ABSTRACTS OF PAPERS OF THE FALL CONVENTION

AT

DETROIT, MICH., OCT. 31–NOV. 2, 1938

The Papers Committee submits for the consideration of the membership the following abstracts of papers to be presented at the Fall Convention. It is hoped that the publication of these abstracts will encourage attendance at the meeting and facilitate discussion. The papers presented at Conventions constitute the bulk of the material published in the Journal. The abstracts may therefore be used as convenient reference until the papers are published.

"Some of the Problems Ahead in Television"; I. J. Kaar, General Electric Co. Bridgeport, Conn.

Now that television standards have been agreed upon in the United States, commercial receiving sets will undoubtedly be available very soon, and regularly scheduled television programs may be expected at the same time. How good will the television be and what are the problems yet to be solved before television reaches the technical maturity that radio has today? These are questions of considerable interest to engineers in related fields, and are the subject matter of the present paper. The quality of present-day television pictures is compared with that of motion pictures both in the theater and in the home. A discussion is given of the problems that have been solved to make television what it is today, and consideration is given to the problems that must be solved to make television what we hope it will be tomorrow. The problems of signal propagation and interference are discussed, and the matter of network program distribution is considered. Finally, a short introduction is given to the commercial problems in television.

"Some Production Aspects of Binaural Recording for Sound Motion Pictures"; W. H. Offenhauser, Jr., New York, N. Y., and J. J. Israel, Brooklyn, N. Y.

Binaural sound recording for motion pictures has a long development history of worthy achievement, yet to date it has not found application in our everyday entertainment sound motion picture. Inspection of the situation reveals that, like

stereoscopic pictures, there is not complete acceptance of any of the various theories and that the shades of interpretation are so many that it is difficult to secure a consensus on what constitutes binaural sound recording for motion pictures. Instances are cited to show that "theoretically perfect" sound is not necessarily the objective; in fact, since it is the illusion produced, both by sound and picture that is in the final analysis important, "theoretically perfect" sound may even destroy the illusion we are trying to create.

The history of binaural sound recording for motion pictures is reviewed and especial reference is made to the early developments of Rosenberg and Kuechenmeister. A short review of the developments since the work of these pioneers covers in a general way the advance of the binaural sound motion picture recording art to date. The production requirements of binaural sound recording for motion pictures are analyzed briefly and the importance of the editing process in the production of the finished picture is outlined.

A new binaural sound motion picture production technic is suggested, based upon the developments of the authors, that may be quite readily adapted to present-day monaural production technic. It is pointed out that the perspective sound control, which is an important added feature, does not affect shooting stage operations; this control is suggested as a logical part of dubbing-room operations. Some of the effects produced include variation of apparent recording-room size from very small, say, 1000 cu. ft. to very large, say, 500,000 cu. ft. Another important effect is the simultaneous yet essentially independent movement of one sound-source with respect to another and the essentially independent left-right movement. All these effects are possible with no movement whatever of the sound-source or sources with respect to the microphones. Essentially the same effects can be obtained with the pseudo-binaural system, a system in which it is possible to take a completed picture of the conventional monaural type and by a simple dubbing operation, provide practically all the important binaural characteristics without any additional original sound recording whatever. The effects described will be demonstrated.

"The Spectroheliokinematograph"; R. R. McMath, McMath-Hulbert Observatory, University of Michigan, Ann Arbor, Mich.

Taking motion pictures of celestial phenomena that show change is not as simple as it would appear at first thought. This work was started in 1928, and in 1931 the instrumentation was donated by the founders of the McMath-Hulbert Observatory to The University of Michigan.

The combined tower telescope and spectroheliokinematograph of the McMath-Hulbert Observatory at Lake Angelus, Mich., is now one of the most powerful pieces of solar apparatus in the world. The optical train will be explained by means of slides, and then the apparatus itself will be illustrated by motion pictures. A second reel will show solar prominences in motion.

"Underwater Cinematography"; E. R. F. Johnson, Mechanical Improvements Corp., Moorestown, N. J.

The dates of the first recorded use of underwater photography and the tendencies toward its increasing use by producers are noted. The author's early experiences in this field are described. The opinion is expressed that for work in natural settings the most useful equipment consists of submergeable cameras

placed on the bottom and operated by divers. The rest of the paper deals with the problems of and equipment for such work. It is pointed out that studio tank work shares most of these problems.

