# NEW MOTION PICTURE APPARATUS

*During the Conventions of the Society, symposiums on new motion picture apparatus and materials are held, in which various manufacturers of equipment describe and demonstrate their new products and developments. Some of this equipment is described in the following pages; the remainder will be published in subsequent issues of the Journal.*

## IMPROVED NOISE-REDUCTION SYSTEM FOR HIGH-FIDELITY RECORDING*

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A new method of noise-reduction for variable-width film recording has been adopted by RCA and has been found to give excellent results. The recording optical system has been modified to incorporate a double-mask shutter and the galvanometer no longer receives biasing current.

The shutter and optical system are shown in Fig. 1. The shutter, the recording aperture, and the associated lenses are incorporated in a single unit, which can be removed at will and re-installed without loss of adjustment.

A schematic diagram of the optical system is shown in Fig. 2, where may be seen the exposure lamp, condenser lens, aperture, shutter masks, aperture projection lens, galvanometer, slit converging lens, slit, ultraviolet filter, objective lens, and film. It will be noted that the recording aperture is a negative of the familiar triangular aperture used for biased galvanometer recording. The two shutter masks are drawn together when current is applied from the noise-reduction amplifier. They separate when the current is reduced by the rectified signal. Since the images of the masks are moved vertically on the mechanical slit by the galvanometer, it is obvious that they must be parallel and perpendicular to the slit; otherwise, there would appear an audio-frequency modulation in the shutter portions of the sound-track. While this would not cause distortion, it is undesirable.

A comparison of the new symmetrical sound-track and the biased galvanometer track is shown in Fig. 3. It will be noticed that in the shutter track there is a change of recorded sound amplitude without displacement of either zero axis line. The unmasking action can be seen in the outer portions of the track as the modulation level increases.

A new feature of the optical monitoring system permits viewing both speech modulation and noise-reduction action simultaneously. Increased light for moni-

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toring and sharper focusing upon the card make visible high intermittent frequency peaks which have heretofore been difficult to see.

The ability to observe the performance of a noise-reduction system accurately during recording has been found helpful. Interference between the speech wave and the masking action, if it should exist, can be discovered quickly and corrected without having to wait for the results of the day's work. These aids to operation assure more consistently good recording.

In detail the method of monitoring is as follows: A portion of the output beam from the galvanometer is intercepted near the plane of the mechanical slit, and is reflected back. In this way a portion of the aperture is focused upon the moni-

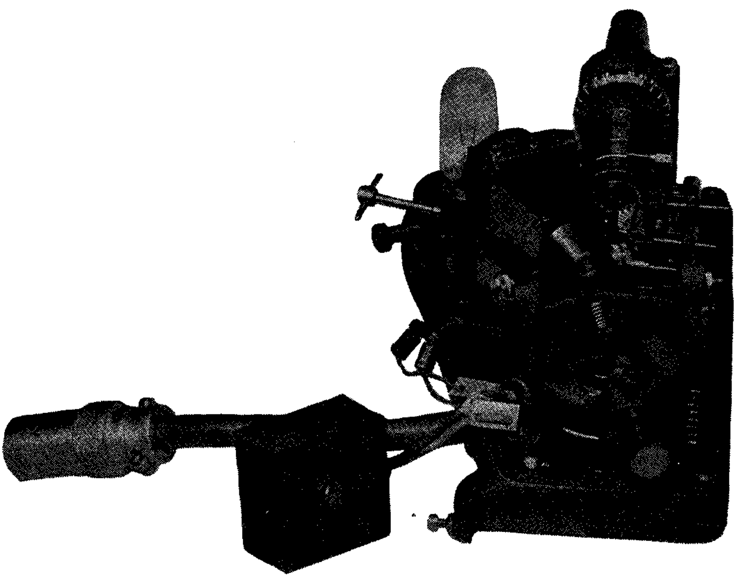

FIG. 1. Shutter and optical system.

tor card. As shown in Fig. 4 movements of the shutter masks are seen as changes in height of the light-spot. Vibrations of the galvanometer are indicated upon the card by lateral movement of one edge of the light-spot. Three conditions are illustrated: (*a*) without modulation and with shutter closed, (*b*) modulation 50 per cent and shutter partly open, (*c*) modulation 100 per cent and shutter fully open. In the two latter cases the arrows indicate the magnitude of the modulation.

