-tension winding is employed. When constant-torque winding is used, the minimum winding tension, which is at the outside of the roll, should be not less than three ounces. It will be recalled that torque is defined as the product of the force times the lever arm through which the force is applied. For the winding of film on a reel at constant torque, this means that the winding tension of a roll is greatest when the first few laps of film are being wound on the reel and that the tension decreases as the diameter of the take-up roll increases. With the standard 2000-ft reel, where the diameter of the empty reel is about one third that of the full reel, the tension as the first few laps are applied is three times as great as that when the last laps are wound. Thus for a minimum tension of three ounces on the outside of the reel, the first few laps are wound at a tension of nine ounces. This difference in winding tension will doubtless result in increased damaging of the perforations at the beginning of the roll, but the decreased abrasion and distortion of the film may more than compensate for this increased damage. The take-up tension which will give the best compromise between breakdown of the perforations and quality of winding has not been established experimentally. Only careful testing by the trade will determine this compromise.

The factors governing the optimum tension on the drive sprocket are quite complicated. Tests designed to determine the influence of these factors have not progressed to the point where any conclusions can be drawn. These studies are in progress at the present time, and the results will be reported at some later date.

It does seem clear, however, that tension on the drive sprocket should be kept low, and that snubbing as the film enters the drive sprocket should be avoided.

Relationship between Pitch of Film, Pitch of Sprocket, and Projection Life of Film.—When a sprocket tooth meshes with a perforation in a projector, certain events must occur. The tooth must

enter the perforation, come into contact with its edge, and finally disengage from the perforation. The manner in which these actions occur depends on the relative pitches of the sprocket and the film, and also on the function of the sprocket in question. In a paper presented before the Society in 1923, Jones² described the theoretical principles involved. Their application to 35-mm intermittent sprockets was reported and discussed by Talbot³ in 1945. Since the considerations involved are essentially the same for 16-mm and 35-mm sprockets, much of the terminology suggested by Talbot is used in this paper.

It may be of interest to review the behavior or movement of film on both drive and holdback sprockets for each of two cases, *i.e.*,

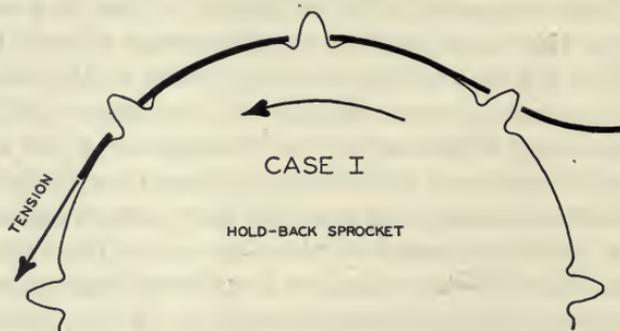


FIG. 3. Action of film on a holdback sprocket when the pitch of the film perforations is greater than the pitch of the sprocket teeth.

Case 1—in which the pitch of the film is greater than that of the sprocket; Case 2—in which the pitch of the film is less than that of the sprocket.

The holdback sprocket, because of the way in which the tension is applied, acts as a driven sprocket. When the pitch of the film is greater than that of the sprocket, the leaving tooth is driven, as shown in Fig. 3. Here the entering tooth engages the film without touching the edge of the perforation, and the film seats at the base of the tooth before it comes into contact with the face of the tooth. As it disengages from the driven tooth, the film slides forward on the sprocket until it reaches the next tooth. Theoretically, these conditions should result in longer life of the film than when the film pitch is shorter than the sprocket pitch, which condition is shown in Fig. 4. Here the edge of the perforation must be forced down on the tooth by a shoe

or a similar mechanism. This wedging of the film on the sprocket tooth produces a severe strain on the perforation and decreases the life of the film.

On a drive sprocket, these conditions are reversed. The film is in contact with the forward faces of the sprocket teeth; and when the pitch of the film is longer than that of the sprocket, the film wedges on the entering tooth. This is shown in Fig. 5.

On the other hand, Fig. 6 shows that when the pitch of the film is less than that of the sprocket (Case 2), the film is driven by the leaving tooth, and the entering tooth engages the film without touching the edge of the perforation. These conditions are similar to those of

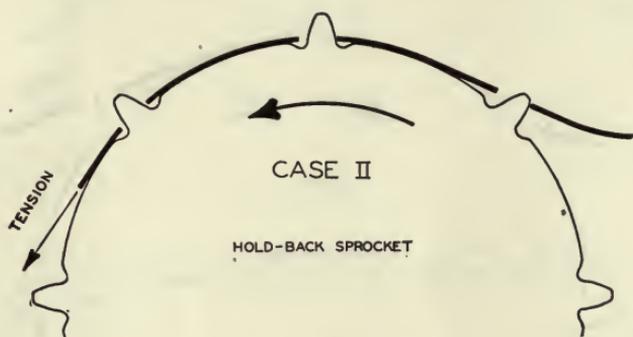


FIG. 4. Action of film on a holdback sprocket when the pitch of the film perforations is less than the pitch of the sprocket teeth.

Case 1 on the holdback sprocket, and should result in less damage than when the film wedges on the sprocket teeth.

Theoretically, the best wear life should be obtained when there is perfect mesh between the sprocket teeth and the film perforations. Under these conditions, the load is carried by more than one sprocket tooth, and each tooth engages perfectly with each film perforation as it enters. However, because film shrinks as it ages, and changes dimensionally with moisture content, the pitch of the film is not constant.

Since perfect mesh is not always attainable, these considerations indicate that the pitch of the film should be longer than that of the holdback sprocket and shorter than that of the drive sprocket.

Experimental verification of these principles is shown in Figs. 7 and 8, where the number of projections required to produce complete breakdown of the film at a constant tension is plotted against the

per cent difference in pitch between the film and the sprocket. As was recommended by Talbot³, these data are plotted so that zero on the abscissa represents a perfect fit of the film on the sprocket. All points to the left of the vertical line through this point represent Case 1, in which the pitch of the film is greater than that of the sprocket. All points to the right of this line represent Case 2, in which the pitch of the film is less than that of the sprocket. These data were obtained from tests of film loops run on the apparatus shown in Fig. 1. The range of differences was made possible by combinations of films perforated to different pitches and sprockets of three different pitch diameters.

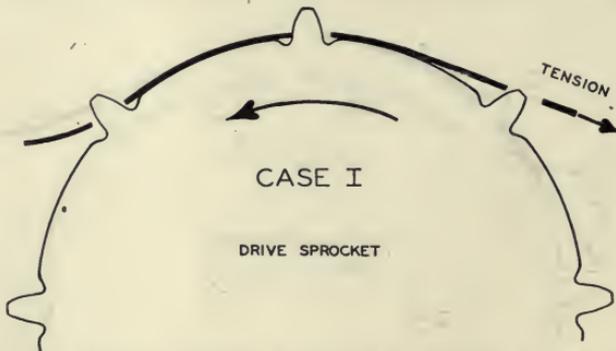


FIG. 5. Action of film on a drive sprocket when the pitch of the film perforations is greater than the pitch of the sprocket teeth.

As is predicted by sprocket theory, Fig. 7 shows that better wear is obtained at the holdback sprocket when the pitch of the film is longer than that of the sprocket (Case 1). However, there is no evidence of a maximum in the curve at or near perfect mesh of the sprocket with the film. Instead, throughout the range of differences studied, the life of the film increases as the pitch of the film becomes progressively longer than that of the sprocket.*

* It is surprising that longer life is not obtained when the tension is divided between two perforations instead of having the entire tension carried by one perforation. A possible explanation for this effect is as follows:

In Case 2, where the pitch of the film is less than that of the sprocket, the film wedges on the sprocket tooth. The face of the tooth shears against the entering perforation when the film is forced down on the sprocket by the shoe. As the film becomes longer, the initial point of contact on the face of the entering tooth

These data show clearly the importance of using a holdback sprocket with a pitch considerably shorter than that of the film. In fact, it may be that the pitch of the holdback sprocket should be as short as possible without causing interference on the front side of the entering tooth.

The difference between the pitch of the drive sprocket and that of the film affects the life of the film, as is shown in Fig. 8. It will be

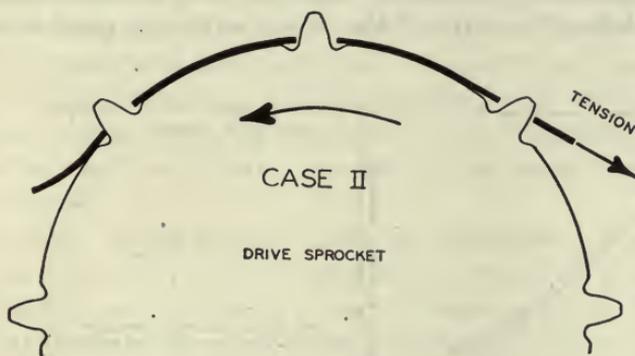


FIG. 6. Action of film on a drive sprocket when the pitch of the film perforations is less than the pitch of the sprocket teeth.

noted that the number of passages obtained at 6 oz, even under optimum pitch conditions, is considerably less than the 600 passages shown in Fig. 2, for the same tension and conditions. However, the data in Fig. 2 were taken from an entirely different series of runs from

approaches closer and closer to the base of the tooth, thus decreasing the strain produced. When perfect mesh is attained, the tension is distributed over more than one perforation. For film longer in pitch than that of the sprocket (Case 1), again only one sprocket tooth touches the film, but here the film slides forward on the sprocket each time the leaving tooth disengages. Part of the applied tension may be absorbed by friction between the film and the circumference of the sprocket, thus decreasing the strain on the perforations. This should result in longer projection life. However, when it is sliding on the circumference of the sprocket, the film in contact with the sprocket surface is under very little tension, because the tension load is still carried by the leaving tooth. Thus, the force normal to the surface is quite small. For this reason, it is difficult to understand how any great amount of the applied tension can be absorbed by friction between the holdback sprocket and the film. It may be that some factor or factors not apparent at the present time will account for the departure of the experimental results from the expected behavior.

those used for Fig. 8. It was noted throughout the investigation that tests involving the use of one projector and one batch of film showed very good reproducibility. But another series, run with a different lot of film on another projector, might show a different level of projection life under comparable conditions, even though the shape of the curves remained unchanged. These differences are due to variations in alignment of film on the sprocket, history of the film, condition of tooth surfaces, *etc.* Although there are not enough experimental points to define the shape of the curves with any great accuracy, it

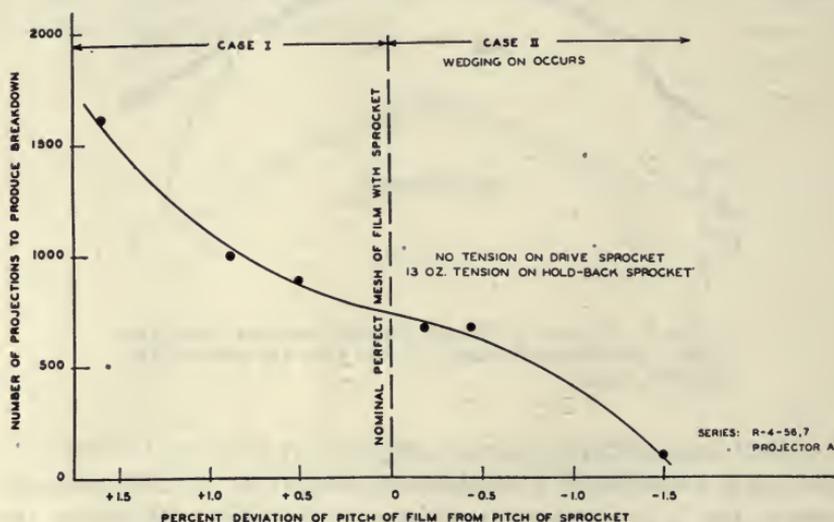


FIG. 7. Relationship between the per cent deviation of the film pitch from the holdback sprocket pitch and number of projections that produce film breakdown.

appears that longest film life is obtained when the pitch of the film is somewhat shorter than that of the drive sprocket. Accordingly, the use of a drive sprocket with a pitch longer than that of the film is indicated. These findings are in agreement with the theoretical conditions discussed earlier and with the results on 35-mm intermittent sprockets (which are drive sprockets) presented by Talbot³ at the Hollywood meeting in 1945.

When the pitch of the film is greater than that of the drive sprocket (Case I), the film wedges on the entering tooth, severely straining the perforations. As the difference between the pitch of the film and the sprocket becomes less and less, this "wedging-on" decreases and the life of the film increases. This same effect was observed for film

wedging on the holdback sprocket. However, when the pitch conditions are such that the entering tooth does not touch the film and the tension on the film is carried by the leaving tooth, the effect of the drive and holdback sprockets on the life of the film is significantly different, as is shown by a comparison of Figs. 7 and 8. As the sliding of the film on the holdback sprocket increases, the running life of the film also increases, at least up to a pitch difference of +1.5 per cent. In contrast, when the pitch difference between the film and the drive sprocket exceeds a certain optimum, the life of the film decreases.*

Thus, it appears that the conditions which permit increased sliding also cause increased damage to film running on the drive sprocket. The reasons for this damaging action and its relationship to the pitch difference between the film and sprocket are discussed in a later section of this paper.

Combination Sprockets and Reverse Projection.—It has been shown that the pitch of the drive sprocket should be greater than that of the film and the pitch of the holdback sprocket should be less than that of the film for the best operating conditions from the

* The failure of the maximum number of passages to occur at the point of calculated perfect mesh may be explained by the stretching of the film or distortion of the perforations when they engage the sprocket teeth under tension. If the film does stretch and becomes deformed on the sprocket, the effective pitch is greater than that measured on a standard pitch gauge, so that perfect mesh occurs when the measured pitch of the film is shorter than that of the sprocket. Experiments now in progress indicate that the stretch and deformation are surprisingly high. Thus it may be that the maximum number of passages is obtained when the film and the sprocket are actually in perfect mesh.

It is possible that the peak in the curves of Fig. 8 is displaced too far from the point of calculated perfect mesh to be explained purely on the basis of stretching or distortion of the film. Another explanation appears quite reasonable. When the pitch of the film is shorter than that required for perfect mesh, the film slides backward on the circumference of the sprocket each time the leaving tooth disengages. On a drive sprocket, the film in contact with the sprocket circumference lies between the driving tooth and the source of tension. Thus, the film is wrapped under tension against the sprocket surface, and the frictional resistance to sliding can be appreciable. When the film slides on the sprocket, the friction between the film and the circumference of the sprocket helps drive the film, thus decreasing the strain on the perforations and allowing a higher number of passages before breakdown of the perforations occurs. The greater the amount of sliding, the greater the amount of strain absorbed by sliding friction. This is true up to a certain pitch difference. When this optimum pitch difference is exceeded, the life of the film decreases, indicating that some damaging action has overcome the beneficial effect of sliding on the sprocket.

standpoint of film life. However, many of the projectors for silent film are designed to project in reverse as well as forward. When such projectors are run in reverse, the sprocket which was the holdback sprocket for forward operation becomes the drive sprocket, and the drive sprocket becomes the holdback. Thus, if the sprockets are of such pitch diameter as to provide optimum conditions for forward projection, both sprockets will be operating under definitely unfavorable conditions when the projector is run in reverse. It has been

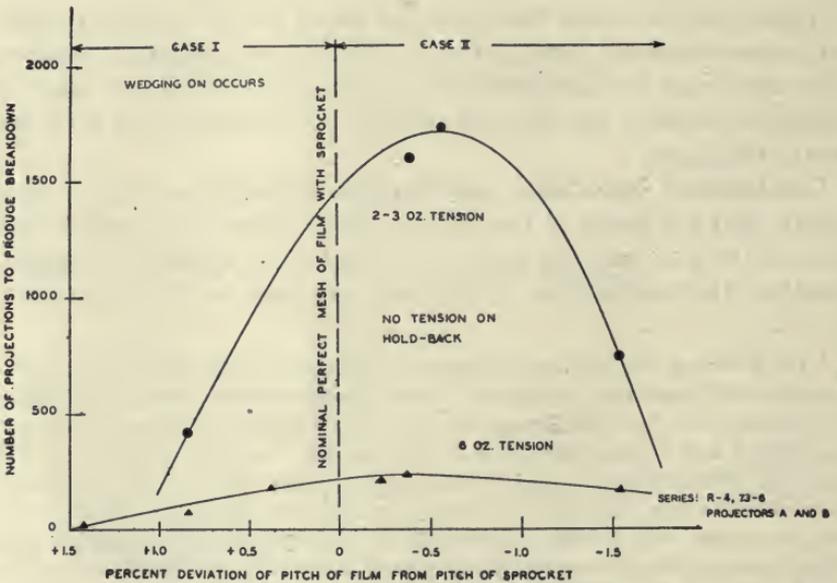


FIG. 8. Relationship between the per cent deviation of the film pitch from the drive sprocket pitch and number of projections that produce film breakdown.

feared that these unfavorable conditions would severely damage the film and make reverse projection impossible. Consequently, combination sprockets of a compromise pitch have been used, and the drive and holdback sprockets have the same pitch diameter, with the result that one sprocket or the other must operate under unfavorable conditions in both the forward and reverse directions. Therefore, provision for reverse projection has resulted in a sacrifice in the projection life of film.

It is unlikely that a film will be projected in reverse more than a small fraction of the total number of times it is projected. Since the life of the film is so dependent on a proper pitch relationship between

sprocket and film, it seems clear that sprockets should be designed to give optimum conditions for forward projection. This is essential if film life in excess of a few hundred runs is desired. The increased damage caused by such sprockets running in reverse should be more than compensated for by the decreased damage during the far more frequent forward projections.

To determine whether or not reverse operation is feasible on sprockets in the proper pitch range, films of 0 and 1 per cent shrinkage were run in reverse on projectors with experimental eight-tooth drive and holdback sprockets of approximately the correct pitch. (Drive sprockets of 0.761-in. root diameter and holdback sprockets of 0.746-in. root diameter were used.) The films projected quite satisfactorily in reverse, with no loss of loop or other trouble. After the rolls had been run forward and in reverse ten times, inspection of the films showed no appreciable damage to the perforations.

These results indicate that sprockets of optimum pitch for forward projection do not prohibit reverse projection. In these experiments, the sprockets were provided with shoes which prevented the film from climbing off the sprockets. Also, the tooth shape was an involute with a low-pressure angle, so that wedging-on did not result in as severe strain on the perforation as would result from wedging on a tooth of more rounded profile. It should be emphasized that elimination or modification of the sprocket shoe, or a change in the shape of the tooth, may result in prohibitive damage to the film perforations when a projector provided with sprockets designed for optimum conditions during forward projection is run in reverse.

Comparison of the Sprocket-Film Interaction at Drive and Holdback Sprockets.—It will be recalled that the experimental data in Figs. 2, 7, and 8 show two essential points of difference in the life of film at the drive and holdback sprockets:

- (1) With the film engaging the sprocket under optimum pitch conditions, the drive sprocket damages film more severely than does the holdback sprocket at the same tension.
- (2) On a drive sprocket, the life of the film is at a maximum at an optimum pitch difference between the film and sprocket and decreases when the film is longer or shorter than this optimum. On a holdback sprocket, there is no such maximum in the life of the film within the same range of pitch differences. Rather, the projection life of the film increases as the pitch of the film becomes progressively longer than that of the sprocket.