The optical properties of water are described. Since water is less transparent than air, photography by natural light is limited to small depths and more power is required for artificial illumination under water. Since colors are not absorbed equally, accurate monochrome rendering and photography in natural color are complicated. Water haze limits the distance at which pictures can be taken under water. This haze is largely confined to a part of the spectrum and can be eliminated partially by color-filters. It is polarized and can therefore be eliminated also by polarizing plates. The advantages of this method are briefly stated: they do not distort the monochrome rendering, and may be used in natural-color photography. The ideal attributes of equipment for use in underwater cinematography are outlined and available equipment is briefly described.

"Improving the Fidelity of Disk Records for Direct Playback"; H. J. Hasbrouck, RCA Manufacturing Co., Inc., Camden, N. J.

Recent advances in equipment design and in materials of which recording disks are composed, have resulted in improved fidelity. Both the volume range and the frequency range have been extended, satisfying present-day requirements of motion picture and broadcast applications.

For reproduction, there is provided a new lighter weight lateral pick-up having high sensitivity and equipped with a permanent diamond point. This reproducer, in combination with its associated circuit, is suitable for use on all laterial-cut disk records.

Pre- and post-equalization are employed in the method described for making high-fidelity records, insuring an extremely low noise-level. This absence of background noise together with the wide frequency range and low overall distortion create an illusion of reality or "presence" during reproduction.

Usually a great many playings are not required of direct playback disks. However, because of the low mechanical impedance of the new RCA pick-up and the improved composition of the disks it is possible to reproduce 75 to 100 times without appreciable increase in noise or distortion. Great differences in record life under various conditions of handling have been noted and are attributed chiefly to accumulation of fingerprints and dust on the record surface. Gradual oxidation of the lacquer coating must also be considered and guarded against by special care when records of this type are intended for long preservation.

"Characteristics of Film-Reproducing Systems"; F. Durst, International Projector Corp., New York, N. Y.

An analysis of sound-picture reproducing-system characteristics, including electrical and acoustical response data collected in the interest of determining the possibilities involved in obtaining an average characteristic for reproducing various film products with uniform response over several combinations of loud speaker equipment. With the aid of a curve tracer having a long-persistent cathode-ray screen, a photographic record was made of the characteristics, starting with various forms and amounts of equalization and exploring their relationship to the power-handling capacity of amplifiers. Following through the system, this record shows the characteristics of dividing networks under various conditions of

load, and finally the acoustical response curves taken for comparison of the loud speaker equipments under study.

The measurements of loud speaker combinations included various types of units, both permanent-magnet and energized, low-frequency horns ranging from open back baffles to folded horns with specially designed rear-loading compartment, and high-frequency multicellular horns of various configurations and constructional details.

After establishing the natural characteristics of the various equipments involved, careful listening tests were made over an extended period with samples of commercial prints and other recordings. A description follows of the difficulties and problems involved in an effort to obtain one overall characteristic, which would give satisfactory reproduction for all types of material. The final results are shown, with a short discussion of the methods for duplication in other equipment combinations, and conclude with recommendations for future designs and ratings.

"Some Practical Accessories for Motion Picture Recording"; R. O. Strock, Eastern Service Studios, Long Island City, N. Y.

The addition of practical operational accessories to standard recording channels as purchased expedites operation and saves time. At the Eastern Service Studios a number of such accessories have been designed and will be described briefly. It is the purpose of this paper to show what has been done at one studio in the hope that it may be of some interest and help to others who are engaged in recording work.

Included in the equipment are the following items: A small collapsible, portable microphone boom for location work; a special microphone suspension to prevent mechanical noises from getting into the recording system; a small mixer console for stage work, to permit the mixerman to operate close to the scene of action; an accurate illumination meter, using a microammeter, for setting and checking the recording machine exposure; a compact re-recording mixer console equipped with equalizers, effect filters, amplifiers, and attenuators; a projected volume indicator and footage counter for use in re-recording rooms; a film playback adapter for use on a Western Electric film machine for location use; playback horns for stage and location use; and an air-brush adaptation for blooping re-recording tracks.

"The Lighting of Theater Interiors"; F. M. Falge, General Electric Company, Cleveland, Ohio.

Here and there a theater is planned with lighting features utilizing the fundamental principles that have been expounded on many occasions. In too many cases, however, interior lighting has lagged far behind exterior lighting for advertising, and owner and public alike have suffered. In too many cases, also, the theater falls far short of complementing the attractive scenes so well projected upon the screen.