With ultraviolet light for recording and printing, and because of the non-slip feature of the RCA printer, it is possible to maintain "standby" or "squeeze" lines approximately one and one-half thousandths of an inch wide on the film without fogging in the print.

The noise-reduction amplifier gain is usually adjusted to make the shutter open fully and clear of the track with 80 per cent modulation. As for the dynamic characteristics of the shutter, the device is entirely controlled by the amplifier current. When properly adjusted, the time required for opening, with a suddenly applied signal fully modulating the sound-track, is 0.012 second. The remasking is accomplished in 0.16 second. This extended closing time avoids shutter modulation at low frequencies, as for example, when recording organ music. Under such conditions poor quality could result were the closing made faster. For class *A* push-pull the only limit to the speed of opening is the filtering of audio-frequency components from the rectified current.

Fig. 5 is a schematic diagram of the shutter mechanism. The driving element consists of a reciprocating motor having a moving iron armature of the inductor type. This construction employs air-gaps of varying area instead of length, the chief features being good linearity over larger displacements and freedom from

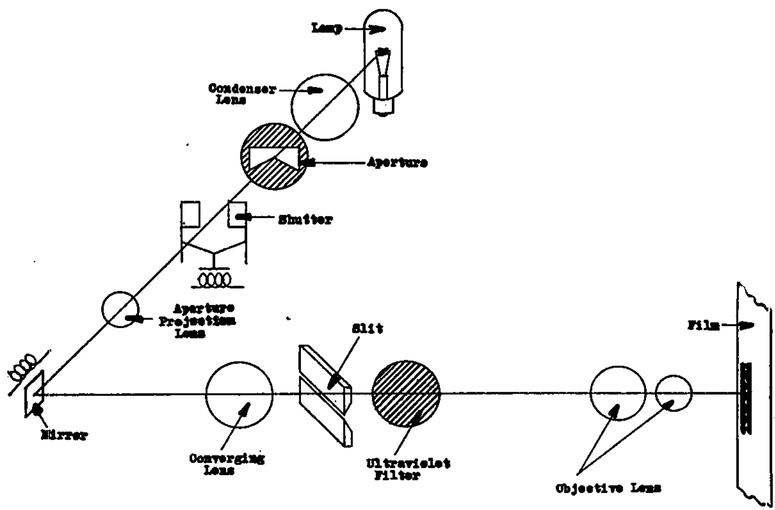


FIG. 2. Diagram of the optical system.

high negative stiffness. The armature is coupled by means of a flexible steel cross spring to a pair of light-weight masks arranged to move in opposite directions when the armature is displaced. These masks are drawn together by current from the noise-reduction amplifier during periods of no modulation, keeping practically all light out of the mechanical slit. The amount of unmodulated light reaching the negative sound-track is limited by the shutter masks, which move apart when a signal is applied to the system. When the limit of travel is reached and the shutter current approaches zero, the masks are in a position immediately to re-enter the slit as the modulation is reduced. This particular direction of current for operation is preferable. If the masks were opened by a rising current the travel would be excessive for conditions of overmodulation and the closing would be delayed. The shutter can not be damaged by excessive modulation levels since there is then the least current in its windings.

Uniform travel of both masks is assured by factory adjustment, and depends upon the relative length of span of the cross-spring either side of center. If the spring were longer on one side, that mask would move over a shorter distance. Equalizing is done on an optical fixture by loosening the clamping screw and sliding the spring in the required direction. The adjustment is then permanently retained.