The explanation for these differences may be in the different geometrical relationship of the leaving film to the teeth on the two sprockets. These considerations are discussed in detail in a paper presented by Chandler, Lyman, and Martin.⁴

The difference is best visualized by considering a stationary sprocket with the film wrapped and anchored around it, and in contact with the first tooth. When the free end of the film is lifted away from the sprocket, the path of the edge of the perforation disengaging from the tooth describes a curve in space. If the sprocket is a holdback sprocket, the edge of the perforation moves away from the face of the tooth. If the sprocket is a drive sprocket, the path of the edge of the perforation more nearly conforms to the curve of the tooth. The

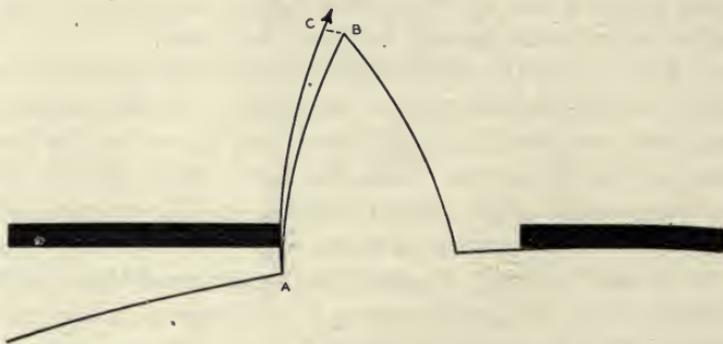


FIG. 9. Relationship between path of the edge of the film perforation and the face of the leaving tooth on a drive sprocket.

difference is shown in Figs. 9 and 10. The curves, AC and $A'C'$, describe the path which the perforation takes when the film is pulled from the sprocket in a straight line and does not slip on the sprocket. The shape of curve AC is influenced by the path of the *film itself* as it leaves the sprocket and moves forward through the projector. When the film is pulled from the sprocket on a straight line, the curve is an involute and has the minimum amount of tilt possible. However, when the film is bent around a guiding element or into a loop as it leaves the sprocket, curve AC is curved or tilted to a greater extent. When the pitch of the film and that of the sprocket are different, slipping occurs on the sprocket, and the perforation must slide up the face of the sprocket tooth until the next perforation reaches the next tooth. The maximum amount of slipping on the sprocket that can occur before the tooth disengages from the film is measured by the

distance BC . If BC is less than the pitch difference between the film and the sprocket, the film snaps against the next tooth, which results in impact loading of the next perforation.

As can be seen from Figs. 9 and 10, the "tilt" of the face of the tooth is important in determining the maximum amount of slipping that can occur on the sprocket before the tooth disengages from the film. This tilt is particularly important on the drive sprocket where the face of the tooth and the path of the edge of the perforation so closely conform. The shape of the sprocket teeth used for the tests described in Figs. 2, 7, and 8 is an involute with a pressure angle of $14^{\circ} 9'$. This means that the face of the tooth is tilted back to a certain extent. This tilt is sufficient to accommodate a pitch difference of 1.0 per cent,

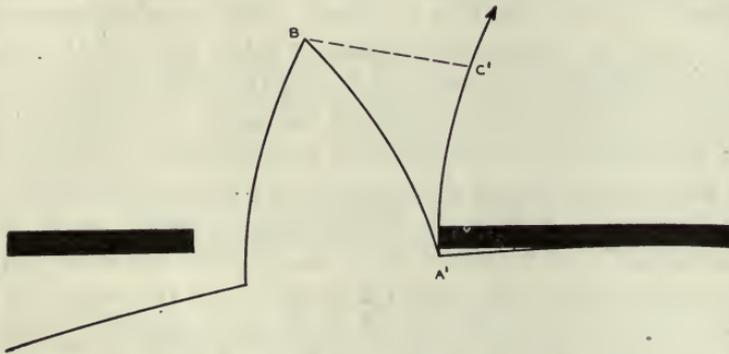


FIG. 10. Relationship between path of the edge of the film perforation and the face of the leaving tooth on a holdback sprocket.

if the film leaves the sprocket in a straight line. However, because the film curves into the loop as it leaves the drive sprocket, the path of the edge of the perforation is also tilted to such an extent that the distance, BC , is equivalent to a pitch difference of only about 0.7 per cent. Thus, films with pitches up to 0.7 per cent shorter than the drive sprocket should slide on the sprocket and engage the next tooth before the leaving tooth disengages. However, films still shorter in pitch are subjected to an impact loading of the next perforation just after the leaving tooth disengages. The greater the difference in pitch, the greater the distance through which the film that is on the sprocket can accelerate before it is stopped by the next tooth. The resulting increased velocity of impact accounts for the progressive decrease in the life of the film as the pitch difference between the drive sprocket and the film increases.

As is shown in Fig. 10, the divergence of the path of the perforation and the corresponding face of the tooth on a holdback sprocket allows a relatively large movement of the film on the sprocket before the tooth disengages. Thus, for any reasonable pitch difference, impact loading of the perforations cannot occur. The absence of this shock action can account for the fact that the life of the film on the holdback sprocket does not decrease as the pitch difference between the sprocket and the film increases. However, some other explanation, not apparent at the present time, is necessary to account for the observed increase in life under these conditions.

A comparison of the data of Figs. 7 and 8 shows that, even under optimum conditions on the drive sprocket, the life of the film is considerably less than that obtained for films at comparable engagement conditions with the holdback sprocket. This same difference in life level is shown by comparison between curves H_2 and D_2 in Fig. 2. These data indicate that some action at the drive sprocket is more damaging than that at the holdback sprocket. A possible explanation for this difference is suggested by a comparison of Figs. 9 and 10. As the film slides out along the back face of a holdback sprocket tooth, the angle between the face and the film changes rapidly, so that sliding becomes easier. On the other hand, as the drive sprocket turns and the perforation slides out along the front face of the tooth, the angle between the face and the film decreases only slightly. Thus, it is much more difficult for the film to slide up and off the leaving tooth of the drive sprocket. The friction between the face of the tooth and the edge of the perforation tends to pull the film past the ideal point of disengagement for the sprocket. On the drive sprocket, this tendency for the perforation to cling to the sprocket tooth is enhanced by the fact that the only force stripping the film from the tooth is the spring-like action of the film in the free loop. Thus, the film and the tooth tend to remain in engagement so long that when the perforation finally is stripped from the tooth, the tooth effectively drives down into the film and produces a strain on the perforation.

Moreover, to disengage from the drive sprocket, the perforation must slide under tension on the tooth face for practically the full length of the face, whereas on the holdback sprocket, the film must slide only a very short distance up the face of the tooth before the film touches the next tooth. This difference results in a greater sawing action of the tooth on the perforation in the case of a drive sprocket. It is probably a combination of all these effects, and

possibly others, that makes the drive sprocket damage film more than does the holdback sprocket.

In order to observe the engagement and disengagement of the sprocket teeth with the film and the influence of certain variables on this action, high-speed motion pictures were made of film passing over drive and holdback sprockets. The pictures were taken with an Eastman High-Speed Camera, Type III, operating at a speed of approximately 2000 frames per sec. On the test projector, the portion of the shoe covering the teeth was removed so that the action could be photographed.

With films and drive sprockets combined to obtain film shorter than the sprocket by 0.7 and 1.7 per cent, pictures were taken with film tensions of 4, 6, and 9 oz. The following observations were made from these pictures:

- (1) After the leaving tooth disengages from the film, the film moves back to the next tooth so rapidly that the perforation humps up or distorts considerably. This effect was noticed only on the shortest film.
- (2) As this tooth starts to disengage, the front of the tooth "saws" on the edge of the perforation, and the film is distorted downward.
- (3) The impact on the tooth that assumes the load is more pronounced at greater tensions and at greater deviations from sprocket pitch.
- (4) For the film which was measured to be only 0.7 per cent shorter than the sprocket, there was some evidence of wedging-on at the entering tooth when the film tension was increased—indicating that the film was actually longer than the sprocket. This effect can be explained only by the assumption that the pitch of the film increased because of stretching or distortion under the applied tension.

At low tensions, these effects are not readily seen. It is only when the tension is as high as 6 or 9 oz that they become pronounced. It is believed that they are present at lower tensions, but to a lesser extent.

Pictures of the holdback sprocket with films longer than the sprocket by 0.2 and 1.3 per cent at tensions of 6 and 10 oz show the following:

- (1) The film slides very easily and smoothly off the leaving tooth, with no evidence of resistance to stripping.

- (2) As the leaving tooth disengages, the film slides on the sprocket circumference and the load is assumed by the next tooth with no evidence of humping of the film on the tooth.
- (3) The film only 0.2 per cent longer than the sprocket touches the entering tooth at these high tensions. This is somewhat surprising, since, with film longer than the holdback sprocket, the tooth should enter freely. This effect can be explained only by the assumption that the distance between the leaving and entering perforations has been decreased by distortion of the perforation by the leaving tooth under the applied tension.

These observations substantiate the explanation advanced earlier for the difference in the damage to the film caused by drive and holdback sprockets.

These considerations suggest the desirability of altering the profile of the tooth of the drive sprocket to facilitate backward sliding of the film as the perforation disengages from the tooth and to ensure the gradual engagement of the film with the next tooth. If the sprocket tooth is cut away more sharply, there will be more damage to the film when the diameter of the sprocket is such that the entering tooth strikes the edge of the perforation and the film is wedged on the sprocket by the shoe. This factor makes it imperative to use drive sprockets with a large circular pitch, in relation to the pitch of the film, to make certain that wedging-on never occurs. It is believed that a section at the base of the tooth should be left as nearly vertical as is practicable, for a height approximately equal to the thickness of the film, to act as a driving face. The paper by Chandler, Lyman, and Martin⁴ proposes a method for specifying the shape of the tooth to comply with these considerations.

Some improvement should result from the placement of a stripper post or roller at the drive sprocket to prevent the film from being carried down past the proper point of disengagement.

There is some evidence to indicate that the stretch of film under tension on a sprocket is considerable. It is possible that this stretching may have to be considered in the design of sprockets. The extent and mechanism of this stretching are under study and the results will be reported at a later date.

Conclusions.—It has been shown that the drive sprocket damages film more severely than does the holdback sprocket at the same tension. This indicates that film tensions must be kept as low as is

consistent with satisfactory behavior of the supply reel and with steadiness in the gate.

It is possible that take-up tensions can be made great enough to give tightly wound rolls without greatly decreasing the number of projections obtained from a 16-mm print. Other things being equal, minimum tensions of 5 oz for constant-tension and 3 oz for constant-torque winding are desirable.

For maximum film life, the pitch of the drive sprocket should always be longer, and the pitch of the holdback sprocket shorter, than the pitch of the film engaging them.

High-speed motion pictures indicate that the shape of the tooth may be the reason for the difference in the damaging effect at the drive and holdback sprockets. A tooth with a more rounded profile may result in more satisfactory action of drive sprockets.

It is recommended that further tests along these lines be conducted by members of the industry.

Acknowledgment.—The writer wishes to express his appreciation to Dr. E. K. Carver for his helpful suggestions and guidance in this work, and to various members of the Department of Manufacturing Experiments, the Kodak Research Laboratories, and the Camera Works for their contributions and suggestions.

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² JONES, J. G.: "Film Sprocket Design", *Trans. Soc. Mot. Pict. Eng.*, **17**, 4 (Oct. 1923), p. 55.

³ TALBOT, R. H.: "The Projection Life of Film", *J. Soc. Mot. Pict. Eng.*, **45**, 2 (Aug. 1945), p. 78.

⁴ CHANDLER, J. S., LYMAN, D. F., AND MARTIN, L. R.: "Proposals for 16-Mm and 8-Mm Sprocket Standards", *J. Soc. Mot. Pict. Eng.*, **48**, 6 (June 1947), p. 483.

DISCUSSION

MR. M. R. BOYER: Do you happen to know whether there is any significant difference in the noise of these different examples given?

DR. E. K. CARVER: Yes, there was. It was mostly when we reached extremes of tension, or when the film was considerably shorter than the drive sprocket. I cannot remember any differences in noise with reasonable tensions and reasonable pictures.

MR. BOYER: The reason I asked was that very often you do hear a clicking noise on a projector, and I was wondering whether it might not be possible to set your projector if you knew what was causing the trouble.

DR. CARVER: Well, sometimes you do get extreme tension in projectors.

DR. E. W. KELLOGG: Would your conclusion be that if you must use, or think you must use, one sprocket for both jobs, would you pick it pretty close to the optimum diameter for a pulling sprocket and let the holdback end of it take care of itself?

DR. CARVER: Yes, you would. This point is discussed at considerable length in the paper. I did not feel I had time to discuss it here. But, the general conclusion is, if you want a good projector, do not use one sprocket for both jobs.

MR. H. O. HILLS: Please tell us what the criterion was in plotting the curves.

DR. CARVER: It was arbitrary, and depended on the judgment of the operator. We never considered film damaged until it was worn out enough to break. If it broke in only one place and the remainder appeared undamaged, we figured that there was something wrong, and discarded the sample. We would run it until it broke and was damaged in other places as well.

MR. HILLS: A fairly advanced degree?

DR. CARVER: Yes.

EFFECT OF TIME ELEMENT IN TELEVISION PROGRAM OPERATIONS*

HARRY R. LUBCKE**

Summary.—A television performance must not suffer interruption. Adequate manuscript treatment, technical perfection, and production teamwork are required. The "preset principle" employed by Don Lee Television is described. Large stages are employed with production auxiliaries overhead. Twelve or more sets can be constructed, dressed, and lighted on a single stage, if required.

Duplicate equipment is cited as important in enabling commercial television to approach the production perfection afforded by the cutting process in motion picture.

The need for a trained, co-operative production crew is emphasized with a hint of the human behavior necessary to attain this end.

It does not require profound reflection to conclude that uninterrupted performance is important in television. In motion picture making, the reverse is true; innumerable "takes" may be had if necessary. On the other hand, this is not true in the motion picture theater, where the "show must go on". In live-subject television, taking and exhibiting occur simultaneously and the passage of time, as it relates to an uninterrupted performance, assumes prime importance.

Two courses of action are open: Either television performances must be simplified so that the chances of error or interruption are negligible, or technical perfection and production teamwork must be combined to provide adequate insurance against faults. Actually, present-day television pursues a path between these courses of action, with the trend slowly toward the latter.

Simplification of action is not necessarily objectionable. In television, as in motion pictures, many scenes are inherently static and changes of camera angle from close-up to longshot relieve the monotony. In television, these changes are accomplished by switching from one to the other of simultaneously operating cameras. It is merely necessary to have the cameras in proper positions, considering the

* Presented Oct. 24, 1946, at the SMPE Convention in Hollywood.

** Director of Television, Don Lee Broadcasting System, Hollywood.

focal lengths of the lenses, and to change these positions as the action moves about the stage, usually while the camera being moved is not "on the air".

Actually, a great deal is accomplished by a well-written script. It is here that the show is "television", or the mere beginning of a performance which the production staff must adapt for television during rehearsal. The script writer must have dramatic sense, which is the stock in trade of his profession, combined with a full comprehension of television instrumentalities and human limitations. Writing for television is fascinating if one is mentally keen and takes satisfaction in marshaling the full facilities of television, much as the master composer visualizes and writes for a full symphony orchestra.

Fundamentally, the limitations of television are few. With respect to motion, the repetition rate is 60 per sec rather than 24 per sec as in motion pictures. Fortunately, the large-spoked wagon wheel has given way to the spokeless automobile wheel, thus removing a frequent exhibition of this motional limitation in motion pictures.

With orthicon cameras the shading limitation is removed, though greater care in maintaining electrical operating adjustments is required.

These cameras have the same photographic limitations as the motion picture camera. In a recent outdoor swimming telecast, the diving exhibition was shot against clear sky from one camera angle and a silhouette effect observed. Later, on some motion picture film taken for record purposes from the same camera angle the same effect was noted.

The motion picture cameraman has the opportunity to relegate such exposures to the cutting room floor, but the television operator must avoid these shots by calling upon his experience or the video director must do likewise by careful attention during rehearsal. In scenes illuminated by sunlight it is desirable that the dress rehearsal be conducted at the same time of day as that for the final performance. The effects involved are of large magnitude.

For pleasing facial rendition in outdoor sunshine scenes it is necessary to employ foil diffuse reflectors to raise the illumination of the darker side in much the same manner as these are employed in motion picture practice. Movement of the principals from sunshine to shade in one scene is to be avoided unless a simultaneous electrical adjustment procedure is developed during rehearsal to maintain a pleasing image.

Within the studio an operating arrangement capable of rapid and convenient movement is desirable. A good start in this direction is to position the cords for the intercommunication system and for the microphone overhead. A weight-and-pulley system for accomplishing this, which has been installed at the Mt. Lee television stage of the Don Lee Broadcasting System, is shown in Fig. 1. The greater portion of the lighting cables has been similarly disposed overhead, and may also be seen.



FIG. 1. View of one corner of television stage 1 of the Don Lee Broadcasting System, Hollywood, California.

This arrangement leaves the floor free for the cameras, microphone-boom stand, personnel, and a few necessary lighting units. The camera dollies, boom and lighting stands are of conventional design with the accent on small size and maneuverability. The relative motion of each must be determined and set forth for the whole show in the shooting script so that "impossible" combinations will not develop.

There are several philosophies of television stage arrangement and operation, from the revolving-stage idea to the practice of intermissions between major acts. In 1938 we determined that the Mt. Lee stages would be built and operated according to what can be called

the "preset principle". This simply entails constructing and dressing all the sets that are to be used for a given telecast in advance and moving the cameras and mike boom from set to set as the show progresses. This plan calls for a large stage, two or more cameras, a double-microphone pickup arrangement, and a large stock of lighting units, scenery, and properties.

It was for this reason that stage 1 at Mt. Lee was made the largest television stage in the country; 100 ft long, 60 ft wide, and 30 ft high. A second stage was also provided 45 ft long, 20 ft wide, and 16 ft high to allow one stage to be "re-preset" while the other was in use, if necessary, as well as a third room, 28 ft long, 16 ft wide, and 14 ft high, which can be used for interviews or simple one-set presentations. With this plant and plan, continuous live-subject television programming can be carried on, if necessary. Practically, with the use of motion picture film or the inclusion of remote pickups, in combination with the finite length of the television broadcasting day, the facilities are adequate for full-scale commercial television.

Thus far a maximum of six sets has been used on any one broadcast and these sets have not required the full area of the large stage. In full production the sets are constructed around all four walls of the stage with the cameras and microphone booms mobile up and down the center of the stage. A maximum of twelve 20-ft wide sets, or a correspondingly larger number of smaller sets, can be accommodated, a few of which are often used in television production.

The lighting units are placed on each set in advance of the broadcast. In this way, the sets can be completely prepared hours ahead of time if desired with nothing to do but maneuver the cameras and sound boom during the show. In day-after-day production the stage crew can begin work in the morning hours for the afternoon and evening performances.

Because of rapid obsolescence, television in the past has seldom been able to afford a complete set of duplicate equipment. Obviously, commercial television operations call for this form of insurance and the coming year will find this practice increasing. In this way former serious failures will become only brief interruptions, and television performances will more nearly approach the perfection attained in the cutting room in motion pictures.

In addition to proper television facilities a trained, co-operative production crew is necessary. Operative teamwork, as found on the football field, the assembly line, and in military operations, is required.

A good crew can sense difficulties at the instant of occurrence and minimize the effect which reaches the receiver screen. Here each member must know or learn his part to perfection and unselfishly cooperate with his crew mates in a constant devotion to over-all perfection. He must be horror-stricken when he himself makes an error, and he must be generous and understanding when an associate makes an error. He must be filled with high resolve that errors are not to be repeated. In short, he must raise the standard of emotional performance of the human race so that we can all enjoy its newest accomplishment, television.