This paper reiterates the aims and advantages of proper lighting, and outlines the problem of locating, coloring, and controlling the lighting properly so that it will be comfortable and pleasing and an aid, psychologically. It discusses the possibilities of systems of lighting such as downlighting and fluorescent lighting. New materials and new light-sources will be demonstrated and discussed.

New equipment for brightness measurement will also be shown as an aid in building up a quantitative background of what conditions conduce to comfort and satisfaction.

"The Evolution of Arc Broadside Lighting Equipment"; P. Mole, Mole-Richardson Co., Hollywood, Calif.

From the earliest days of artificial lighting of motion picture sets the broadside type of unit has been a fundamental lighting tool. Regardless of the type of light-source used in such lamps—whether mercury-vapor tubes, carbon arcs, or incandescent filament globes—the broadside is a lamp of the floodlight type, designed to emit a relatively wide flood of soft, moderately powerful illumination. It has withstood innumerable sweeping changes in lighting and photographic technic, including the introduction and acceptance of spotlighting, the change from orthochromatic to panchromatic film materials, the changes from silent to talking pictures and from arc to incandescent light-sources, and the present growing popularity of natural-color photography.

The present paper will trace the evolution of arc broadsides only. It will comment upon the design and performance of the early-day units, which were adapted almost intact from previous similar lamps used in photoengraving. It will follow the evolution of the broadside through successive improvements in silent-picture usages; through its decline at the introduction of sound and Mazda lighting; through the relatively recent rebirth of arc lighting due to the requirements of modern natural-color photography; and the most recently introduced units of this type which are replacing equipment designed less than five years ago at the introduction of the three-color Technicolor process. Comparison will be made between the early, intermediate, and modern units as regards color distribution, light distribution, steadiness and length of burning period, indicating that though less public attention has been given to these types than to the more familiar spotlighting units, the broadside has kept pace with advances in lighting and equipment design.

Report of the Projection Practice Committee; H. Rubin, *Chairman.*

This report deals with two major projects completed by the Committee within the past six months, namely, the third revision of the Projection Room Plans and the proposed revision of the NFPA "Regulations for Handling Nitrocellulose Motion Picture Film." These two projects are given in detail. Other projects now under consideration by the Committee are briefly mentioned.

"A Machine for Artificial Reverberation"; S. K. Wolf, Acoustic Consultants, Inc., New York, N. Y.

Sometimes there arises the necessity of introducing into recorded sound a liveness that is not present in the original sound-waves impinging upon the microphones in the recording studio. Reverberation chambers have been used to provide the additional liveness, but such chambers are not very flexible in use and are costly to install.

A new machine has been developed by means of which reverberation may be introduced into the recorded sound artificially. The sound is recorded upon an endless magnetic sound-carrier or tape, which passes beneath a number of pick-ups or reproducers at intervals along the carrier. These pick-ups are connected to a mixer panel, and the sound level of each is adjusted to produce the reverber-

ant effect required. After passing the last pick-up head in the series, the sound is "wiped off" the magnetic carrier.

Such a machine finds many applications, and is useful not only in studios for direct recording, but also for adding liveness to records during the process of dubbing.

"A Silent Wind Machine for the Production Stage"; F. G. Albin, United Artists Studio Corp., Hollywood, Calif.

The machines generally used on the motion picture production set to create wind for pictorial effects are large motor-driven propeller fans mounted on floor stands. The noise level produced at high velocities is so high that satisfactory sound recording of the scene is practically impossible. Furthermore, the size and shape of these machines are such that they must be placed at such a distance that the directivity is not readily controllable. The additional hazard to sound recording of causing wind around the microphone always exists and, commonly, the desirable microphone placement is sacrificed in order to avoid the wind.

A new type of wind machine has been adopted and used for several years with a great improvement realized. The new type is a centrifugal blower, such as is commonly used in ventilating systems. The air is conducted by means of light canvas ducts from the exhaust of the blower to the set where the scene is being enacted. The ducts are equipped with variously shaped fittings and nozzles so that the air stream may be directed as desired.

It has been found expedient to locate the blower outside the stage building and enter the duct through a special portal. Thereby, the greatest noise source, the blower, is remotely located and insulated from the scene by the walls of the stage building. Furthermore, it incidentally serves as a ventilator, supplying fresh air to the scene. Measurements of noise level for various wind velocities indicate improvements up to 70 decibels in noise reduction. Thus sound recordings of scenes requiring wind are made possible where heretofore it was necessary to photograph the scene without sound and provide synchronized sound subsequently.