To provide the necessary overall linearity of the shutter it was necessary first to determine over what range the armature alone would travel in a linear fashion. The drive ratio to the masks was then established, knowing the required displacement of the masks. It is obvious that the geometry of the cross-spring and attached masks is such that after a certain distance the movement becomes non-linear in such a manner that with uniform armature motion the mask travel

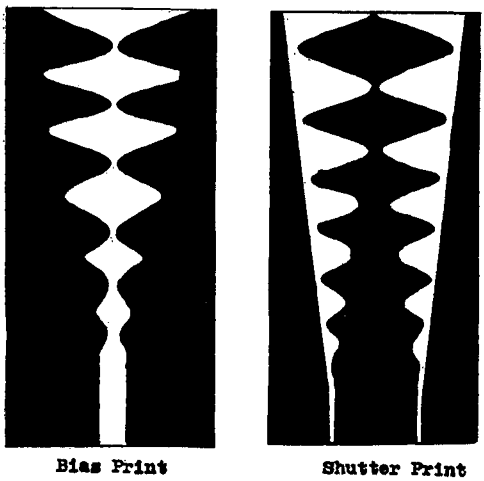


FIG. 3. Comparison of the new symmetrical sound-track and the biased galvanometer sound-track.

would be accelerated toward the end of the opening movement. A drive ratio was adopted so that the acceleration would begin as the armature motion diminished. This increased the overall linear range. In Fig. 6 may be seen the opening displacement with current, showing that the linearity is well within the required limits.

Another design problem was that of sufficiently reducing the moving mass to obtain a high natural frequency for the shutter, below which it would be controlled by stiffness and its excursions strictly governed by the amplifier current. The masks were made of duralumin and arranged to provide maximum coverage with minimum actual area of surface. The mass of the masks and the stiffnesses of the cross-spring and supporting hinges were proportioned to attain the desired natural period and yet retain good sensitivity. The complete shutter is tuned to a frequency of 140 cps. Damping is accomplished electrically by using heavy copper spools for the coils. This, plus the fact that the shutter resonates at a frequency well above the highest that can appear in the output current of the control amplifier, prevents "bouncing" or overshooting of the masks.

One matter to which particular attention has been paid in the design of recording equipment is that of phasing for speech. It has been well established that the majority of speech waves and many sounds from musical instruments are not symmetrical, having lesser amplitudes during the half-waves corresponding to rarefaction of the air. This is because of the construction of the human voice mechanism. The lack of symmetry is plainly revealed in a variable-width sound-track. If proper care is not exercised in phasing the recording channel from microphone to galvanometer, including the noise-reduction amplifier, considerable interference can occur between the speech wave and the masking action. The requirements vary slightly depending upon the type of track being made. For standard recording, the longer peaks of a non-symmetrical wave should extend away from the noise-reduction or shuttered portion of the sound-track. This applies also to biased galvanometer recording. The noise-reduction amplifier is then phased to rectify the half of the wave containing the smaller amplitudes.

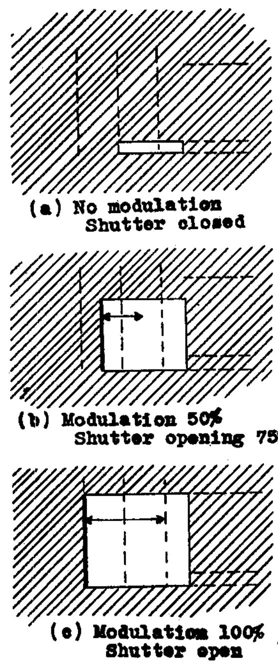


FIG. 4. Movements of the shutter masks as seen on monitor card.

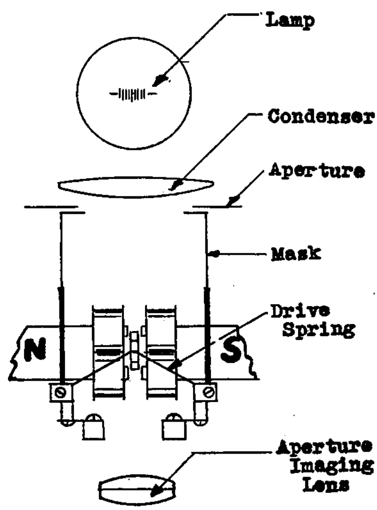


FIG. 5. Diagram of the shutter mechanism.

How this appears in the new shutter type of track is shown in Fig. 7. At the left is an example of wrongly phased speech. The correct phasing is at the right. It will be noticed that in the latter track the large peaks project toward the center, where there is plenty of room, and away from the shutter or masked portions where the clearance is maintained at a minimum.