LIGHTING AND EXPOSURE CONTROL IN COLOR CINEMATOGRAPHY*

RALPH A. WOOLSEY**

Summary—Lighting is the most important phase of the cinematographer's art. But the technical aspects of lighting should require only a minimum of time and thought. By adopting simple controls of illumination contrast, brightness range, and exposure, the cameraman will know at any time how close he is working to the limits of film latitude and will be able better to obtain consistent results from scene to scene and from day to day.

This paper describes a new incident-light exposure instrument which also performs the functions of a light-intensity meter and a brightness meter by means of interchangeable light collectors and suitable calibration.

The practice of basing exposure determination on the sound principle of incident-light measurement has long been employed in Hollywood. Also related to this principle is the determination of illumination contrast with a light-intensity meter as the first step in the recognition of film latitude limits.

For scenes with "normal" lighting, the ratio of key-to-shadow illumination on principal areas seldom exceeds 4 to 1 in practice. Greater contrast generally may be classified as "effect lighting". Processes where separation negatives are made directly from the subject allow wide limits of lighting contrast insofar as color rendition is concerned because colors photographed in shadow areas are reproduced merely as lower values of the same colors as photographed in high-light areas. However, the use of integral tripack materials does not permit such wide range in lighting contrast. Most of these materials show degraded color in shadow areas when the illumination ratio begins to exceed 4 to 1.

Recognition of film latitude limits also involves determination of the scene brightness range, as measured with a brightness meter. The maximum range of tones or colors reproducible with fidelity by any process may be correlated with the over-all level of illumination

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** Photo Research Corporation, San Fernando, Calif.

on any scene. This permissible brightness range is limited by the latitude of the process itself. Most processes will give satisfactory color rendition in extreme tones through a range of 25 or 30 to 1, while 20 to 1 may be the brightness limit for certain integral tripacks.

Efficient correlation of over-all exposure, lighting contrast, and brightness range is provided by the new Norwood Director universal exposure meter, by means of three interchangeable light collectors (Fig. 1). When used for exposure determination a hemispherical

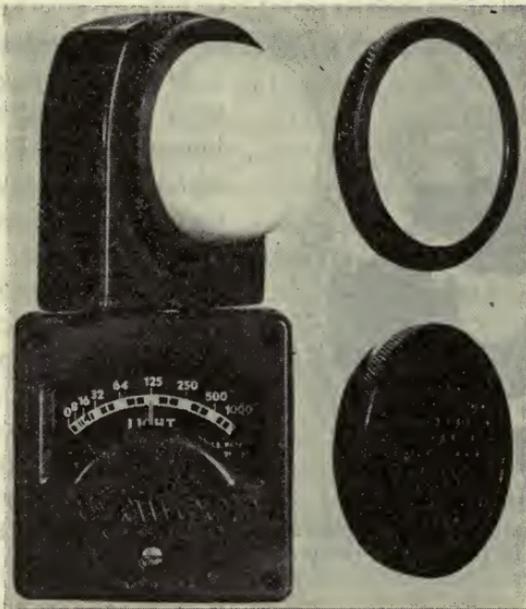


FIG. 1. Norwood Director universal exposure meter, with interchangeable light collectors.

light collector called the "Photosphere" is used on the meter, which is faced toward the camera lens from the principal subject position. The Photosphere integrates and evaluates all useful light incident on the subject's camera side.

The meter scale is calibrated in "light values". (These may be thought of as "effective footcandles" when the Photosphere is used, for lack of a more specific term.) If the light value exceeds 1000, a 25X multiplying slide is inserted behind the Photosphere. Light values are referred to a computer provided with two arrows, marked "in" and "out" (Fig. 2). Depending on whether the multiplying

slide is in or out, the appropriate arrow is set to the indicated light value. Then, with the proper emulsion speed set on the computer, correct exposures may be read from the aperture and shutter-speed scales.

Lighting contrast is measured with the "Photodisk", a flat light collector. With this in place on the meter, the scale reads directly in footcandles up to 1000. The 25X multiplying slide is inserted in the meter for reading greater light intensities. Key, fill, or other light sources may be individually measured and adjusted to desirable balance. A record of intensities or relative balance may be noted for use in matching or duplicating a scene at another date or location.

Brightness range is measured with a reflected-light collector known as the "Photogrid", and when this is attached to the meter the scale reads in candles per square foot. As measured with the Photogrid, the brightness of a subject of approximately 12 per cent reflectance, when referred to the *R* arrow on the computer, will indicate the same exposure as obtained by reading the light incident on the subject with the Photosphere. This is based on a relation of 25.4 to 1 between

illumination in effective footcandles and the brightness in candles per square foot of a so-called "average subject".

The Norwood computer has a contrast scale adjacent to the light-value dial, with a total range of 128 to 1. This scale may be marked off for any brightness ratio desired. For example, 32 to 1 may be indicated by placing dots at 32 and 1. An index point near the middle of the range should also be marked by a dot. In this case it would be placed at 6, as it is advisable to favor the shadow areas slightly.

As an illustration of lighting and balancing a set for Technicolor to be exposed at Stop 1 (equivalent to $f/2$) with a lighting contrast of 3 to 1 and a maximum brightness range of 32 to 1 the following procedure is offered:

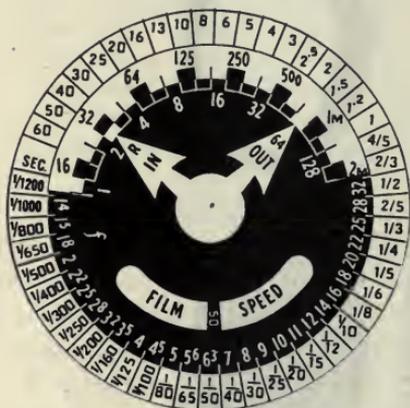


FIG. 2. A computer for correlation of all exposure factors is an integral part of the meter.

- (1) Assuming a film speed of Weston 8, the computer is set accordingly. To determine final over-all light-value requirement, $f/2$ is moved next to $1/50$ second. With slide out this will be 500 for correct exposure.
- (2) Photodisk is used on meter and pointed directly at key light to measure its intensity in footcandles. If key is located approximately 45 deg from camera direction, this intensity is adjusted to read about 400, or one third stop less than the total requirement.
- (3) Fill lights are turned on and adjusted until shadows read one third of key intensity, or about 125 footcandles.
- (4) Over-all illumination may be checked with Photosphere, which will evaluate both key and fill together, and a reading of 500 will result. Kicker, back lights, and other sources are added according to cameraman's artistic conception. These embellishments do not appreciably affect principal lighting balance or exposure.
- (5) Using principal area as a reference, rest of set is balanced to it visually. However, because the eye is not infallible, especially if the cameraman has just come onto the set from outdoors, or if he has inadvertently looked into a light, it may be advisable to check the illumination at important points with the Photodisk. The light is measured in various directions within 90 deg of the lens axis to determine how the highest and lowest intensities compare with the lighting of the principal area.

If, in this example, it is decided to light the background not to exceed one half the principal key intensity and to maintain at least one half the principal shadow intensity, the meter should read not more than 200 footcandles on the high side while at least 64 footcandles would be required on the low side. Illumination on flat walls or other plane surfaces of importance would be measured with the Photodisk held parallel to the surface.

- (6) It should be mentioned that, up to this point, it is often unnecessary even to use stand-ins while balancing the light. Now, however, it would be advisable to introduce people to aid in exact lighting placement, and another exposure check with the Photosphere may be made. With little or no light adjustment the required over-all illumination level of 500 should be indicated.
- (7) With this light value set at the "out" arrow on the computer, reference to the *R* arrow will show that the established middle tone of 12 per cent reflectance will have a brightness of 20 candles per square foot. Move the index dot in the middle of the 32-to-1

brightness range scale (previously marked) opposite this middle-tone value of 20.

- (8) Now adjacent to 1 on the contrast scale will appear 3 candles per square foot, while opposite 32 is found 100 candles per square foot. These represent the minimum and maximum permissible brightnesses chosen for purposes of illustration for assurance of good color rendition in extreme tones.

From this point it is a simple matter to approach any questionable area with the Photogrid on the meter and measure its brightness at close range. If a window, hot spot from a lamp, white shirt, or similar bright area goes beyond the desirable range, corrective measures either in lighting, repainting, or substitution of darker materials would prevent the area from being "burned up". An exterior backing showing through a window might be too "hot" for good balance and its brightness could be lowered as required by decreasing illumination. In the case of dark areas where tone rendition was important, either more light, repainting, or lighter materials would be necessary.

Since certain materials and textures absorb or reflect undue amounts of light, and since the scale of sensitivity is not the same for all colors, the cinematographer must either rely on his experience in avoiding the use of anything which he knows will not reproduce well in color or, as is customary in most studios, should test wardrobes and any questionable materials for color prior to shooting of a picture. During production it is easy to keep a check on any questionable areas. With the Photogrid, for example, the brightness of faces may be measured for maintenance of uniform make-up relations between important players.

As in the case of lighting contrast, it is up to the cameraman to decide when he wishes to exceed the permissible brightness range for the achievement of effects. It may be desirable to allow shadows or areas of low brightness to go completely black. (Indeed, in the case of most tripack materials it seems better to do this very thing whenever lighting contrast cannot be held within proper ratios, rather than suffer degraded color in shadow areas.) It may be desirable to "burn up" areas of high brightness for specific effects. Or for other results achieved through printing control, the lighting contrast may be increased or decreased along with departures from normal exposure.

Exterior lighting contrast may be controlled in essentially the same manner used for interior work. Since the key light intensity is fixed,

it is measured first with the Photodisk. Reflectors or booster lights are then adjusted until shadow areas are illuminated as desired. An exposure reading is then taken with the Photosphere on the meter, which is pointed at the camera from the subject position. In the case of distant or inaccessible scenes where no additional light is used and the illumination is uniform, exposure readings may be taken from any convenient position in light equivalent to that which strikes the subject, with the Photosphere held at the same angle with respect to the camera as it would be if it were actually at the subject position.

With the new Norwood Director, which performs the multiple functions of an incident-light exposure meter, a footcandle meter, and a brightness meter, the cameraman has a convenient tool for correlating exposure, lighting contrast, and brightness range. He is in a position not only to establish his basic lighting quickly, but to check the limits within which he chooses to work at any time while elaborating on the basic lighting according to his artistic requirements.

MOTION PICTURES ON OPERATION CROSSROADS*

RICHARD J. CUNNINGHAM**

Summary.—The photographic work involved in "Operation Crossroads" was the largest project of its kind undertaken by the Armed Services to date. The highly successful character of this operation is based on the quantity of equipment available and the co-operation of all branches concerned. The technical and scientific aspects of the undertaking are described in the following paper.

Conduct of the Atomic Bomb tests at Bikini was a genuinely composite operation, blending the resources and personnel of the Manhattan District, the Navy, and the Army Air Forces into a great pattern of applied research. The magnitude of this operation has been stressed in public information, but it is difficult to comprehend except through personal experience in planning and accomplishing the mission. The project was big in every way—in the problems presented, in technical requirements, in numbers of crack personnel and masses of equipment needed, and in the final job of analyzing and reporting the information obtained. The results were also big. From a technical and scientific standpoint, "Operation Crossroads" has been the most successful major operation observed by the writer in five years' association with the armed forces research and development program.

The mission of the Army Air Forces on Crossroads was twofold: (1) to put the bomb on the target and to drop blast gage and other scientific recording instruments in the target area at the right time; (2) to record the effects of the blast by an intricate plan of instrumentation and aerial photography.

The photographic operation is our immediate concern. It was by far the biggest photographic job undertaken by the armed forces to date. Practically every type of camera available to the services was used in one capacity or another. Relative importance was about equally divided between still and motion pictures, one being used to

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** Lt. Col., AC, Wright Field, Dayton, Ohio.

complement the other in the scientific recording of the phenomena.

The scope of the operation can be determined by the fact that the Army Air Forces used 328 cameras in the air alone. This does not include Navy or Manhattan District equipment. A total of 366,000 ft of motion picture film was exposed by the Air Forces on the two explosions, with about 1,500,000 ft on practice missions and general ground and air coverage of the operation. Camera equipment ranged from standard and high-speed Mitchells to 16-mm gun-sight aiming point cameras, and included a total of 36 Eastman and Fastax high-speed cameras. Jerome cameras with internal heaters were used on the gun turrets, which were operated remotely from central fire-control stations. Eighty cameramen were required and many cameras were automatically operated. Aside from coverage of the bursts and incidental phenomena, motion pictures were used to record instruments, television screens, radar scopes, timing devices, and critical mechanical operations.

While the photographic coverage on Crossroads constitutes a complete and detailed record of the operation and provides an invaluable historical document, the primary objective of the photographic units was to deliver film technically qualified to serve as a basis for scientific analysis. This called for the most precision and control in all phases of the operation, from flying the aircraft to operating the equipment. Photography provided the basic instrument for the extremely accurate measurements of movement against time required by the scientists to analyze the blast forces and characteristics of the bursts. This was the vital role of photography on Crossroads, and it pleases me greatly to report that many of the finest results established in the preliminary technical reports have been derived from motion pictures.

It would be impractical to attempt an adequate description of the complete photographic operation here. Since timing was the most critical single factor, and because the solutions developed for timing on Crossroads are adaptable for future applications of photography to technical problems, our discussion will describe the Crossroads timing requirements and equipment designed to meet them.

Essentially our problem centered on the fact that our camera platforms consisted of ten *B-29* and two *C-54* aircraft, orbiting the target at fixed altitudes and given slant range, at indicated air speed of 200 mph. For the Able burst, where timing was most critical, the exact position of the bomber in space at the instant of bomb release had

to be determined. The exact position of each camera aircraft in space at time of detonation must be known. Since anchored vessels move considerably over brief periods, the exact position of target ships in relation to each other a few seconds before detonation must be known. These relative positions in space were accurately determined by photogrammetric plotting and radar plotting, each using photography as its prime implement.

With these basic factors provided for, the timing problem resolved itself into development of an electronic control system for starting cameras, a system for recording the operation of all cameras, and the establishment of a time base for high-speed motion picture photography.

For description, the electronic control system which was developed can be divided into three parts: (1) The remote controls, employing a radio-relay receiver to pick up timing signals and activate camera controls in all photographic aircraft, and special control boxes in the aircraft with time-delay relay controls to distribute the starting impulse as required by the various camera setups. (2) The camera time recorder, which records the time of starting and duration of operation of cameras. (3) A pulse amplifier, which produces a timing signal and operates an argon lamp to be recorded directly on the edge of high-speed films, establishing an accurate time base for film analysis.

Omitting the myriad problems encountered in installation and operation of this system, which were laboriously but satisfactorily solved, the various elements operated, briefly, as follows.

A standard radio-relay receiver, developed under direction of the Manhattan District and built commercially, was used to meet requirements of the Air Forces, Navy, and Manhattan technicians. Approximately 300 of these receivers were used in the combined timing system.

Equipment installed aboard the *USS Cumberland Sound* was capable of transmitting a series of time signals correlated with detonation. These signals indicated the following times: minus 20 min, minus 2 min, minus 20 sec, minus 5 sec, minus 2 sec, detonation and a recycling signal. The receivers had filters capable of selecting any of these signals. The AAF requirements were met by using a receiver operating on the minus 5-sec and minus 2-sec signals.

The bombing aircraft established time with respect to detonation by broadcasting the actual time of fall, which was calculated by the bombardier, and the release point. The release point was established

mechanically by having the bomb-release mechanism interrupt a continuous signal which had been started one minute prior to release time. The interruption of this continuous signal automatically started a timing device on the *USS Cumberland Sound*, which then transmitted the interval signals described above. In the photographic aircraft, the turret cameras were started when the radio-relay receiver picked up the 5-sec signal, and the high-speed cameras were started by the 2-sec signal.

The special control boxes on the photographic aircraft consisted of a time-delay relay control, remote controls, and sequence controls. After the radio receiver picked up the desired signals, it in turn operated one or more controls. These controls were capable of starting cameras at the exact time the signal was received, or by virtue of time-delay circuits, at a predetermined later time. For example, the time-delay relay control was operated by the minus 2-sec signal and started a Fastax high-speed camera at minus 1.5 sec, and then started an Eastman high-speed camera at minus 0.5 sec. The remote control boxes started turret cameras and *K-24* cameras at the time the signal was received. The sequence control equipment, on getting a similar signal from the receiver, started three or six high-speed cameras in a sequence pattern.

The camera time recorder was designed to provide an accurate time record of the frequency of operation of cameras in the photographic aircraft. Essentially, the time recorder consisted of a modified *A-4* motion picture camera which photographs 24 small indicator lights mounted on a panel around an accurate clock. The zero lamp is wired to the 2-sec time signal. Each remaining lamp is connected to a specific camera, flashing on each exposure or burning constantly while the camera is in operation. The *A-4* camera was modified with a rotary solenoid to operate at the rate of 3 frames per sec. The camera control employed a *B-5* intervalometer and delay relays.

The pulse amplifier was designed to establish time-base indications on ultra-high-speed motion picture film. The principle of operation is new and of extreme interest in technical applications of photography.

This device operates a $1/4$ -w argon lamp which exposes a small area of known duration at predetermined intervals on the film. The pulse amplifier contains an accurate electronic oscillator capable of producing a standard frequency with good stability under normal operating conditions. The sine wave generated by this oscillator is

fed into a pulse-shaping circuit to trigger a square-wave "flip-flop" generator. The "flip-flop" generator excites the argon lamp to full brilliance within one microsecond, and maintains the excitation for a specified time interval. At the end of this interval, the intensity of the lamp falls to zero within one microsecond. The interval of excitation is variable. For this operation it was set at approximately 2000 microseconds.

The pulse amplifier operates from a 110-v, 400-cycle power supply and embodies a voltage-regulator circuit in the rectifier section to compensate for variations in the power supply. All parts of the set susceptible to change in climatic conditions were protected by a special lacquer to prevent deterioration and loss of calibration. Resistors and condensers used in the oscillator circuit were hermetically sealed to prevent a drift in frequency. Each unit is capable of operating a maximum of four $\frac{1}{4}$ -w argon lamps.

The frequency of the pulse amplifier was determined, to a large extent, by the linear velocity of the film. Since on Crossroads it was desired to expose at the rate of 1000 frames per sec and maintain a measurable spacing of pips during the acceleration period without loss of time resolution at maximum speed, it was decided to use a frequency of 60 cycles per sec. This resulted in a pip separation of 5 in. at 1000 frames per sec. The duration of the pips is approximately 2 milliseconds.

By use of the types of equipment described, it was possible for Crossroads photographers to provide the scientists with an accurately controlled medium with all essential factors established for analytical research.

All lenses on cameras used for precision results, of course, had to be calibrated, and careful detailed records were maintained on each piece of film.

On the whole, while it is obviously much easier to tell than it was to accomplish, the operation was highly successful. Aircraft operation was 100 per cent, with no "aborts" on either mission, and the precision flying was superb. The number of camera failures in critical positions was extremely small, considering the operating conditions, and these failures were more than covered in duplication of equipment. The only failure of importance technically also concerned timing. On Able day a false signal was accidentally put out which started many cameras prematurely, and much valuable photography was lost, particularly in operation of photometers and spectrographic

equipment. Fortunately, some operators caught the discrepancy and operated their equipment manually to save the day. In spite of this failure, the camera-control equipment was considered completely successful, as far as operation was concerned.