"Silent Variable-Speed Treadmill"; J. E. Robbins, Paramount Pictures, Inc., Hollywood, Calif.

Treadmills of various designs have been used by the motion picture industry for many years for obtaining animated shots in front of moving backgrounds. The adoption of sound practically eliminated them except for synchronized and other types of silent scenes.

This loss was keenly felt, and as a result immediate steps were taken to develop a unit that could operate throughout a wide range of speed, with fine control, instantaneous start and stop, and ability to reverse in the same shot, still maintaining a noise level that would allow the recording of intimate, quiet dialog. This was not as simple as it appeared, due to the fact that in addition to the above-mentioned requirements it also had to support the weight of two horses running, fifteen or twenty men on a march, automobiles and motorcycles in motion, *etc.* This all had to be accomplished with a unit restricted in size and weight in order to maintain mobility.

The paper discusses the problems confronting the engineering and mechanical departments throughout the design and construction of a machine that comes fairly close to doing all that was hoped for originally.

"Independent Drive for Camera in the A-c. Interlock Motor System"; F. G. Albin, United Artists Studio Corp., Hollywood, Calif.

The "Selsyn" or alternating-current interlock motor system used to drive cameras, recording, re-recording, and projection machines in synchronism, is a popular type of motor system in large studios. It has special advantages in such applications as driving projector and camera for projection background process. The one inexpedient feature is that the system is generally started from a central point such as the recording room, and the cameraman does not have means for running his camera independently as is so often required for photographing slates, exposure tests, and silent scenes.

An addition has been made to the a-c. interlock system to give it the advantages possessed by the synchronous motor system: namely, the facilities enabling the cameraman to operate his camera at will at regular speed.

The addition consists of a set of relays with control circuits, and a frequency changer and field exciter set. Normally, the camera motors are connected to the common interlock system through the relays. If, however, the button provided at the camera is depressed, the pilot relay operates and energizes the main relays which transfer the camera motor circuit to the bus of the frequency changer and field exciter set. The camera motor is operated as a true synchronous motor. One phase of the rotor is short-circuited, and the remainder is excited with direct current and serves as the field. The three-phase stator is supplied with three-phase power of a frequency that will cause the motor to run at the required speed, the same speed as when driven with the interlock system.

The power developed by the a-c. interlock camera motor when operated as a synchronous motor is approximately the same as under normal operating conditions. The acceleration is typical of small synchronous motors when the power supply is suddenly connected. The pull-in torque is superior to the slotted-rotor type of as-synchronous motor. The operation of the system is smooth, simple, and efficient, and has, after several years of use, proved its value.

"A 16-Mm. Studio Recorder"; R. W. Benfer, Electrical Research Products, Inc., New York, N. Y.

Recent advances in the commercial use of 16-mm. sound-film have stressed the importance of improving the product. Certain limitations imposed by the optical reduction process for obtaining 16-mm. sound prints are eliminated by recording 16-mm. negatives expressly for contact printing. A studio recorder for this purpose is described. The paper deals briefly with the results of considerable investigation to determine the desirable recording characteristics and concludes with a demonstration of experimental recordings.

"New Sound Recording Equipment"; D. R. Canady and V. A. Welman, Canady Sound Appliance Co., Cleveland, Ohio.

Recorder for 16-Mm. Film.—This recorder is characterized by its constancy of speed and its convenience and simplicity of operation. The constant-speed drum is not affected by temperature changes. The recorder has an aluminum magazine of 400-ft. capacity, with friction take-up and fitted for either galvanometer or glow-lamp recording, the glow lamp being preferred because of its simplicity.

Noise-Reduction Unit for Glow-Lamp Recording.—A self-contained unit, either portable or for panel mounting, which provides polarizing voltage and noise

reduction for glow-lamp recording. It has simple adjustments for setting the minimum and maximum current desired, and when these adjustments are set the unit is fully automatic. It is variable over a wide range and will give recordings from 5 to 25 ma. of current or from nearly clear negative to fully exposed negative. It has no time lag, can not react in any way with the amplifier, and may be connected to any amplifier.