Phasing speech for class *A* push-pull is not so important. With equal travel of both shutter masks a non-symmetrical wave might, however, interfere on one side of the track, depending upon the galvanometer polarity. It is possible and practicable to increase the travel of one mask a predetermined amount by means previously explained, to take care of average speech conditions, permitting the noise-reduction amplifier to continue rectifying the small side of the wave. Other methods have been proposed; for example, duplicate control amplifiers operating on opposite halves of the wave and driving isolated shutter masks. Most of the

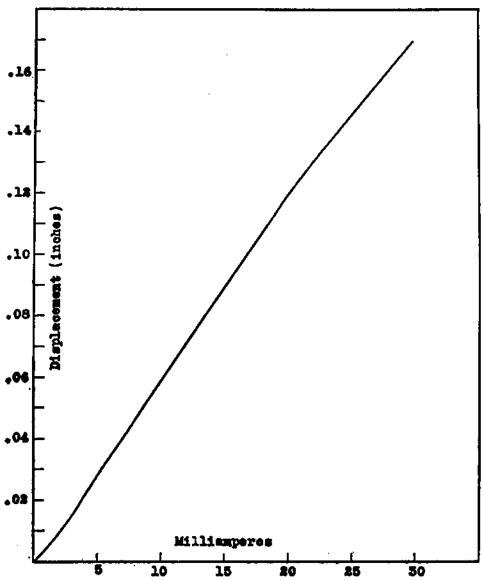


FIG. 6. Displacement *vs.* current.

arrangements suggested made the entire system unnecessarily complex in return for a negligible improvement.

Because of its inherent flexibility the new noise-reduction system can be used with a wide variety of sound-tracks, including special forms for original recordings as well as standard symmetrical track for release prints.

Using the twin mask shutter in conjunction with a standard galvanometer as light-modulator, three different types of sound-track can be produced:

(*1*) Standard symmetrical variable-width.
(*2*) Class *A* push-pull variable-width.
(*3*) Variable-density squeeze-track.

Push-pull sound-film recording is gaining favor for original negatives, and of the available types the class *A* variable-width is considered preferable. Its advantages are total elimination, by cancellation, of sibilant distortion commonly known as "zero shift," allowing, therefore, considerably wider latitude in develop-

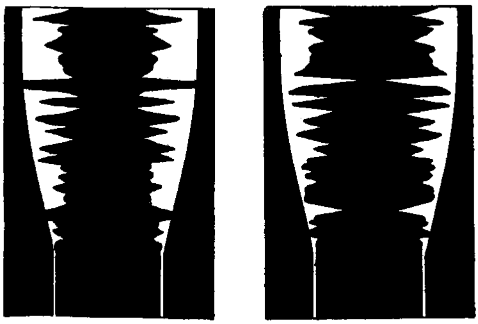

FIG. 7. Incorrect (*left*) and correct (*right*) phasing of speech.

ment of both negative and positive than can be tolerated with standard track; and second, cancellation of any disturbances that might result from incorrectly adjusted noise-reduction equipment.

## DISCUSSION

MR. TOWNSLEY: Will you explain by what means you accomplish proper phasing of the voice? Suppose we have a track that is improperly phased; what was done incorrectly in the recording to phase improperly? How are you sure you get the track in the proper phase?

MR. BATSEL: The purpose of phasing the system in respect to a non-symmetrical wave is to prevent excessive clipping by the shutter as it opens up the track.

Phasing is accomplished by applying a non-symmetrical wave to the input of the system, and observing on the visual monitoring card the deflection of the galvanometer. Looking at the card from the position of the operator, the left-hand side of the light-beam represents the outside or maximum width of the track. Our practice in phasing the system is to have the long peaks of the non-symmetrical wave point to the right of the monitor card, which on the track is to the center. The shutter amplifier is then phased to rectify this side of the signal. This practice permits full track for the long peaks and reduces clipping by the shutter as it backs out to clear the short half of the signal.

It is known that the pressure side of the sound-waves produces the long half-cycle. By observation the microphone is likewise phased so that the long half-cycle deflects the galvanometer to the right, as seen on the visual monitor.