A great wealth of photographic material was accumulated during the Atomic Bomb tests. To date, only analysis which could be quickly completed has been accomplished. Scientists have estimated that it will take three to five years to complete research and analysis of the photography on hand.

The Atomic Bomb tests provided a great opportunity for photography as a prime implement of technical development. It was a rare privilege to be included in the Group assigned to the Crossroads Project, to play a part in planning and accomplishment of a photographic mission of such scope and importance, and to help demonstrate once again the inestimable value of the motion picture as a source of real technical information.

DISCUSSION

MR. H. W. MOYSE: Was it necessary to have protection against the radiation striking the film in the cameras as they were in the various spots?

COL. CUNNINGHAM: In some cameras it was. All the cameras on the Island of Bikini were heavily insulated, but we had to take very little precaution in the aerial cameras.

MR. L. R. MARTIN: You mentioned the Mitchells used 35-mm with high speed; at what rates were they run?

COL. CUNNINGHAM: At 90 frames.

MR. MARTIN: Was the time-resolving power of a 1000-frame camera needed?

COL. CUNNINGHAM: It was needed, definitely, for certain information at the beginning immediately after detonation, but for all general purposes, some of the best photography was with the high-speed Mitchell at 90 frames.

A HIGH-QUALITY RECORDING POWER AMPLIFIER*

KURT SINGER**

Summary.—A power amplifier which provides high-quality performance because of the utilization of negative feedback over three stages is described. The mechanical design presents a novel and convenient front service arrangement.

The subject of this paper is an amplifier which will be used primarily as a power amplifier in recording channels. It is capable of driving light modulators as, for instance, galvanometers or disk recorders. It is intended to be used also as a monitor amplifier to supply power to loudspeaker installations for small monitor rooms.

When the design of this amplifier was started, the following specifications had to be met:

- (1) Input impedance, 500 to 600 ohms or bridging.
- (2) Sufficient gain to obtain full power output from a one-milliwatt, 500- or 600-ohm bridging bus.
- (3) Frequency characteristic flat within 0.5 db, from 20 to 10,000 cycles.
- (4) The amplifier must deliver 10 w with a maximum permissible distortion of 0.5 per cent from 50 to 8500 cycles. The cross-modulation products, when a 9000-cycle carrier modulated 80 per cent with 400 cycles is applied, must be at least 66 db below output level.
- (5) Its output impedance had to be dimensioned in such a manner that it can deliver full rated power output into a 500- to 600-ohm load, such as a loudspeaker. Also, the output impedance must be adjustable, by means of a soldered connection, so that it would always match a 500- to 600-ohm load, that is, actually measure 500 to 600 ohms. This is particularly important when working into a device where the generator impedance has some influence on its frequency characteristic like a recording galvanometer.

* Presented Oct. 22, 1946 at the SMPE Convention in Hollywood.

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

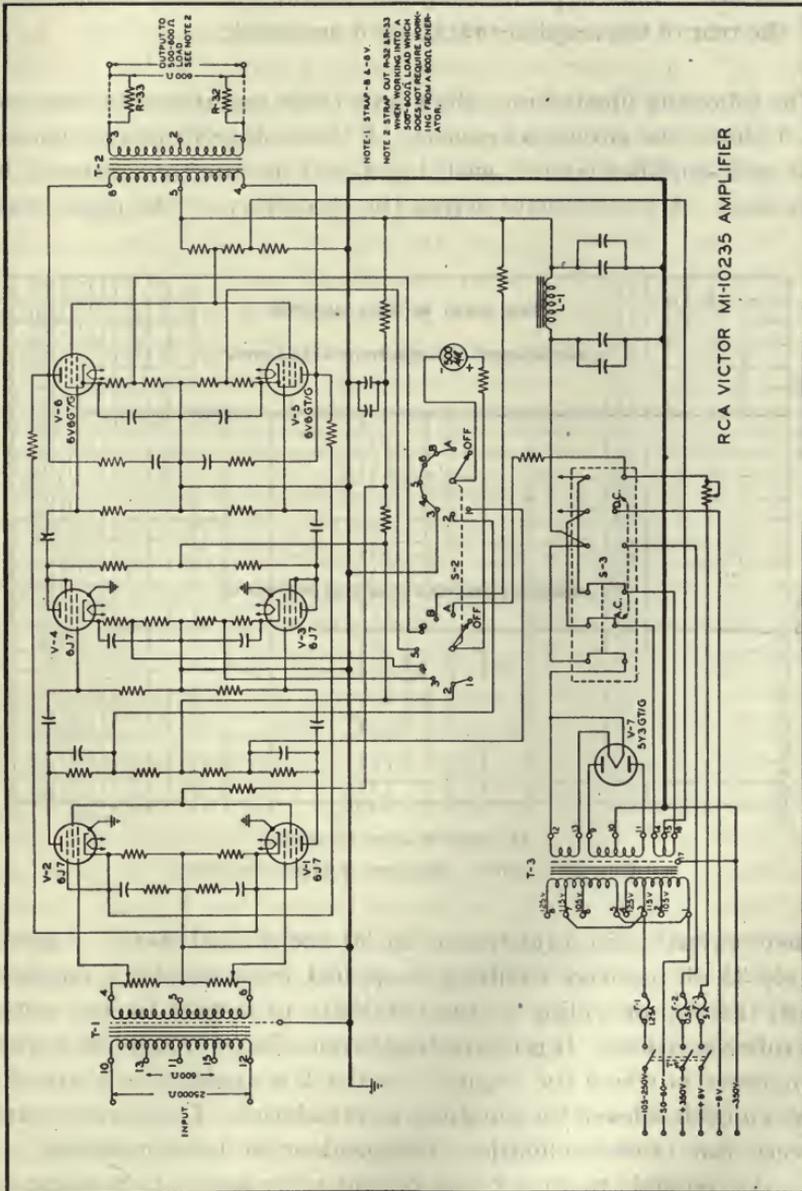


FIG. 1. Circuit schematic.

- (6) The amplifier should operate from a-c mains or d-c.
- (7) The mechanical arrangement must provide for 100 per cent front service. This is particularly important for installations where the rear of the amplifier rack is not accessible.

The following illustrations show how these requirements were met. Fig. 1 shows the circuit schematic. A three-stage resistance-coupled push-pull amplifier circuit, with input and output transformers, has been used. A gain control across the secondary of the input trans-

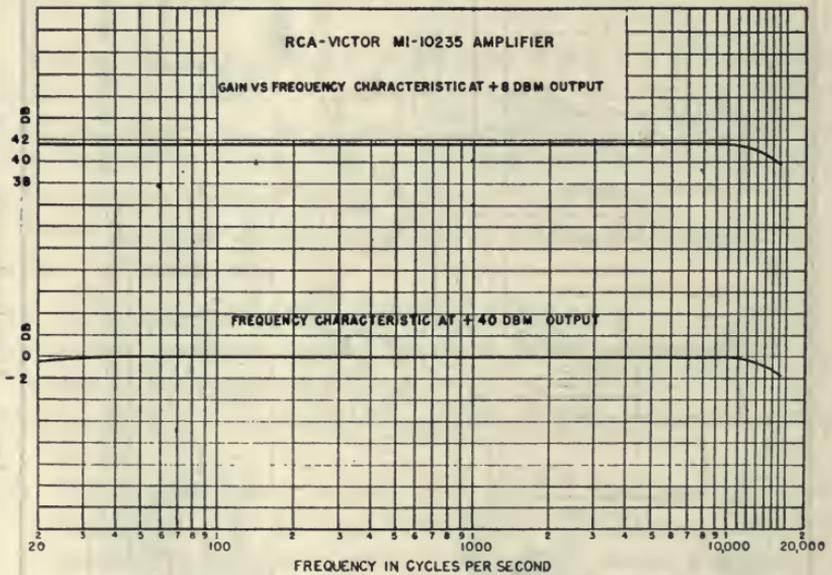


FIG. 2. Gain vs. frequency characteristic.

former permits gain adjustments in 30 one-decibel steps. Approximately 35 db negative feedback is applied from amplifier output to input, thereby providing unusual stability in respect to line voltage and tube variations. It is interesting to note that, through the particular manner in which the negative feedback is applied, cross-coupling between both sides of the amplifier is introduced. This feature results in very low cross-modulation, independent of tube matching. In fact, it is possible to interchange output tubes without obtaining any significant change in cross-modulation percentage. The frequency response of the amplifier without negative feedback is still quite good, being down approximately 6 db at 20 cycles and 16,000 cycles.

Consequently, the distortion-correcting ability of the negative feedback is almost fully utilized at the extremes of the frequency band.

The input transformer can be connected for bridging or matching input. Its input impedance is 25,000 ohms when connected for bridging, and 600 ohms when connected for matching. The output impedance of the amplifier, when set up to deliver full power output into a 500- or 600-ohm load is approximately 100 ohms. When the building-out resistors *R-32* and *R-33* are used, the output impedance is actually 600 ohms. However, under this condition, the rated power output is reduced by 4 db. The bridging gain of this amplifier is 41 db when working into a 500-ohm load, and 35 db when its output impedance is adjusted to 600 ohms by means of the building-out resistors *R-32* and *R-33*. The matching gain is 56 db or 50 db, respectively.

A rotary tap switch in conjunction with a 500 μ a meter permits metering of all tubes, and of the *A* and *B* supply. The metering resistors are of such dimensions that when a meter indication in the center of the dial is obtained, correct operation is assured. A simple switching arrangement *S-3* permits selection of either a-c or d-c supply. The a-c supply is self-contained. Direct current has to be supplied from external sources such as batteries, regulated power supplies, or dynamotor. In the studio, the amplifier is intended to be operated from the alternating-current mains. When operated from alternating current, the noise level from the amplifier is -50 dbm. In truck installations, direct-current supplies are generally used.

Fig. 2 shows the frequency characteristics of the amplifier at two different output levels, +8 dbm at the top and +40 dbm at the bottom. The frequency characteristic does not vary with level except for the 20-cycle response which results from the output transformer. Since it would have required an output transformer of considerably larger size to maintain 20-cycle response, it was decided against, because increasing the size of the output transformer would also have made it more difficult to retain very low leakage inductance, which is highly desirable when one demands full power output from an amplifier at the high frequencies.

Fig. 3 shows the distortion characteristics of the amplifier. Distortion percentages are shown at 60, 400, 4000, and 8500 cycles. At all frequencies the maximum permissible distortion requirement of 0.5 per cent at +40 dbm is met. The oscillator distortion at 60 cycles was on the order of 0.1 per cent, which is also shown on Fig. 3. We found it very difficult to reduce the oscillator distortion at low

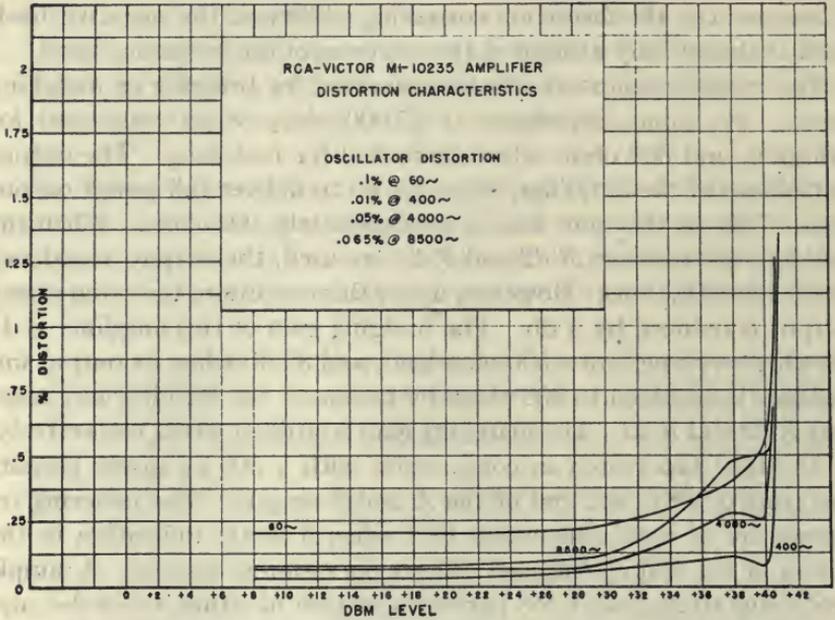


FIG. 3. Distortion characteristic.

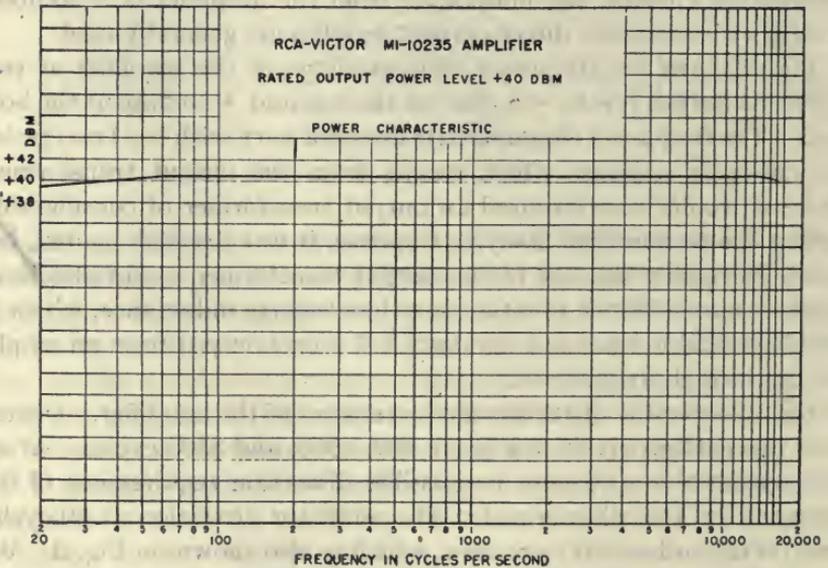


FIG. 4. Power characteristic.

frequencies below this point. Consequently, if we show 0.2 per cent distortion at 60 cycles at low levels, one tenth of one per cent is contributed by the oscillator. While one should hesitate to make the

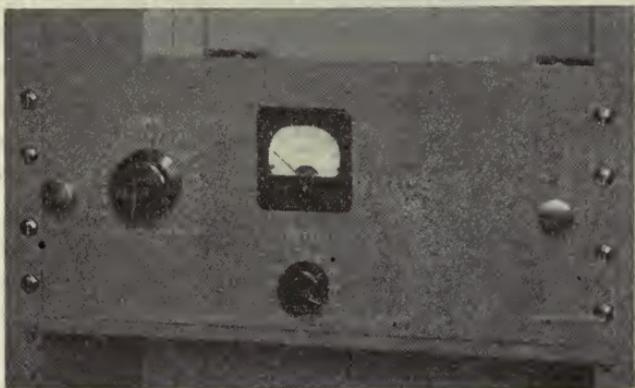


FIG. 5. Front view of amplifier.

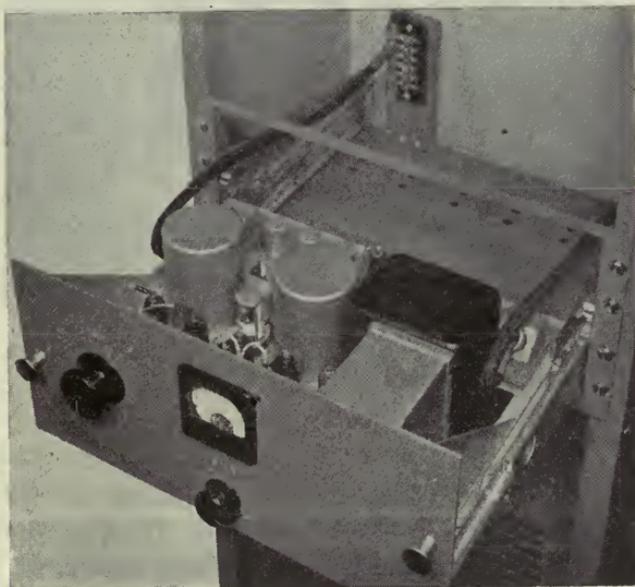


FIG. 6. Amplifier pulled out from shelf.

categorical statement that no distortion cancellation is taking place at these low levels between oscillator distortion and amplifier distortion, it is believed, from a large number of measurements that, in this

particular case, the oscillator distortion adds almost directly to the amplifier distortion.

Fig. 4 shows the power characteristic of the amplifier. In addition to distortion, we have also measured cross-modulation of the amplifier by applying a 9000-cycle carrier which was modulated 80 per cent with 400 cycles. The output of the amplifier was then passed through a 400-cycle bandpass filter, and the amplitude of the 400-cycle cross-modulation product was measured. We found that at an output

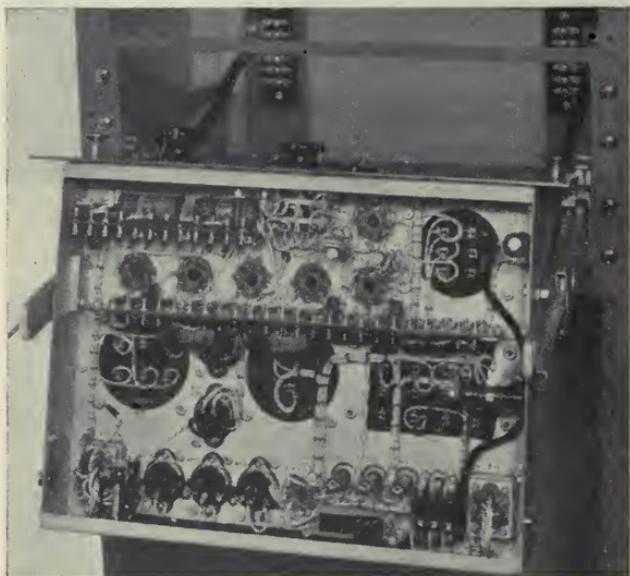


FIG. 7. Amplifier pulled out from shelf and tipped for accessibility of chassis wiring.

level of +40 dbm, the 400-cycle component was 74 db down. At an output level of +38 dbm, the 400-cycle component was 90 db down. While this type of measurement is usually not of interest to the amplifier designer, it is of particular importance to us, since we are using cross-modulation measurements to determine optimum processing conditions for our variable-area recordings. Consequently, any amplifier which is intended to drive a film recorder must have cross-modulation products substantially below what will be measured from film. We have also made intermodulation measurements. At +40 dbm output level, we have obtained

- 1.45 per cent when using 400 and 4000 cycles
- 2.4 per cent when using 100 and 4000 cycles
- 2.4 per cent when using 60 and 4000 cycles
- 2.25 per cent when using 50 and 4000 cycles
- 3.2 per cent when using 40 and 4000 cycles
- 3.1 per cent when using 30 and 4000 cycles

2 db below full power output, that is, at +38 dbm, intermodulation was less than 0.5 per cent at all frequency combinations.

Fig. 5 shows a front view of the amplifier mounted in a standard equipment rack. By means of two knobs located on the horizontal center line, the amplifier chassis can be pulled out on drawer slides similar to those used in filing cabinets. After the amplifier has been pulled out, as shown on Fig. 6, the top of the chassis and rear of the front panel are accessible. This is the position normally required for routine service, like replacement of tubes or cleaning of gain control, *etc.* Suitable locks hold the chassis in the pulled-out position, thereby preventing accidental pinching of fingers, should a man work on the amplifier and lean against the withdrawn chassis at the same time. Should one desire to inspect the underside of the chassis, it is merely necessary to press two push buttons located on the two sides of the chassis toward the rear, and the whole assembly pivots, as shown on Fig. 7. Now full access to the underside of the chassis is easy, for any repair or measurement that might be necessary.