Galvanometer for 35- or 16-Mm. Recording.—An oil-damped galvanometer, so designed that each of its component parts is readily adjustable, making it possible to be fitted to almost any recorder. The galvanometer has a straight-line output to 10,000 cycles.

Projector for Background Projection.—A claw projector, noiseless in operation and rock-steady, designed for the extreme requirements of background projection. The claws have three teeth on each side, the tension shoes are long, with adjustable tension, and the wear on the film is a minimum. The mechanical parts are enclosed and lubricated by an oil pump from an oil sump.

"A Color-Temperature Meter"; E. M. Lowry, Kodak Research Laboratories, Rochester, N. Y.

The recent advances in color photography have made more apparent than ever before the need for some simple and accurate method for the estimation of the color-temperature of light-sources. Photographers, whether professional or amateur, are only too well aware of the influence that the quality of the illumination has upon the color rendering of photographic subjects. For example, the difference in color-temperature between general-purpose tungsten filament lamps, and studio modeling lamps, or between modeling lamps and photoflood lamps, is often the deciding factor between correct and incorrect photographic color reproduction. In order that the photographer may easily determine the quality of the lighting he is using and make the proper adjustments to secure standard lighting conditions, an instrument that is at once compact, simple in operation, and accurate, has been developed in these laboratories. No auxiliary light-source is required for making measurements since each source is tested by means of the radiant energy that it itself emits. In this paper a discussion of the principles applied in construction of the instrument, a description of the instrument, and data showing the probable error of results are given.

"Some General Characteristics of Chromium-Nickel-Iron Alloys as Corrosion-Resisting Materials"; R. Franks, Union Carbide and Carbon Co., Inc., Niagara Falls, N. Y., and F. L. LaQue, International Nickel Co., Inc., New York, N. Y.

Those features of the chromium-nickel stainless steels are described that make these alloys useful as corrosion-resisting materials, and data are presented on the influence of the several alloying elements commonly present. It is shown how the high chemical activity of chromium benefits corrosion-resistance by reaction with oxygen or other oxidizing agents to form inert films which prevent progressive attack. The effect of chromium content upon corrosion resistance in typical reducing and oxidizing solutions is illustrated by test data.

Data are presented to illustrate the effect of nickel in achieving the desirable austenitic state, in increasing the stability of the alloys, and in supplementing the protective film-forming properties of chromium. Included in the discussion are iron-base alloys with chromium predominating, iron-base alloys with nickel

predominating, and nickel-base alloys containing high percentages of chromium. The peculiar usefulness of each type of alloy is indicated and illustrated with appropriate data.

The effect of molybdenum is treated in much the same way as the effect of nickel. The usefulness of molybdenum in improving corrosion resistance under both oxidizing and reducing conditions is pointed out, as well as its specific beneficial effects in connection with organic acids and vapors, and in reducing the susceptibility to local attack or pitting by chlorides or other halogen compounds.

There is included, also, a discussion of the effects of carbon upon corrosion-resistance with especial reference to intergranular corrosion of the austenitic alloys. Supplementing this discussion of carbon there is a description of several methods of avoiding intergranular corrosion, including the use of such stabilizing elements as columbium and titanium.

"Coördinating the Acoustical and Architectural Design of the Motion Picture Theater"; C. C. Potwin, Electrical Research Products, Inc., New York, N. Y., and B. Schlanger, New York, N. Y.

Successful design of the motion picture auditorium involves the effective coordination of both auditory and visual requirements. Past practice has favored vision and decorative treatment, usually leaving the acoustical problem as a final consideration.

In this paper a study is made of the basic outline, the volume, and the detailed form of a motion picture auditorium, to show that auditory and visual requirements can both be met successfully if they are treated with equal importance in fundamental planning. This does not preclude the ability to obtain economical design and pleasing architectural form. Actually, the study proves that economical construction and creative architectural forms are more readily inspired.

"Chemical Analysis of an MQ Developer"; R. M. Evans and W. T. Hanson, Jr., Kodak Research Laboratories, Rochester, N. Y.