If the amplifier chassis must be removed from the rack for any reason, all amplifier leads may be disconnected by pulling the two rectangular plugs on the back of the chassis. The chassis may then be lifted from its cradle and removed for service or storage. Another chassis may be dropped into place in the cradle, and the two Cannon plugs may again be connected. We believe that this front service arrangement will appeal to the man who has to service recording amplifiers on a routine basis as well as in cases of emergency, since it is so simple to get at every part and, if necessary, to replace an entire amplifier in a matter of minutes. The components used in the amplifiers have all been selected for close tolerances and long life. While electrolytic condensers have been used, their removal for replacement has been facilitated by utilizing a plug-in arrangement. Since some studios have included in their maintenance routine the periodic testing of electrolytic condensers at specified intervals, perhaps every three months, their removal from the amplifier for bridge measurements has

thus been considerably simplified, as no unsoldering of connections is required.

In conclusion, it should be mentioned that the circuit for this amplifier has been contributed by our circuit development group in the East, whereas the mechanical development and design was done on the West Coast.

A METHOD FOR DETERMINING THE SHAPE OF THE IMAGE SURFACE IN 16-MM PROJECTION*

F. J. KOLB, JR., A. C. ROBERTSON, AND R. H. TALBOT**

Summary.—Sixteen-millimeter projection is becoming more and more professional in its application, and it is beginning to be judged by professional standards. One characteristic of 16-mm projection which needs improvement is the sharpness of the projected image. A method is presented for describing the shape of the focal surface; the departure of this surface from a plane explains a great deal of the lack of sharpness in the image. The contributions of the elements of the optical system and the design of the gate are discussed.

Introduction.—Sixteen-millimeter motion pictures came on the market in 1923 and were made to satisfy the desire of the amateur photographers to make movies which could be presented in the home. In the beginning, it was not intended to have the small film used commercially, nor to show the pictures to large audiences accustomed to the high quality of 35-mm entertainment films. Within recent years, however, 16-mm film has been used commercially to an increasing extent, and many people feel that this phase of its development will increase.

As 16-mm productions enter into the commercial field, they will naturally be judged by professional standards. Advantages of reduced cost, greater portability, and simplification may be forgotten while the performance is being viewed. Because 16-mm productions with increased screen sizes and increased illumination are being shown to larger audiences, and because the presentations are being made not to people within the home circle, but to a more critical group, it becomes apparent that presentations ought not to fall very far short of the standards found necessary for 35-mm film.

Anyone observing a large 16-mm screen image critically from the minimum viewing distance will note that the definition is neither so good nor so uniform as one would desire. Detailed subjects and

* Presented Oct. 25, 1946, at the SMPE Convention in Hollywood.

** Eastman Kodak Company, Kodak Park Works, Rochester, N. Y.

titles, in particular, offer a critical test, and it is usual to find that only part of the image can be focused sharply, while marked "fuzziness" prevails for the rest of the image. This is especially noticeable because most audiences are accustomed to the excellent definition that has been obtained in 35-mm projection practice.

It is probable that 16-mm will never equal the quality of concurrent 35-mm projection because the improvements which may be developed for its use can be applied to 35-mm; accordingly, there will always

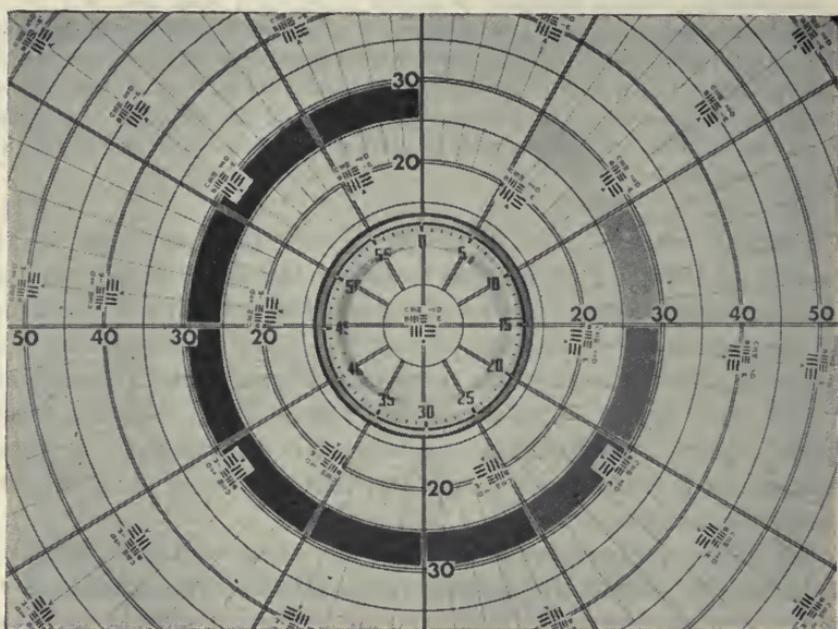


FIG. 1. Test object used for making prints.

remain a gap in quality that depends solely upon the difference in film sizes. This difference will be least, of course, for the best equipment. It must be pointed out that most present-day 16-mm equipment is made with every effort to keep the cost low since it is sold to the amateur who cannot afford an expensive projector. When a market develops for the best possible 16-mm projection equipment—made without price considerations—we may expect to find the image on the screen greatly improved. Another limitation beside that of cost is the fact that 16-mm equipment must have lenses of very wide aperture in order to obtain a bright screen image. Apertures of $f/1.6$

and $f/1.4$ are as common as apertures of $f/2.3$ and $f/2.0$ in the 35-mm field. It is difficult to make the faster lenses perform as well as the slower ones. Still another limitation is the fact that the 16-mm aperture is small in terms of actual dimensions. Accordingly, if one uses sources of equal brightness, and optical systems of the same f value, to illuminate screens to the same illuminance value, then the 16-mm screen image will be only 0.465 times as wide as the 35-mm screen image.

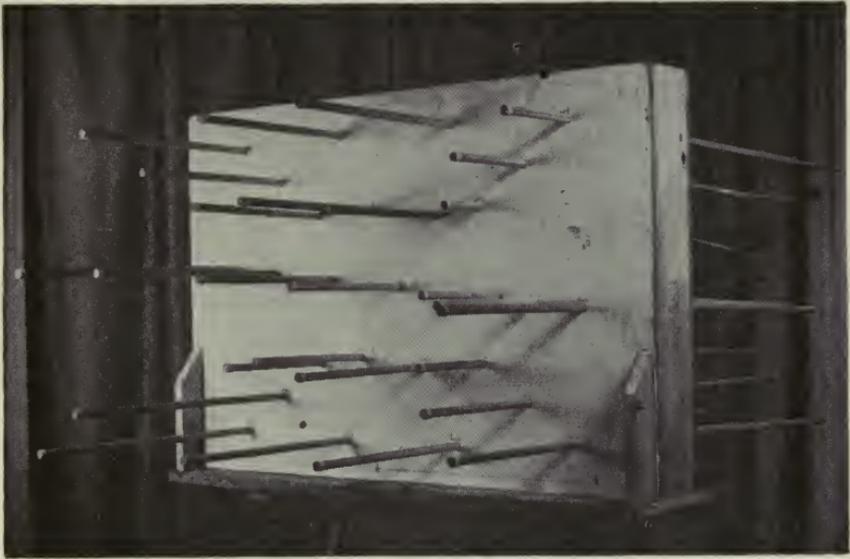


FIG. 2. Photograph of test "screen".

The foregoing relationships suggest that there will be a region where either 16-mm or 35-mm projection equipment can satisfy requirements, as well as regions in which one or the other will be pre-eminent. The comparisons in this investigation are made for equal screen sizes partly because there is an overlapping region of usefulness, and partly because there is no satisfactory, absolute scale of performance. A cross comparison seems the most acceptable way of rating performance. In all fairness, it must be pointed out that the 16-mm projectors used in this study were current models, which, in the main, represent slightly modified amateur projectors, and that they are being compared with 35-mm projectors designed for professional use.

Anticipating a demand for an improvement in 16-mm projection, we have considered methods for judging the quality of the projected image. Measurements of the resolving power on a flat screen can be used, but these values are of limited assistance when one is seeking the reason for poor projection. On the other hand, the data, describing the shape of the surface upon which the best projected image is found, do allow one to evaluate the importance of various factors. For example, the effects of variation in the gate, or in the projection lens, can be studied by making changes in these elements. The effect of distortions in the film can be studied similarly. This com-

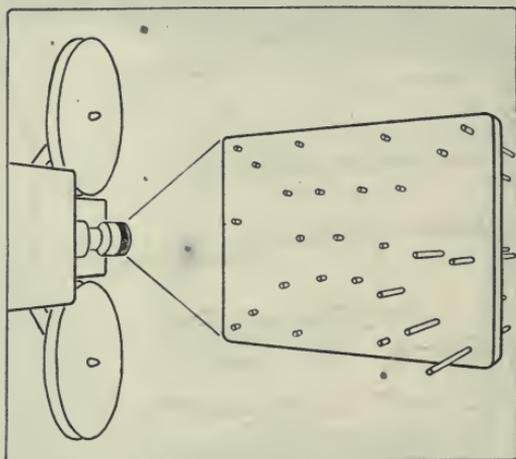


FIG. 3. Schematic drawing, showing the use of the "screen" and projector.

parison must be made when projecting film in the projector, under entirely normal conditions. We are interested fundamentally in the quality of the finished product, and not only must the lens, gate, film behavior, *etc.*, be perfected, but they must act together to produce the best possible screen image.¹

Description of the Method.—It was apparent that one of the main reasons the 16-mm projected image was not sharply defined was that the surface upon which the image was at its best was not a plane and accordingly did not correspond closely to the flat screen. An observer can confirm this roughly by holding a card up in the projection beam, intercepting a portion of the image near the edge of the frame, for example, and moving the card back and forth along the beam until that portion of the image is focused sharply. When other

selected points are focused upon the movable card, it will be found that many of these images will be sharpest at a considerable distance away from the screen.

Elaborating upon this method, we prepared a film suitable for critical judgment of focus by making a print of the test object shown in Fig. 1. This object provides a large number of resolution charts spaced over the picture area; the use of these charts makes possible a critical determination of the best focus at various locations. (The resolution chart shown here resembles that mentioned² in American War Stand-



FIG. 4. Screen model, showing focal surfaces for a 35-mm projector using a Super Cinephor lens, at low illumination level.

ard Z52.1-1944. However, our first experiments antedate this publication and were conducted with simpler equipment.) A roll of this test film was projected in the projectors being tested upon a special screen shown in Fig. 2. This screen is designed for a 30-in. width of picture. When the test film is projected upon it, at the proper magnification, each of the resolution charts falls upon a card held at the end of a horizontal, movable rod supported by the walls of a tall, narrow box. It is as if the screen consisted of a number of segments, each movable independently of the others, so that each could be set in such a position as to bring its portion of the projected image to maximum sharpness. During the running of the roll, the point of best focus for each of the small resolution charts is determined and the

appropriate rod is set to that point. This procedure is illustrated in Fig. 3. At the conclusion of the test, it is then possible to measure how far each of the rods projects from the plane of the screen, and so to determine how far a screen surface, giving optimum results for this projector, would have to depart from a plane.

Measurements of the image displacement can be recorded and shown by a contour map, but this representation takes time to prepare and is not comprehended quickly enough to be used in a discussion. Accordingly, we made scale models of the screen results. Their shape can be judged, although with slight difficulty, from photographs of the models in the figures to follow.



FIG. 5. Screen model for best 16-mm. projector, equipped with a flat gate and a "field-flattener" lens.

35-Mm Standards.—Since we have been assuming that 35-mm projection should be a standard of comparison, actual measurements were made of the screen surface produced by such a projector equipped with a Super Cinephor Lens. Using the 30-in. special screen, previously described, the test film was projected, with only the light from a 32-candlepower automobile headlight bulb. This small light was placed in the arc lamphouse, with its filament at the crater position. It should be pointed out that the film was traveling at normal speed through the projector illuminated by this weak source; under these conditions we have assumed it to be subjected to negligible thermal effects.

Fig. 4 is a photograph of a scale model of the test screen. It is apparent that the best surface for these projection conditions would be the inner surface of a saucer. The points farthest away from the plane of the center of the image, were perhaps 6 or 8 in. out of the plane of the 30-in. screen. How these results would appear if the screen sizes were enlarged will be discussed later, but for the purpose of comparing the data herein presented, it will be apparent that all of the results are directly comparable. The explanation of this

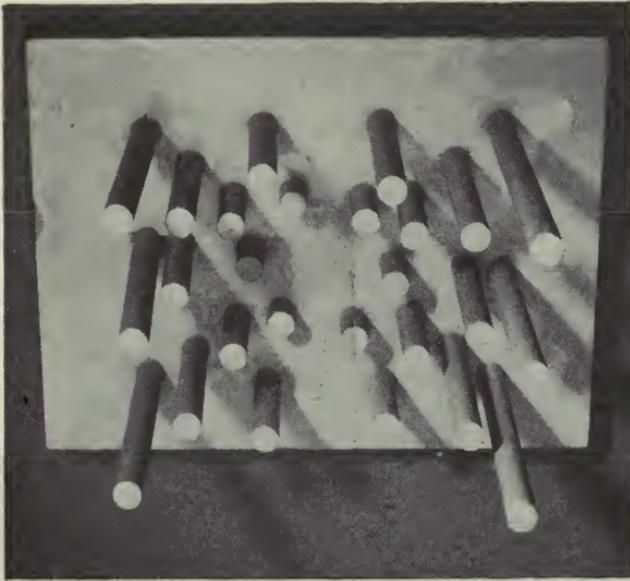


FIG. 6. Screen model for 16-mm projector using lens without "field flattener".

saucer shape will become apparent when one realizes that the conventional projection lens is not ideal. It images a flat object best not upon a plane but upon a curved surface concave to the lens. To produce a good image upon a flat screen requires that the film surface be similarly curved, and concave to the lens. The field curvature of a lens varies appreciably, as will be shown, with the design of the lens. The six-element anastigmat used for the 35-mm comparison gives a much flatter field than the cheaper four-element lenses used in some 35-mm projectors and in most 16-mm projectors.

16-Mm Results.—The best screen surface that we obtained in 16-mm projection is shown in Fig. 5. This is a representation of the

data obtained using a projector with a flat gate and a lens well corrected for field curvature. Despite the addition of an extra optical element near the film, often called a "field flattener", this screen figure is perhaps twice as distorted as the 35-mm standard shown in Fig. 4.

Quite frequently, 16-mm film is projected with lenses which do not incorporate "field-flattener" elements, and which accordingly possess a greater degree of residual field curvature. Fig. 6 represents data obtained from a projector equipped with a lens of this type.

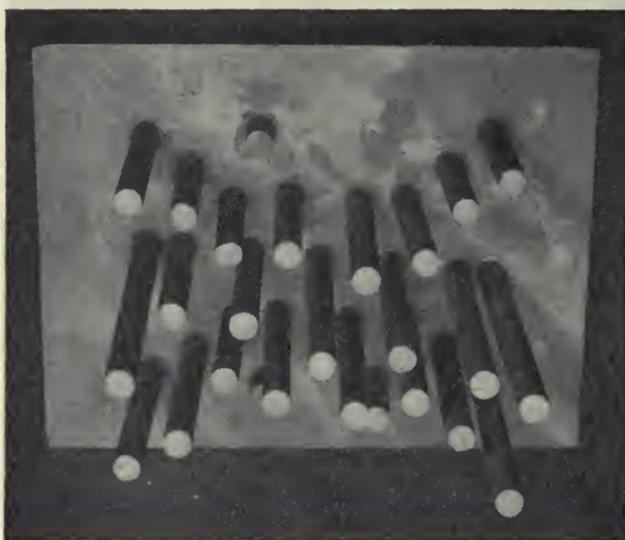


FIG. 7. Screen model showing effect of cylindrical gate, used with a "field-flattener" lens.

Similar results were obtained for nine projectors representing the product of four different manufacturers. This surface is a strikingly deep hollow bowl concave toward the projector; it departs so much from a plane surface that it is difficult to believe the results. Independent checks by several observers, however, confirm the fact that at the edges of the screen some points do come to focus 20 in. or so in front of the 30-in. screen. It will be apparent from further data to be presented that these large departures from an ideally flat screen are very common in 16-mm projection and that they represent one of the larger problems to be overcome. These deficiencies, no doubt,

are a heritage from the days when the selling price was the dominant factor in the matter of design.

Our test object, it will be recalled, contains both radial and tangential lines. A perfect lens would focus both sets at the same dis-

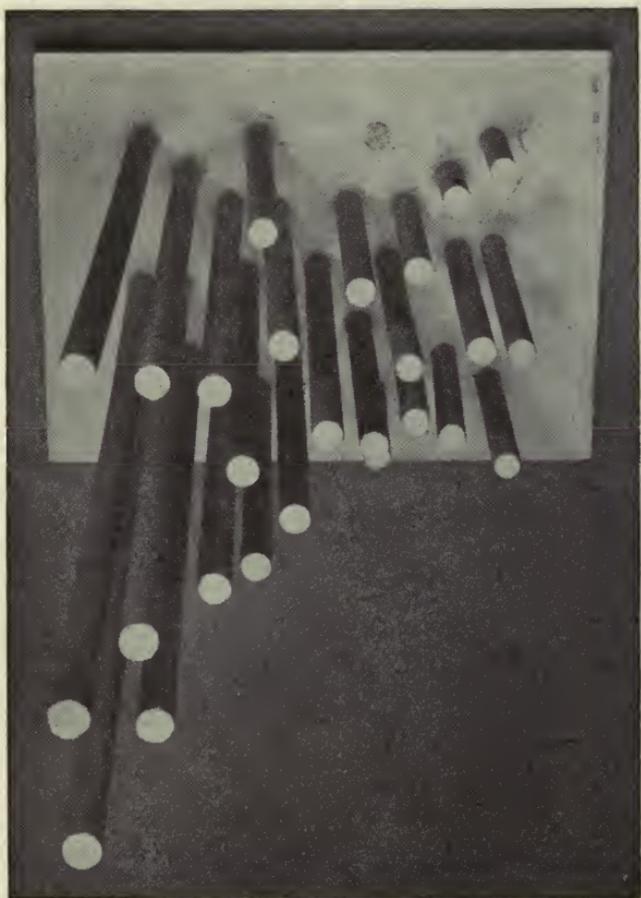


FIG. 8. Screen model showing effect caused by a gate "cocked 0.005". Compare with Fig. 7.

tance. Commercial lenses all suffer from some degree of astigmatism, and accordingly, the radial lines focus at a slightly different location from that in which the tangential lines focus. This difference is real and found by all observers, but it is difficult to show in our models. We have taken for our data a compromise focus,

approximately midway between the sharpest focus for the radial lines and the sharpest focus for the tangential lines. In this compromise, both sets of lines are equally lacking in sharpness. It corresponds to the usual condition in which the picture is composed of lines orientated in all directions. The net effect of astigmatism upon our test procedure is to limit the maximum sharpness that can be obtained for image points off the optical axis, and to make the test procedure more difficult. When an image of this kind is produced on projection, it will appear fuzzy except at the center. We have thus seen that both curvature of field and astigmatism tend to produce poor images.



FIG. 9. Screen model for 35-mm projector, equipped with Super Cinephor lens as in Fig. 4; illumination increased to 17 per cent of normal.

It is the task of the optical engineer to flatten the field, reduce astigmatism, and minimize other aberrations not discussed here.

The data presented so far have shown only the effect of changes in the lens design. It is equally possible to change the shape of the focal surface by modifying the gate construction, or by distorting the film. A cylindrical gate is sometimes preferred for the rigidity it imparts to film, and this preference is greater when film with a slight initial distortion must be handled. Fig. 7 presents the data for a projector having a cylindrical gate of 2-in. radius concave toward the

projection lens, the cylindrical axis being horizontal.* These data were obtained with a lens which had a very flat field. Accordingly, the lens aberrations, alone, have a small effect upon the shape of the image except at the corners. If the lens were indeed ideal, the image projected from this cylindrical gate would be a horizontal cylinder convex toward the projection lens. Since the lens used was not entirely free from field curvature, it distorted the cylinder by bringing the corners of the image closer to the lens. The cylinder is accordingly modified to a shape difficult to describe; it can be called hat-shaped, or saddle-shaped, as one prefers.

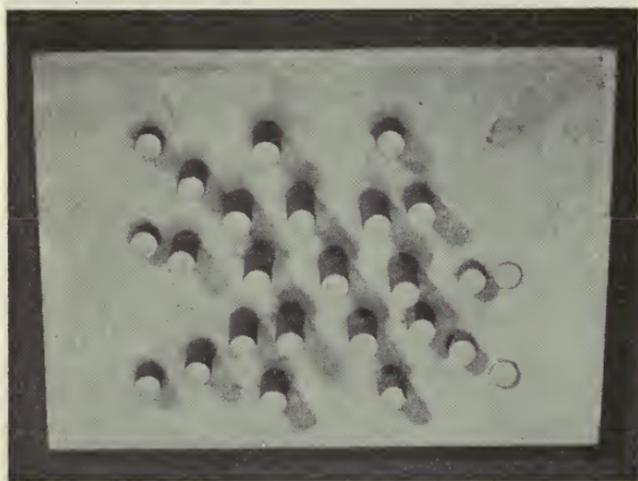


FIG. 10. Screen model for 35-mm projector, comparable with Figs. 4 and 9, but with full illumination from Hy-Candescent arc.

The contour of the focal surface can be influenced not only through the use of gate surfaces that depart from a plane, but also through errors and inaccuracies in the assembling of the entire optical system. The film must be held at right angles to the optical axis of the projection lens, and the center of the aperture must coincide with the

* In our models it was not convenient to represent points behind the screen by rods recessed into the base of the models. Therefore, these models are assembled so that the point farthest away from the projector comes at the surface of the model base. In comparing the various models, it is necessary to keep this fact in mind. A model with long pegs can represent a surface which includes a comparatively large area that is acceptably flat.

optical axis, within close limits, in order to obtain good results. Fig. 8 shows data obtained when a projector with a cylindrical gate similar to that shown in Fig. 7 was cocked about a vertical axis, so that one edge was 0.005 in. farther from the lens than the other. Under such conditions, the points of best focus for portions of the picture may lie 40 to 50 in. out of the plane of a 30-in. screen. It is apparent, therefore, that one can detect small differences in align-

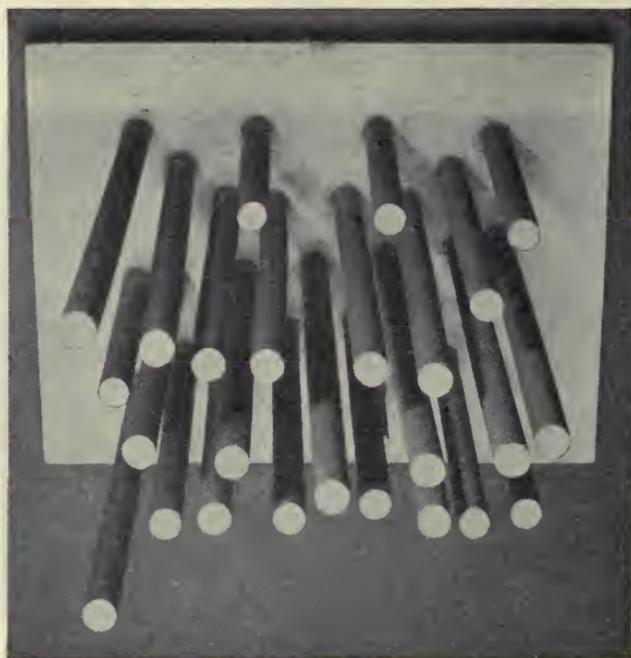


FIG. 11. Screen model for 16-mm projector, with cylindrical gate and low illumination level.

ment and position. By examination of the focal surfaces, we actually have been able to note errors of this kind, when the gate was displaced as little as 0.001 in.

Thermal Effects.—Thus far in the discussion, we have considered the effects upon screen definition which may be produced by the projection lens or by the gate design. Another feature influencing image distortion is the fact that, generally speaking, motion picture film does not occupy the position in the projector gate that might be predicted from the gate construction. Slight deviations may occur because of the unsymmetrical nature of 16-mm sound film. It also

was expected that thermal effects might play a part; such effects for 35-mm projection were reported by Carver, Talbot, and Loomis.³ In their paper, they demonstrated that the heat of an arc momentarily distorts each frame, even though it is held in a flat gate, into a "pincushion"-shaped figure during the short time in which it is being projected upon the screen. It was expected that the amount of this thermal distortion could be measured by the new technique just outlined.

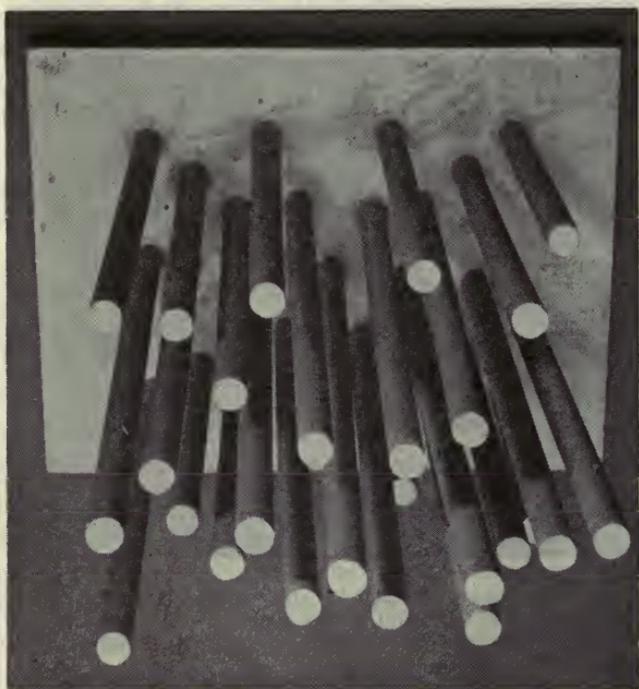


FIG. 12. Model for projector described in Fig. 11; illumination increased to that of 30-amp arc.

Let us return to an examination of Fig. 4 in order to discuss thermal effects in 35-mm projection. This model was obtained from experiments with very weak illumination, which presumably produced no thermal distortion of the film. Therefore, it may be assumed that this model illustrates the influence of the projection lens. Fig. 9 shows the data from a second series of 35-mm projections using the light from a Hy-Candescent arc reduced in intensity by the use of wire screens, which cut the beam down to approximately 17 per cent

of the full intensity. It appears from these data that the center of the film has moved, by reason of "negative drift" (or thermal distortion³ described) away from the projection lens. The center of the screen image accordingly has moved toward the projection lens. Therefore, the focal surface is flatter than before.

A similar series of 35-mm projections was made using the full intensity of the Hy-Candescent arc. These results are shown in Fig. 10, where it is apparent that the film distortion has now grown

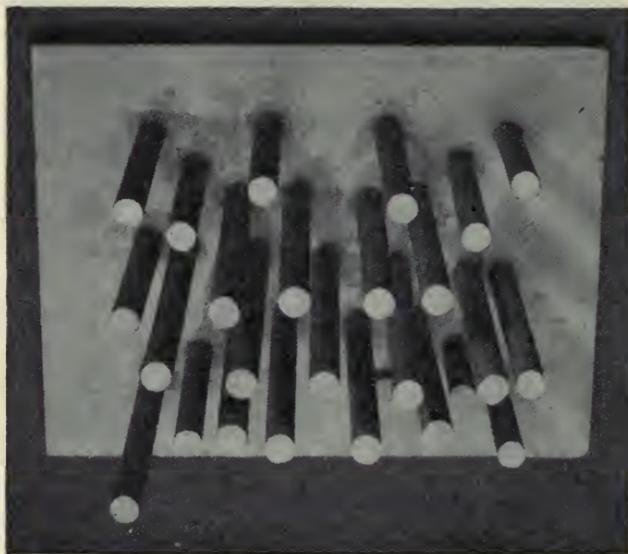


FIG. 13. Screen model for projector described in Figs. 11 and 12, but with double the illumination of the latter. (See footnote on page 583 for precautions necessary to permit this increase.)

so great that the screen surface for best focus has actually been "turned inside out" and is now convex toward the projection lens. Thus, it is shown that, for 35-mm projection, the shape of the focal surface at the screen is influenced as much by the intensity of radiation upon the film as it is by the residual aberrations of a well-corrected projection lens.

In order to learn the importance of these thermal effects in 16-mm projection, we altered a projector so that the intensity of illumination could be varied over a wide range. Fig. 11 shows the results obtained with this projector (one having a cylindrical gate) when the

film was illuminated by a weak source. When a conventional 16-mm arc operated at about 30 amp was used with this projector, the results are as shown in Fig. 12. It will be observed that the pattern has been altered slightly, but that the characteristic hat-shaped appearance remains.

When, by special means, we doubled the light incident upon the film,* we obtained the results shown by Fig. 13. It will be apparent that there has been some change, particularly between Figs. 12 and 13. This change is in the proper direction to be explained by a film distortion which tends to make the cylindrical surface more nearly flat. Since these data were obtained by projecting the film with the emulsion toward the lens, this change corresponds to an expansion of the emulsion. It is, therefore, entirely similar to the effect called "negative drift" in 35-mm projection.³

The actual magnitude of the thermal effects thus demonstrated in this 16-mm arc projector equipped with a curved gate are obviously much less than those found for a 35-mm projector provided with a flat gate. It thus appears that 16-mm film may resist thermal distortion at the instant of projection more than 35-mm film does. Presumably this difference arises from the greater ratio of the thickness to span in the smaller film, but we have not had the opportunity to assess completely the contribution made by the curved gate.

Effect of Screen Size.—All our work reported herein was based upon data for a 30-in. screen, which was chosen as a convenient size for laboratory tests. Reference to books on optics⁴ will show that the screen displacements we have been measuring are related to the axial magnification of the optical system, and that this axial magnification varies as the square of the lateral magnification. Therefore, the actual displacement of any point from a flat screen depends upon the selected size of the image. It is true, however, that the general nature and the relative relationships of such screen contours will remain the same.

* It was possible to use this higher level of illumination with safety to the film, when certain precautions were observed. The film was always projected at the rate of 24 frames per sec, and was cooled at the aperture by a current of air from a small blower. Most important of all, the film was protected from double exposure to the light beam by means of a rear framing aperture. If the spot of light from the arc is not confined to a single frame, parts of each frame will be exposed twice the normal time. We have found that such double exposure greatly reduces the maximum light intensity that the film will withstand.

Our purpose has been to study the screen quality of 16-mm projection as the various elements of the system are altered. Such a study based upon any one constant size of screen is consistent; systems classified in order of excellence on one size of test screen will retain their order unchanged for other sizes of screens.

A question might also be raised concerning our choice of a reference point in comparing 16-mm and 35-mm film projection at the same screen size. It can be argued that, instead, they should be compared at the same magnification. If this is done, the superiority of 35-mm is no longer so great. When we compare 16-mm projection upon a 30-in. screen, for example, and 35-mm projection upon a 64-in. screen, the lateral magnification has been increased by a factor of 2.15, which would increase the axial magnification of the image by a factor of 4.62. Under these conditions, the 35-mm projector with a flat gate and a very low level of illumination would be expected to give data not as shown in Fig. 4, but nearly identical with those shown in Fig. 6. Furthermore, the 35-mm projector at high intensities of illumination, under these conditions, would be expected to give a screen pattern not as shown in Fig. 10, but entirely similar to that shown in Fig. 7.

We have chosen to compare our data on the basis of equal screen size, believing that the final selection between 35-mm and 16-mm equipment will be made after the screen size has been fixed by considerations of size of the audience, design of the auditorium, *etc.*, assuming that for this particular purpose either 16-mm or 35-mm equipment could be used. Although this basis, therefore, demands a higher standard in 16-mm, we believe it more nearly corresponds to the conditions under which the equipment will be used.

Conclusions.—(1) Sixteen-millimeter motion picture projectors used for large audiences show deficiencies not generally regarded as important in the case of projectors used in the home.

(2) An important deficiency is the lack of sharpness in the image on the screen, an effect largely due to the curvature of the focal surface. Models are shown of focal surfaces for typical projectors.

(3) The effect of high-amperage arcs is relatively slight in cases where the 16-mm projector is provided with an auxiliary mask between the film and the arc.

(4) Mechanical perfection is required for professional 16-mm projectors because the lenses generally used with them have a small depth of focus.

(5) Better lenses are needed for professional 16-mm projectors, since for equal performance, the 16-mm lens must excel a comparable 35 mm lens.

Acknowledgments.—We wish to acknowledge the assistance of A. Earl Quinn in the preparation of this paper. Mr. Quinn made many of the screen measurements, constructed the models, and prepared the illustrations herein reproduced.

We wish also to express our appreciation to Dr. E. K. Carver, who has supervised this project and contributed greatly to its development. We have also called upon our colleagues elsewhere in the Kodak organization, and we wish to thank them at the same time.

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THE SIMULATION OF RADAR PRESENTATIONS FOR BRIEFING PURPOSES*

JOSEPH WESTHEIMER**

Summary.—The problem of briefing American fliers on bombing missions over Japan was acute from the standpoint of accuracy and time. Motion pictures were prepared in advance of missions, showing course, target area, visible landmarks, and return course. As part of this project, motion pictures of a radar scope were simulated. Not only was an accurate replica of a scope portrayed, but these films were rapidly produced. The process is described in the following paper.

In August, 1944, the Army Air Forces, 18th Base Unit was requested to make briefing films for the 21st Bombardment Group on their projected raids on Japan. Japan was unknown to American fliers and long missions of thirteen hours and more, mostly over Japanese-controlled waters, contributed to the always present mechanical difficulties of a shorter routine mission. The crews, moreover, did not know the nature of the resistance to expect, a fact which made complete briefing a necessity.

Motion pictures of the mission, prepared in advance, seemed to be a way to minimize any danger attributable to the human element. Films must show the course to the target, the target area, visible landmarks and, of course, the way out and back home. Maps and photographs from travel bureaus supplied the best information and were usually printed no later than 1939. Target areas were usually airplane factories newly built or expanded as our own, the shape of which was a matter for conjecture. Despite the difficulties, a remarkable job was done, and, later, reconnaissance photographs proved the reconstructions to be extremely accurate.

The films were divided into three parts: (1) animation, (2) visual run, and (3) radar run.

The "animation" section explained the route followed to the target. Railroad patterns, bridges, and rivers were accentuated, and the

* Presented Oct. 25, 1946, at the SMPE Convention in Hollywood.

** Eagle-Lion Studios, Hollywood.

situation of the target in relation to the surrounding terrain was explained in great detail.

The "visual run" consisted of a huge miniature built to the scale of one foot to the mile. A matte shot introduced the miniature at "landfall" and we were taken over the predetermined course at the correct altitude and speed until "bombs away". Narration, of course, covered the entire picture.

The third part of the briefing films was the "radar run" and served two purposes: (1) navigation and (2) bombing. The radar operators could not only navigate a fleet of planes across the ocean to Japan but could also bomb the target in case it was overcast.

Navigation was comparatively easy, islands were easily spotted, and the range markers and azimuth ring indicated their distance and direction. By means of the scope and a few calculations, the operator could determine his drift and relay the information to the bombardier who could avail himself of the information in case he was unable to take his readings. The target could be tracked by synchronizing the scope to the bomb sight, and in case there was a break in the clouds, the bombardier could bomb visually.

It is the simulation of the above activities of the radar operators that we were asked to show on the screen and it is this phase of the briefing films with which this paper is concerned.

It should be mentioned here that, even if we could have photographed an actual mission with fast film and faster lenses for briefing purposes the result would not have been satisfactory for it would not look like the real thing. Photographs of a scope do not, on the movie screen, look like a scope.

During scope operations the operator has a hood over his eyes and he usually is in a curtained-off portion of the plane. The front lights on the scope consist of lucite range markers across the face of the indicator and azimuth markings in degrees around the periphery. The lights are set low enough not to fog the tube and high enough to be just barely visible. As the blue sweep revolves, a trained operator is not conscious of its presence even though special settings necessitate high values. He sees and makes use of the yellow persistence although it is not as sharply defined as the sweep itself. The tuning of the set is dependent upon the operator and whether he is bombing or navigating; and in general, any normal settings are not suitable for motion picture photography. The solution of the problem resolved itself to a process of simulating the appearance of a scope in

operation and then photographing this to create the illusion to one viewing the picture.

The method evolved was quite simple in operation and proved to be extremely flexible so that all types of presentations which we were asked to simulate could be easily accomplished. It not only was

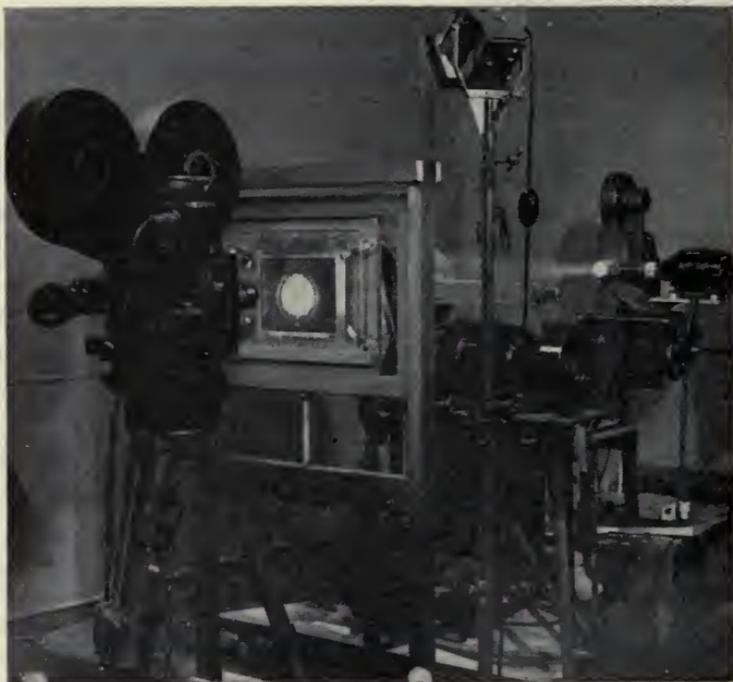


FIG. 1. The process plate is projected upon a translucent screen mounted behind a scope face. Rotating in the beam and simulating the sweep and ground-return persistence is a wedge varying in intensity and definition. The scope face is photographed with a Mitchell camera.

an accurate replica of how a scope actually looked, fooling many experienced operators who were not acquainted with our methods, but also was rapidly produced. Within three or four days a radar mission would be on its way with the rest of the picture to Guam. All would be quiet for a few days until the headlines told us of the bombings.