The maintenance of developer activity over a long period of time is among the most important problems of a motion picture laboratory. The developer is oxidized by the silver halide in the emulsion and by air. When known amounts of these two oxidizing materials react with the developer, simple calculations, which were presented in a previous paper, are sufficient to determine the equilibrium condition of the developer as well as the replenisher formula to give a chosen equilibrium. Under ordinary conditions there are large variations in the amount of developer oxidation. A chemical analysis immediately detects any deviation from the correct equilibrium and permits readjustment of the replenisher formula. Chemical analyses are presented which require a minimum of equipment and time. In most cases, ease of manipulation and speed have been considered as more important factors than a high degree of accuracy but in all cases the methods are capable of giving results to an accuracy of five per cent or better. Whenever possible the analyses are colorimetric in nature, the measurements being made on an instrument called an Opacimeter. One operator can make a complete analysis in about half an hour. Analysis for any one constituent may be made in a much shorter time. It is emphasized that no *one* control variable is significant for specifying the activity of a developer. Sensito-

metric curves are included demonstrating the time lag in pH equilibrium but not in photographic equilibrium when hydroxide is added to or released in the developer. The aim of chemical control is to insure a constant condition of the developer and thus constant photographic quality, rather than to determine the degree of development.

"Opacimeter Used in Chemical Analysis"; R. M. Evans and G. P. Silberstein, Kodak Research Laboratories, Rochester, N. Y.

The opacimeter is an optical instrument designed to measure the light transmission of a colored or turbid solution. A Loewenthal photronic type light-sensitive cell connected to a microammeter is used to measure the intensity of the light transmitted by the solution under test. The light intensity falling upon the sensitive cell is kept within a fixed range by varying the distance of the cell from the source. The instrument is arranged so that a 30-cc. test tube or a 300-cc. Kohle flask may contain the reaction mixture. The results of analyses are determined from calibration curves prepared from known solutions.

"Some Television Problems from the Motion Picture Standpoint"; G. L. Beers, E.W. Engstrom, and I. G. Maloff, RCA Manufacturing, Co., Inc., Camden, N. J.

There are certain characteristics of television that have counterparts in motion pictures. Also, motion picture film and motion picture practice are applicable to television; some of the problems and limitations are outlined.

The following television image characteristics are briefly discussed: (*1*) number of scanning lines and the relationship to image size and viewing distance; (*2*) number of frames; (*3*) interlacing. The effect of film and optical system limitations upon reproduced television images is illustrated by photographs. Curves are given showing the spectral characteristics of Iconoscopes. The screen color characteristics of Kinescopes are discussed. The overall range and gamma characteristics of a television system are reviewed.

"Unidirectional Microphone Technic"; J. P. Livadary, Columbia Pictures Corp., Hollywood, Calif., and M. Rettinger, RCA Manufacturing Co., Inc., Los Angeles, Calif.

The paper contains a description of the construction of the unidirectional microphone, and an equation is obtained showing the cardioid directional response for this microphone.

Four definite advantages are listed for the use of this microphone in the recording of sound in motion picture studios. These advantages are (*1*) attenuation of undesirable sounds striking the microphone from the tear; (*2*) lack of frequency discrimination for sounds striking the microphone within its solid cone of reception because of the directional response of the microphone, which is practically independent of frequency; (*3*) the greater permissible microphone distance to obtain the same ratio of direct to reflected sound that exists at the position of a pressure-operated transmitter; and (*4*) the large solid angle of reception, which allows the use of fewer microphones to cover an action.

Six illustrations are given to show how this transmitter may be used to advantage under specific set conditions, and four diagrams illustrate its use for the recording of various types of music.

"A Super Sound and Picture Printer"; O. B. Depue, Burton Holmes Films, Inc., Chicago, Ill.

An improved contact printer for the continuous printing of 16-mm. sound and picture has some new film-handling features. The film may be threaded over either picture sprocket or sound printing drum or both, according as the negative is of the double- or single-film system. The picture is printed while the film is supported by a sprocket engaging the perforated edge of the film. At the same time, the other edge is supported on a roller tread and flange which, instead of being carried on the extended sprocket shaft, has its own ball-bearing mounting and is driven by the film. In this way the section of shaft is eliminated from the center of the sprocket, making possible a better location of the printing illumination beam. Thus it is possible without the addition of complicated optical elements to have the illumination fall perpendicularly upon the film at the center of the area of contact between negative and positive. The sound printing takes place similarly on a nearby drum. Provision is made at this point for the insertion of an optical filter. Lamp current is supplied by a built-in motor-generator set at any required voltage between 90 and 130.

The printer is driven through a rubber disk vibration filter. All bearings are either enclosed grease-packed ball bearings or "oilite" oilless bronze. Sprockets are made of stainless steel. The electrical system is protected by the use of an overload cut-out instead of fuses.