The process consisted essentially in photographing a drawing to represent the persistence. This was projected through a rotating

variable density and diffusing wedge to a translucent screen located on the back of a scope face. It was then photographed from the other side.

The Persistence.—The afterglow or persistence of the sweep as it rotated was drawn on a black card with its center located by animation registration pins. Information for this drawing was obtained by comparing actual radar still photographs of areas in this country with maps of the same area. This gave us a fairly good estimate on distortion, resolving power, and the distribution of tones. Then, with the help of maps of Japan and radar predictions secured from the Navy, we were able to start artists on the project.

The lubber line (indicating the direction in which the plane flies) and range markers were airbrushed on an overlaying celluloid. The artists determined the correct contrast of the drawings to produce the desired result and, in a short time, were able to work exclusively from maps. All efforts were directed towards the illusion as it would finally appear on the screen, and many tests were made before a balance was obtained between the contrast as drawn by the artist and the result after the image had been projected through the diffusing wedge.

Photographing the Persistence.—The prediction drawings were photographed in stop-motion on an animation stand. At this point in the process we can fade in and out on the range markers, lubber lines and, in fact, the entire scope can be faded in or out to simulate the set's being turned on or off. The negative used was Eastman Type 1231, printed on 1365.

Adding the Sweep.—The film shot on the animation stand was regarded as a process plate. It was projected through a specially prepared variable-density and diffusing wedge onto a fine-grained screen behind the scope face, and photographed from the front.

The wedge consisted of an airbrushed celluloid varying from clear to dark, and although the persistence varies inversely with time it should approximate this only so far as it lies within the photographic range of the film. It must necessarily work close to the screen which arrests the image and still must be fine in texture and consistent enough throughout not to show strokes or other blemishes. A motor rotated the wedge in electrical interlock with both the process projector and camera motor. A variable-speed distributor of special design drove the entire system.

Animation registration pins registered the center of the wedge to the

exact center of rotation no matter which face of the celluloid was forward. This enabled the wedge to paint forward or backward for special simulations, one of which follows as an example of the operations.

This describes the sector scan on the *APQ-23*; it paints in both directions over a 60-deg portion of the scope, and is used for the bomb run. Here a special wedge was developed having three sections, each one covering 120 deg.

- (1) Lock up, mark frame and position of wedge.
- (2) Roll both forward for length of scene.
- (3) Close shutter and rewind.
- (4) Turn wedge over and rotate it 60 deg backwards.
- (5) Lock on original frame and new wedge position.
- (6) Roll camera forward and wedge backwards.

In closing, it may be said that future studio productions will most certainly contain sequences showing radar scopes, and it is worth bearing in mind that these operations can be done with regulation equipment and personnel of a special effects department.

CURRENT LITERATURE OF INTEREST TO THE MOTION PICTURE ENGINEER

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

- Acoustical Society of America, Journal**
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- Convex Wood Splays for Broadcast and Motion Picture Studios (p. 343) M. Rettinger
- American Cinematographer**
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- D.C. Versus A. C. as Projection Illuminant (p. 6) R. E. PULMAN
- The Design of Studio Lighting Fittings (p. 11) F. S. HAWKINS AND W. R. STEVENS
- Colour Television (p. 28) J. E. B. JACOB, L. C. JESTY, R. B. MACKENZIE, AND A. E. SARSON
- Projection Screen Efficiency (p. 37) J. L. STABLEFORD
- 10, 2 (Mar.—Apr. 1947)
- Auditorium Requirements in Sound Film Presentation.
- I.—Picture Projection (p. 58) R. E. PULMAN, J. L. STABLEFORD, AND H. P. WOODS
- II.—Acoustics (p. 72) L. AUDIGIER, A. P. CASTELLAIN, W. F. GARLING, AND L. KNOPP
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- Magnetic Playback-Recorder Using Paper Discs (p. 32) J. H. JAMES
- Lateral Recording (p. 38) W. H. ROBINSON

Ideal Kinema

13 (Apr. 1947)

Employment and Dissipation of Heat in Projection
(p. 15)

R. H. CRICKS

New Ideas in Intermittent Motion (p. 21)

International Projectionist

22, 4 (Apr. 1947)

Two New 35-Mm Projection Test Reels (p. 10) 24-Frame
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(p. 16)RCA Research Lab-
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Complete Projection Data Charts (p. 19)

R. A. MITCHELL

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New Production Technique. British Colour: Pioneer
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R. H. CRICKS

Radio News

37, 5 (May 1947)

The Recording and Reproduction of Sound—Pt. 3
(p. 61) Miniature Tubes for Television (p. 6)

O. READ

E. M. NOLL

SOCIETY ANNOUNCEMENTS**NEW ELECTRON TUBE STANDARDS**

The Joint Electron Tube Engineering Council has recently announced publication of new RMA-NEMA Standards for Dimensional Characteristics of Electron Tubes. Silhouettes of acorn, miniature, metal, *GT*, *G*, and glass-type tubes are given. This is the most recent publication of this material. It supersedes previous listings of such data in other standards and electronic trade papers and will be of interest to equipment designers and manufacturers. Copies of the standards, which are listed as *J5-G2-1*, March 1947, are available from the Radio Manufacturers Association, 1317 F Street, N.W., Washington, D. C., at 80 cents per copy.

These standards are adopted and issued jointly by the Radio Manufacturers Association and the National Electrical Manufacturers Association. They were developed by the Joint Electron Tube Engineering Council (JETEC) which is sponsored by both RMA and NEMA to develop such standards, proposals, and technical data dealing with electron tubes and allied sealed devices.

The JETEC points out that these standards are developed and adopted in the public interest and are designed to eliminate misunderstandings between tube manufacturers, equipment designers, and equipment manufacturers as an aid in selecting the proper products for any particular need. They emphasize also

that these are voluntary standards that assure interchangeability if they are used, but are not enforced and do not preclude any member or nonmember of RMA or NEMA from manufacturing or selling products which do not conform to the standards. This is customary practice in industrial standardization and provides the engineer with necessary latitude for deviation from accepted "standard" items and does not compromise individual initiative in the development of new products.

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PATENT ATTORNEY: Warner Bros. Studios, Burbank, Calif., has opening for young patent attorney familiar with modern techniques in motion picture production equipment, color photography, sound recording, radio, and television. Give full details of background. Write N. Levinson, Warner Bros. Studios, Burbank, Calif.

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SOCIETY OF MOTION PICTURE ENGINEERS

SUPPLEMENTARY MEMBERSHIP DIRECTORY

May 31, 1947

This Supplementary Membership Directory is published in the JOURNAL to cover the interim since the last complete Directory was issued dated June 30, 1946. It contains all new members admitted up to May 31, 1947, and is published solely for the information and use of members of the Society in connection with SMPE activities.

Grade of membership is indicated as follows: S—Student, A—Associate, M—Active, F—Fellow, and H—Honorary. Sustaining members are listed on the outside back cover of this issue. Honorary members and names of distinguished pioneers who are listed on the Honor Roll of the Society are given on the inside back cover.

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Carbajal, J. C., Juan Sanchez Azcona No. 423, Colonia Narvarte, Mexico City, D.F.....	A
Carreau, Gerald, 402 Foster Ave., Brooklyn 30, N.Y.....	A
Carter, W. H., Jr., 1309 Marshall Ave., Houston 6, Tex.....	A
Case, J. T., 4520 N. Clarendon St., Chicago 40, Ill.....	A
Castle, Carol, 25 E. Delaware Pl., Apt. 15B, Chicago, Ill.....	A
Cavelli, D. D., 79 Williams St., Jersey City 4, N.J.....	A
Chamberlin, M. H., Metro-Goldwyn-Mayer Studios, Culver City, Calif.....	M
Chen, Tieh-Seng, 810 E. Fairmont Rd., Burbank, Calif.....	A
Chisholm, E. E., Calle 25, No. 859, Vedado, Havana, Cuba.....	A
Chu, D. L., 509 California St., Los Angeles 12, Calif.....	A
Clark, F. C., Jr., 1105 Camino San Acacio, Santa Fe, N.M.....	A
Cobb, E. S., 24 Danbury St., S.E., Washington 20, D.C.....	A
Coe, G. B., 148 N. Queen St., Lancaster, Pa.....	A
Colburn, F. W., 732 Echo Lane, Glenview, Ill.....	A
Colburn, J. E., 164 N. Wacker Dr., Chicago 6, Ill.....	M
Colburn, R. A., 19 N. Lincoln Ave., Park Ridge, Ill.....	M
Coltman, A. D., 560 Granville St., Vancouver, B.C., Canada.....	A
Conn, J. W., 4633 Coldwater Canyon Ave., North Hollywood, Calif.....	A
Conte, E. C., 426 Belmont Ave., Chicago 14, Ill.....	A
Cooper, F. S., Haskins Labs., 305 E. 43d St., New York 17, N.Y.....	A
Cooper, M. F., 138 Bedford Court Mansions, London, W.C. 1, England.....	A
Cossette, J. I., P. O. Box 235, Robervai, Quebec, Que., Canada.....	A
Cox, John, 9 The Green, Amersham, Bucks, England.....	A
Craig, W. S., 4315 Burt St., Omaha 3, Neb.....	M
Crot, Andre, 5105 Laurel Canyon Blvd., North Hollywood, Calif.....	M
Crowhurst, C. E., Denham Studios, Denham, Bucks, England.....	M
Cunningham, K. M., Eastman Kodak Co., 343 State St., Rochester 4, N.Y.....	M
Czarda, Theodore, 90 Plum St., New Brunswick, N.J.....	A

D AGGY, C. S., 4329 Sunnyslope Ave., Sherman Oaks, Calif.....	A
Dahl, E. A., Rm. 1133, C.R.I. & P. Ry., La Salle St. Station, Chicago 5, Ill.....	A
Dallstream, G. M., 5254 W. Eddy St., Chicago, Ill.....	A
Daniels, W. E., 2557 S. Bronson, Los Angeles 16, Calif.....	A
Davey, Hubert, Kinocrat House, Cromwell Rd., London, S.W. 7, England.....	A
de Anda, Raul, Nicolas San Juan, 232 Col Narvarte, Mexico City, D.F.....	M
deBoer, J. J., Western Electric Co. (Caribbean), Industria 307, Habana, Cuba.....	A
Decker, H. M., 464 Marsh St., San Luis Obispo, Calif.....	S
Dellage, C. J., 205 Second St., Osage, Iowa.....	M
Demetros, N. K., 631 Roscoe St., Chicago 13, Ill.....	A
Denney, J. A., 5024 Seventh Ave., Los Angeles, Calif.....	A
Dieter, Henry, 217-19 135th Ave., Springfield, N.Y.....	A
Dollman, S. C., Engineering Service, General Chemical Co., Edgewater, N.J.....	A
Dopkowski, W. J., 8270 Lyford St., Detroit 5, Mich.....	A
Dowling, R. H., 1324 Paloma Ave., Burlingame, Calif.....	A

Drakeley, C. E., 100-05 Ascan Ave., Forest Hills, N.Y.	M
Dreyer, E. H., 1844 Nortrand Ave., Brooklyn, N.Y.	A
Dudgeon, R. F., Byer Industries Pty., Ltd., 8 Dorcas, South Melbourne, S.C.4, Victoria, Australia.	A
Dunlavy, R. J., 7253 W. Rascher Ave., Chicago 3, Ill.	M
Dupy, R. A., Sound Dept., Metro-Goldwyn-Mayer Studios, Culver City, Calif.	M
Dworkin, Sol, Audio-Visual Center, Indiana University, Bloomington, Ind.	A

E ASEY, A. W., 58 Ickenham Close, Ruislip, Middlesex, England.	A
Eckhardt, E. F., 2237 Moore St., Los Angeles 26, Calif.	A
Edkins, W. G., 84 Stanley Rd., Erlsdon, Coventry, England.	A
Egger, R. J., 264 Connecticut Ave., New London, Conn.	A
Eckerman, I. A., Rua Guaianazes 159, São Paulo, Brazil.	A
Elhamer, R. G., R.R. 1, Box 59, Buena Park, Calif.	A
Erickson, F. A., 4615 Henry Way, Sacramento, Calif.	A

F AHLEN, G. L., % John Green, 800 Swenson Pl., Bellmore, N.Y.	A
Farberman, Arnold, 6622 Cameron Court, Brooklyn 4, N.Y.	A
Felstead, Charles, Sound Dept., Universal-International Pictures, Universal City, Calif.	M
Fernaglich, Charles, 2300 Caroline St., Houston, Tex.	A
Fernandez, Ricardo, Estudios San Miguel, Bella Vista FCP, Buenos Aires, Argentina.	A
Fetherston, J. A., 2 Franklin Ave., Brooklyn, N.Y.	A
Fisher, H. M., DeVry Corp., 52 Vanderbilt Ave., New York 17, N.Y.	M
Fishoff, L. A., 6 Rue Denis Poisson, Paris, France.	A
Follis, G. S., 31A Revere Rd., Quincy 69, Mass.	A
Francisci, Bruno, Via A, Cerasi 19, Rome, Italy.	A
Franzen, N. C., 210 S. Elmwood Ave., Oak Park, Ill.	A
Fraser, Lt. Comdr. W. R., 2669 S. Nash St., Arlington, Va.	A
Frater, Lt. L. J., TSEPF Eng. Div. Photo Lab., Wright Field, Dayton, Ohio.	A
Frazer, R. C., 6063 Sunset Blvd., Hollywood, Calif.	A
Freese, C. F., 253 W. 73d St., New York 23, N.Y.	M
Freuler, J. R., 241 Fairview Rd., Glencoe, Ill.	M
Friedman, M. H., 1348 Boone Ave., New York 59, N.Y.	A
Fullerton, R. D., 38 S. Quenton Ave., Dayton 3, Ohio.	A

G AHAGAN, J. E., Anso, 29 Charles St., Binghamton, N.Y.	M
Gahlot, Kunji, K E M Road, Bikaner, India.	A
Ganz, E. C., Ganz and Company, Bahnhofstrasse 40, Zurich, Switzerland.	M
Gaytan, R. B., Cerrada Guaymas No. 3-C, Mexico City, D.F.	M
Geiler, R. L., 4570 Ardine St., South Gate, Calif.	A
Gibbs, C. R., Kodak Limited, Hornby Rd., Bombay, India.	A
Gilwood, Einar, 222 Maple Ave., Elmhurst, Ill.	A
Gioga, P. C., 6039 Hollywood Blvd., Hollywood 28, Calif.	A
Goda, L. E., Jr., Kodak Philippines, Ltd., Manila, P. I.	A
Goldbach, F. P., 30 Parkview Dr., Scotch Plains, N.J.	M
Goldbloom, Leroy, 3509 Ingleside Ave., Baltimore, Md.	M
Gout, Tito, Rio de la Plata No. 31-7, Mexico City, D.F.	M
Govil, H. G., Hotel Lincoln, 8th Ave. and 44th St., New York 1, N.Y.	A
Grant, R. F., Eastman Kodak Co., 1712 Prairie Ave., Chicago, Ill.	A
Greer, J. H., 56 Thomas St., Hampton, Melbourne, Australia.	A
Gretzinger, V. T., 1066 Trestle Glenn Rd., Oakland 10, Calif.	A
Griffin, M. D., 8950 Cadillac Ave., Los Angeles 34, Calif.	M
Grossman, G. B., 629 Sixth St., Manhattan Beach, Calif.	A
Grubel, R. M., P.O. Box 32, Valley Village, Calif.	M
Guerra, E. T., Hereos de Churubusco No. 42-3, Col Portales, Mexico City, D.F.	M
Gwynne, Gerry, 713 N. Hudson Ave., Hollywood 38, Calif.	M

H AILE, R. V., 215 Walnut St., Cincinnati 2, Ohio.	A
Haines, J. H., Punta Gorda, Fla.	S
Hajduk, E. C., 5150 N. Mulligan, Chicago, Ill.	A
Hall, G. H., 104 Hampden Rd., Rochester 10, N.Y.	M
Hallett, H. C. G., Morgan Crucible Co., Ltd., Battersea Church Road, London, S.W. 11, England.	A
Hance, Paul, Jr., Morris Plains, N.J.	M
Harper, E. R., 1933 N. Bronson Ave., Hollywood 28, Calif.	M
Harris, W. M., 6650 Franklin Ave., Hollywood 28, Calif.	M

- Hart, E. W., Cinecolor Corp., 2800 W. Olive Ave., Burbank, Calif. M
 Harwood, E. G., 3036 Brighton 3d St., Brooklyn 24, N.Y. A
 Hedge, Maj. L. B., 2921 S. Buchanan St., Fairlington, Arlington, Va. M
 Hehn, Otto, Kings Mountain, N.C. A
 Heinz, J. A., 4732 21st Ave., N.E., Seattle 5, Wash. S
 Heister, E. W., 1124 Murray Ave., Akron 10, Ohio. A
 Held, S. P., 30-60 36th St., Long Island City, N.Y. A
 Hendry, James, duPont Club, Parlin, N.J. A
 Hepler, E. O., Jr., 906 Shamrock Ave., Boonville, Mo. A
 Heppberger, C. E., 231 N. Mill St., Naperville, Ill. M
 Herren, Maj. E. A., British Lion Studio Co. Ltd., Littleton Park, Shepperton, Middlesex, England. A
 Herrick, J. B., P.O. Box 1105, San Diego, Calif. A
 Herrick, Margaret, Academy of Motion Picture Arts and Sciences, 9038 Melrose Ave., Los Angeles 46, Calif. M
 Herrnfeld, F. P., 2750 Dumfries Rd., Los Angeles 34, Calif. A
 Hilf, Victor, 1564 Unionport Rd., Bronx 62, N.Y. M
 Hind, H. S., The Cones, Oxshott Way, Cobham, Surrey, England. A
 Hirschfeld, G. J., 117 Waverly Pl., New York 11, N.Y. A
 Hiss, J. K., 1728 Pearl St., Santa Monica, Calif. A
 Hoff, J. L., 4201 Beard Avenue, S., Minneapolis, Minn. S
 Holm, H., Kungsgatan 24, Stockholm, Sweden. M
 Holm, H. R., 1115 Bay, Toronto, Ont., Canada. A
 Hopkins, Ben, Ger-Bar, Inc., 442 N. Illinois St., Indianapolis, Ind. A
 Horvitch, J. U., P. O. Box 1523, Johannesburg, South Africa. A
 Howard, A. J., 488 Broad Ave., Leonia, N.J. A
 Hu, W. C. K. Eastman Kodak Company, 14 Queen's Rd. Central, Hongkong, China. A
 Hughes, L. V., 165 Southgate Rd., Islington, London, N. 1, England. A
 Hunt, G. C., 4223 Gentry Ave., North Hollywood, Calif. M
- IBARRA, F. S.**, Alzate No. 121-9, Mexico City, D.F. M
Irons, C. N., 608 Ridgemont Dr., Rochester, N.Y. A
- JACKSON, J. C.**, 4619 S.E. 46th St., Portland, Ore. M
 Jacobson, Irving, 2353 Canyon Dr., Hollywood 28, Calif. M
 Jefferies, H. H., 2136 N. Eastern Ave., Los Angeles 32, Calif. A
 Jeune, V. T., M. L. C. Building, Martin Place, Sydney, N.S.W., Australia. A
 Johnson, S. W., 1203 Collings Ave., West Collingswood, N.J. A
 Jubandhu, S. B., P. O. Box 309, Bangkok, Siam. A
- KALMAN, A. A.**, 6842 Selfridge St., Forest Hills, N.Y. A
 Kaufman, C. S., 144 S. Second Ave., Mt. Vernon, N.Y. A
 Keim, L. B., 30 W. 58th St., New York 19, N.Y. M
 Kellison, P. C., 1849 Whitley Ave., Hollywood 28, Calif. A
 Kellock, Alan, 381 Sigmond St., Freeport, N.Y. A
 Kerr, M. A., R.R. 2, Box 38, Naperville, Ill. A
 Kingcome, P. B., 227 Wilton St., Glasgow, N.W., Scotland. A
 Kinsey, G. B., 1231 Crescent St., Apt. 7, Montreal, Que., Canada. A
 Kjelstrom, Axel, Angskarsgatan 3, Stockholm, Sweden. A
 Klosner, M., 3010 Valentine Ave., Bronx 58, N.Y. A
 Knapp, R. T., California Institute of Technology, 1201 E. California St., Pasadena 4, Calif. A
 Knipp, H. E., Jr., 2121 Ridgeland Ave., Berwyn, Ill. A
 Knopp, Leslie, Cinematograph Exhibitors Association of Great Britain and Ireland, 127-133 Wardour St., London, W. 1, England. A
 Knowlton, Arthur J., 295 Fairlawn Ave., Toronto, Ont., Canada. A
 Knox, A. C., 256 E. First South St., Salt Lake, Utah. M
 Koch, Lt. R. A., USNR, Apt. 6, 123 Danbury Ave., Anacostia, D.C. A
 Kollmorgen, E. O., 6 Woodland Ave., Mountain Lakes, N.J. M
 Kottman, J. J., 101 Murray St., Binghamton 43, N.Y. M
 Kotwal, S. N., Evergreen Pictures, Saklat House, 15 New Queen's Road, Bombay, India. A
 Kovner, Harold, 400 E. 57th St., New York 22, N.Y. M
 Krainin, Stanley, Furnald Hall, Columbia University, New York 27, N.Y. S
 Krienke, A. G., 94 Grove St., North Plainfield, N.J. A
 Krupa, V. C., 1140 N. Gower St., Hollywood 38, Calif. M
- LAFON, J. E.**, Berlin No. 30, Mexico City, D.F. M
Lambert, K. B., Sound Dept., Metro-Goldwyn-Mayer Studios, Culver City, Calif. F

- Langan, M. J., P.O. Box 2037, University, Ala..... A
 Langton, J. B., 218 McLean Ave., Yonkers 5, N.Y..... A
 Lavictoire, George, 1140 Juliet Ave., St. Paul, Minn..... A
 Law, T. A., The Shrubbery, Ashchurch Terrace, London, W. 12, England..... M
 Lee, Edward, 1110 Steuben St., Pasadena 5, Calif..... A
 Lembach, L. A., Armour Research Foundation, 35 W. 33d St., Chicago 16, Ill..... A
 Lessman, Gerhard, 5842 Harper Ave., Chicago 37, Ill..... M
 Levy, E. H., 4108 Coldwater Canyon, North Hollywood, Calif..... S
 Lewis, P. R., General Aniline and Film Corp., 11 W. 42d St., New York, N.Y..... A
 Li, N. F. C., 9 Seymour Road, Hongkong, China..... M
 Lindgren, T. F., 7133 S. Yates Ave., Chicago 49, Ill..... A
 Linko, M. C., 2245 W. Irving Park Rd., Chicago 18, Ill..... A
 Logan, J. P., Westinghouse Electric Corp., 420 S. San Pedro St., Los Angeles 13, Calif..... A
 Long, C. R., Westinghouse Lamp Div., 420 S. San Pedro St., Los Angeles 13, Calif..... A
 Lorin, G. A., 37 Rue Condorcet, Paris, France..... A
 Lovick, J. B., 233 Spencer St., Glendale 2, Calif..... A
 Lowell, M. L., 1829 S. Fairfax Ave., Los Angeles 35, Calif..... A
 Lustig Frank, 320 E. 21st St., Chicago 16, Ill..... M
- M**
 McCULLEN, J. V., P.O. Box 1092, Somerton, Ariz..... A
 McDonald, George, 3745 Lindell Blvd., St. Louis, Mo..... A
 McGee, R. P., 1446 Acushnet Ave., New Bedford, Mass..... A
 McGookin, E. J., Revere Camera Co., 320 E. 21st St., Chicago, Ill..... M
 McIntyre, C. H., Industrial Microfilm Co., 2970 W. Grand Blvd., Detroit 2, Mich..... A
 McKinley, George, 6149 N. Ozark Ave., Chicago 31, Ill..... A
 McLaren, D. M., 1142 S. Curson Ave., Los Angeles 35, Calif..... A
 McPherson, Lt. Comdr. Duncan, 2946 Second St., S.E., Washington, D.C..... M
 McProud, C. G., 90 Bank St., New York 14, N.Y..... A
 MacIlvain, K. M., Cross Highway, Westport Conn..... A
 Mann, T. H., 11355 Farlin St., Los Angeles 24, Calif..... A
 Mansfield, Lewis, 601 W. 163d St., New York 32, N.Y..... M
 Marshall, C. J., One Twain Place, Dayton 10, Ohio..... A
 Martin, R. D., 1909 Parkside Ave., Burbank, Calif..... A
 Marzari, Antonio, San Marco 557, San Zulian, Venice, Italy..... A
 Mason, K. M., Motion Picture Film Dept., Eastman Kodak Co., 343 State St., Rochester, N.Y..... M
 Matthews, W. D., 1299 Brook Ave., Bronx 56, N.Y..... A
 Maubetsch, J. L., 2 Franklin Ave., Brooklyn 11, N.Y..... M
 Maurer, J. A., 6356 Greenwood Ave., Chicago 37, Ill..... M
 Medill, J. W., 136 Malden Ave., La Grange, Ill..... M
 Meisel, W. H., Harris Road, Princeton Junction, N.J..... M
 Middleton, E. B., P.O. Box 63, Parlin, N.J..... M
 Miller, M. C., Jr., 522 Glen Rock Ave., Los Angeles 24, Calif..... A
 Millet, V. M., Santa Margarita No. 413, Mexico City, D.F..... A
 Millgate, I. H., 151 W. Central Ave., Bergenfield, N.J..... M
 Milligan, J. C., Kollmorgen Optical Corp., 2 Franklin Ave., Brooklyn 11, N.Y..... M
 Minsk, L. D., 2341 Marcy Ave., Evanston, Ill..... S
 Monleone, Jules, Westrex Corp., 111 Eighth Ave., New York 11, N.Y..... A
 Montgomery, K. H., Walters Electric Co., 740 Third Ave., New York 17, N.Y..... A
 Mooney, Tom, 571 S. Griggs Ave., St. Paul, Minn..... A
 Moran, A. J., 1026 S. Orange Grove Ave., Los Angeles 35, Calif..... A
 Morgan, T. B., Victor Animatograph Corp., Davenport, Iowa..... M
 Moser, A. J., 2615 Ivanhill Terrace, Los Angeles 26, Calif..... A
 Moura, J. J., Republic Pictures (Trinidad), Inc., P. O. Box 566, Port of Spain, Trinidad, B.W.I..... A
 Mowrey, P. B., 239 Claremont Ave., Montclair, N.J..... M
 Murray, W. G., 220 Guigues, Ottawa, Ont., Canada..... A
- N**
 NAIR, N. O., 133 N. Rose St., Burbank, Calif..... A
 Nemeier, Sheldon, 245 E. 21st St., New York 10, N.Y..... A
 Norden, P. V., 72-38 113th St., Forest Hills, N.Y..... A
 Nunan, J. K., Anso, 6424 Santa Monica Blvd., Hollywood 38, Calif..... M
- O**
 OBERG, O. G., 8431 Croydon Ave., Los Angeles 45, Calif..... A
 O'Bryne, F. E., 1900 Royal Bank Bldg., Toronto, Ont., Canada..... A
 Ochse, B. D., 1201 California St., San Francisco 9, Calif..... A
 O'Connell, L. W., 10717 Wellworth Ave., West Los Angeles 24, Calif..... M

Ogle, M. H., 1723 E. 86th St., Cleveland, Ohio..... A
 O'Horan, E. F., Nebraska No. 135, Mexico City, D.F..... M
 Oliveres, Charles, 88 Avenue Kleber, Paris 16, France..... M
 Oulmann, R. J., 20 E. 69th St., New York 21, N.Y..... A

PA-CHANG, Cheng, Rm. 40, Lane Hotel, 1431 N. Cahuenga Blvd., Hollywood 28, Calif..... A
 Pakswer, Serge, Continental Electric Co., Hamilton and Richards Sts., Geneva, Ill..... M
 Paterson, Robert, 69 Fern Ave., Toronto, Ont., Canada..... A
 Pearson, L. K., 10 Wesley Pl., Monmouth Beach, N.J..... A
 Peck, G. T., 11 Westover Rd., High Wycombe, Bucks, England..... A
 Percy, C. H., 7100 McCormick Rd., Chicago 45, Ill..... A
 Perry, J. B., 3001 Adeline St., Oakland 8, Calif..... A
 Peters, Rudolph, 30-15 33d St., Long Island City 2, N.Y..... A
 Peterson, R. A., 4081 24th Ave., S., Minneapolis 6, Minn..... A
 Phillips, I. H., 45 Seatonville Road, Whitley Bay, Northumberland, England..... A
 Pilzer, H. R., Circle Film Labs, 33 W. 60th St., New York, N.Y..... A
 Pond, J. E., 736 1/2 N. Hobart, Los Angeles, Calif..... M
 Posner, H. H., 261 Seaman Ave., New York 34, N.Y..... A
 Priego, A. R., Reforma No. 12-405, Mexico City, D.F..... M
 Prosch, J. P., 24 Fourth St., Johnson City, N.Y..... M

RATHCKE, William, 514 Halsey St., Brooklyn 33, N.Y..... A
 Rentoumis, G. M., 211 Bedford Rd., Pleasantville, N.Y..... A
 Reynolds, F. D., 680 Siebert St., Columbus 6, Ohio..... A
 Richardson, W. P., 6523 First St., N.W., Washington 12, D.C..... A
 Rivers, W. H., 314 E. 54th St., New York, N.Y..... M
 Rochin, J. V., Orozco y Berra No. 62-A, Mexico City, D.F..... A
 Rockar, W. F., 152 N. Latrobe Ave., Chicago, Ill..... A
 Rogne, C. O., 348 N. Cedar St., Glendale 6, Calif..... A
 Rollins, F. S., Jr., E. R. Squibb and Sons, 745 Fifth Ave., New York 22, N.Y..... A
 Rope, R. S., 50 Prospect St., Williston Park, N.Y..... A
 Ross, H. C., Wholesale Supply Co., 1047 N. Wilcox Ave., Hollywood 38, Calif..... A
 Roth, W. A., R.F.D. 2, Luxmanor, Rockville, Md..... A
 Rothberg, Joseph, 739 Boylston St., Boston 16, Mass..... A
 Ruelas, E. R., Asturias No. 259 Colonia Alamos, Mexico City, D.F..... M
 Rutherford, Kenneth, 293 Church, Toronto, Ont., Canada..... A
 Ryan, F. D., Bell and Howell, 7000 McCormick Rd., Chicago 45, Ill..... A

SANDBACK, I. C., 2942 N. Oak Park Ave., Chicago 34, Ill..... A
 Sandin, S. A. S., A/B Svensk Talfilm, 47 Drottninggatan, Stockholm, Sweden..... A
 Scanlon, W. A., 3738 84th St., Jackson Heights, N.Y..... A
 Schlake, M. F., 3558 S. Jefferson Ave., St. Louis 18, Mo..... A
 Schwartz, A. R., Westrex Corp., 111 Eighth Ave., New York 11, N.Y..... M
 Scott, Richard, 24 Netherby Dr., Fenham, Newcastle, Tyne, Northumberland, England..... M
 Seeley, E. S., Altec Service Corp., 250 W. 57th St., New York 19, N.Y..... M
 Shamroy, Leon, 6235 Primrose Ave., Hollywood 28, Calif..... M
 Skinner, J. C., Interstate Theatres, Inc., Majestic Theatre Bldg., Dallas 1, Tex..... M
 Slater, D. M., Regent Theatre, Gisborne, New Zealand..... A
 Slott, H. M., 1560 Sacramento St., San Francisco, Calif..... A
 Smalley, B. L., 11453 S. Bell Ave., Chicago 43, Ill..... A
 Smith, Harry, 8 Bathurst Road, Ilford, Essex, England..... A
 Smith, M. B., 12135 Morrison St., North Hollywood, Calif..... A
 Smith, P. E., 39-12 219th St., Bayside, N.Y..... A
 Smith, W. B., 212 Humble Bldg., Houston, Tex..... A
 Sobel, Nathan, Cinefects, Inc., 1600 Broadway, New York, N.Y..... M
 Soucy, Louis, Macdonald College, Quebec, Que., Canada..... S
 Souther, H. T., 1548 N. Hudson Ave., Los Angeles 28, Calif..... A
 Spector, R. M., 260 S. Lucerne Blvd., Los Angeles 4, Calif..... A
 Spires, J. B., RKO Radio Pictures Near East Inc., P. O. Box 1319, 25 Sharia Tewfik, Cairo, Egypt..... M
 Stapleton, Lt. W. B., Operations Officer, Pict. Div., Oahu Signal Service, APO 958, % Postmaster, San Francisco, Calif..... A
 Steiger, J. B., 1690 35th Ave., San Francisco, Calif..... A
 Steuvold, Alan, 3724 Muirfield Rd., Los Angeles 16, Calif..... A
 Stewart, J. G., 2758 Selby Ave., Los Angeles 34, Calif..... M
 Sticht, E. W., 839 S. Gramercy Pl., Los Angeles 5, Calif..... A
 Susskind, I. R., 5143 Rockland Ave., Eagle Rock 41, Calif..... A
 Svigoon, A. C., 34-21 78th St., Jackson Heights, N.Y..... A

Swank, J. A., Swank Films, Inc., 1150 U. B. Bldg., Dayton 2, Ohio.....M
 Swanson, K. N., Bell and Howell, 7100 N. McCormick Rd., Chicago 45, Ill.....A
 Sweeny, W. H. O., 2 Trevelyan Crescent, Kenton, Harrow, Middlesex, England.....A
 Swinney, C. L., 530 C. & S. Bank Bldg., Atlanta, Ga.....A
 Sze-Jen, Wang, Hotel Lane, Rm. 44, 1431 N. Cahuenga Blvd., Hollywood 28, Calif.....A

TARABA, Vilem, State Film Studios, Prague, Barrandov, Czechoslovakia.....A
 Teague, G. J., 1009 8th Ave., Los Angeles, Calif.....M
 Thake, A. E., 7635 Irving Park Rd., Chicago, Ill.....A
 Thelen, J. M., 1 Palermo Pl., Dayton 4, Ohio.....A
 Theyskens, A. L. L., 40 Rue du Chatelain, Ixelles, Bruxelles, Belgium.....A
 Thiel, W. H., 102 E. Bellevue Pl., Chicago 11, Ill.....A
 Thomas, P. M., R.R. 1, Box 232d, Dayton, Ohio.....A
 Thompson, B. H., 1416 Comstock Ave., Los Angeles 24, Calif.....A
 Tonderau, A. W., 3840 Mound View, North Hollywood, Calif.....M
 Tower, W. S., Jr., Westrex Corp., 111 Eighth Ave., New York 11, N.Y.....A
 Travis, B. B., 637 F St., N.E., Washington 2, D.C.....A
 Tremaine, H. M., 1655 N. Cherokee St., Hollywood 28, Calif.....M
 Trent, S. N., Altec Service Corp., 250 W. 57th St., New York 19, N.Y.....A
 Truhan, C. S., 255 Mt. Hope Pl., New York 57, N.Y.....A
 Tucker, R. H., Triangle Productions, Reg., 46 Napier St., Paddington, N.S.W., Australia...A
 Tyler, J. G., 603 Alta Ave., Santa Monica, Calif.....A

URGOITI, Ricardo, Antonio Maura 6, Madrid, Spain.....A

VALLEN, R. B., Vallen, Inc., 225 Bluff St., Akron, Ohio.....A
 Van den Broek, J. A., 1128 Birk Ave., Ann Arbor, Mich.....A
 Van Utfall, Johan, Swedish Broadcasting Corp., Kungsgatan 8, Stockholm, Sweden.....A
 Van Vliet, J. D., 318 W. 56th St., New York 19, N.Y.....A
 Verbanec, W. R., 2908 N. Troy, Chicago 18, Ill.....A
 Vivie, Jean, 96 Rue de Miromesnil, Paris 7, France.....A
 Vorisek, J. F., 267 E. 188th St., Bronx 58, N.Y.....A

WALES, L. R., Eastman Kodak Co., 185 Yuen Ming Yuen Rd., Shanghai, China.....A
 Waller, J. V., Bell and Howell, 816 13th St., N.W., Washington, D.C.....A
 Walsh, W. H., 65-08 182d St., Flushing, N.Y.....A
 Warde, R. F., 348 N. Palm Dr., Beverly Hills, Calif.....M
 Ware, J. P., 1632 Central Parkway, Cincinnati 10, Ohio.....A
 Waterman, William, Waterman Products Co., 2445-63 Emerald St., Philadelphia 25, Pa...M
 Watermeyer, E. W., % Mrs. E. Akey, 633 Morse St., San Jose 11, Calif.....A
 Watkins, A. W., MGM British Studios Ltd., One Belgrave Place, London, S.W. 1, England...M
 Watton, Alan, Jr., 425 Grand Ave., Dayton 5, Ohio.....A
 Waxman, Harry, 63 Merton Mansions, W. Wimbledon, London, S.W. 20, England.....A
 Wehlau, W. P., 5916 W. Patterson Ave., Chicago 34, Ill.....A
 Welch, C. E., Apt. 407, 1332 S. Hope, Los Angeles 15, California.....A
 Westfall, E. F., 4737 Burnet Ave., Sherman Oaks, Calif.....A
 Wheeler, R. T., 137 Costello St., Charleston, W.Va.....A
 Whitman, V. E., 90 Windemere Rd., Rochester, N.Y.....A
 Wilding, N. E., Wilding Picture Prod. Inc., 1345 Argyle St., Chicago 40, Ill.....M
 Williams, Capt. J. P., 4515 19th St., N., % C. J. Winston, Arlington, Va.....A
 Williams, L. P., Poynat's Manor, Skirmett, Near Henley on Thames, Oxon, England.....A
 Winter, E. A., 896 Liverpool Rd., Southport, Lancs., England.....A
 Wolfe, Halley, Western Electric Co., 6601 Romaine St., Hollywood 38, Calif.....A
 Wong, Thompson, Eastman Kodak Co., 185 Yuen Ming Yuen Rd., Shanghai, China.....A
 Woo, William, 1050 Grant Ave., San Francisco, Calif.....A
 Woolsey, R. A., 20158 Observation Dr., Topanga, Calif.....A
 Wolzen, F. E., 11213 Hortense St., North Hollywood, Calif.....A

YAVRU, Zareh, 233 Sevom Esfand Ave., Tehran, Iran.....A
 Yen, Homing, % Booker Lee, P.O. Box 671, Port Washington, N.Y.....M

ZACHRITZ, J. A., 1833 Cedar St., Hayward, Calif.....A
 Zell, H. A., 125 Hyde St., San Francisco 2, Calif.....A
 Zint, K. E., Western Electric Co. (Mexico), Apartado 2032, Mexico City, D.F.....M
 Zuckerman, J. V., Memorial Hall, Stanford University, Palo Alto, Calif.....A

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