Glow-lamp noiseless recording

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UNDER normal conditions unmodulated sound track has a noise ratio, depending mainly on the amount of transient opacities interspread on the track. The levels of these transients vary as the ratio of the density of the unmodulated track to the transients, as represented on the print by dirt, scratches, oil, wax, etc. It being beyond the ability of any electrical circuit to discriminate between desired signal and acoustic background noise, it is apparent that no effective results can be obtained in the elimination of acoustical noises. This paper describes the general principles of surface noise reduction as applied to recording glow-lamps. The circuits and film data represented are classical rather than those in use or applied by any producing company using this type of recording.

The first requirement in the making of a film record is that the fidelity of the density indicated on the print does not noticeably deviate in relationship from the applied sound pressure on the microphone diaphragm.

In considering the design of noise reduction circuits, whether they be intended for application with variable density or variable area, the work to be accomplished is the same in both instances, i.e. that for such periods of no modulation extreme opacity will be interposed between the light beam and the photocell of the projector.

It might be well at this point to consider what constitutes an ideal sound-track with regard to the elimination of surface noise as represented on the film. Obviously, a sound-track, wherein the speech signal is totally transparent and is surrounded by complete opaqueness, will constitute an ideal track. Such a track is shown in Fig. 1, and is a record made of a 50-cycle wave. It will be noticed that this negative track is opaque in portions of the track occupied by the signal and is completely transparent in the unused area. It will be noticed that the signal does not modulate a carrier exposure such as used in variable area records. It will also be observed that the positive half of the cycle lies above an imaginary center line and the negative half lies below this point. A print from this negative track will reverse the conditions and give us a signal that is transparent with a surrounding area completely opaque. Such a track is inherently noiseless and is made without the use of secondary exposure control devices.

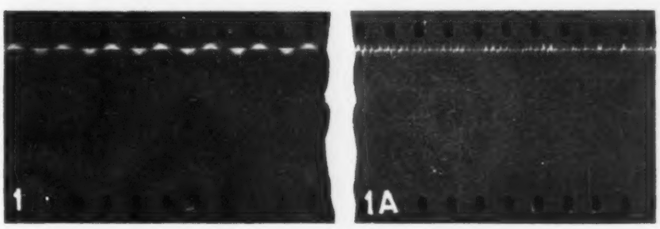

Fig. 1—Fifty-cycle modulation with zero center line recording, 1A speech and music modulation

Methods of noise reduction

Although the example is of the variable area type, such a principle is equally applicable to variable density. Such a negative variable density track would have exposure only during the signal period, reverting to clear transmission at all other times. The above ideal is varied in general practice by an attempt to provide the maximum opacity around the speech envelope in the print, rather than an attempt to fill in between every cycle or component thereof. In the variable area method two devices have been employed, one wherein the center line is varied, and the other where the center line remains in its usual position in the sound track, and then a secondary exposure surrounds the speech envelope.

In the variable density method the unmodulated exposure is varied according to the strength of the speech signal, and ranges from the normal density of the unmodulated track when fully modulated to the maximum density for the weakest speech signal. The above conditions apply naturally to the print.

Although it is possible to make variable area records with a glow-tube by actually photographing the expansion and contraction of the glow itself, the usual type of recording with the glow tube is of a variable density character.

Figure 2, shows a typical glow-lamp recording circuit and consists of microphone pickup, control for same, a main amplifier having a gain of approximately 80 to 100 db., and then depending upon the number of recording cameras used, bridging amplifiers connected to the glow lamp control circuits, the usual glow-lamp control circuit consisting of a voltage supply connected to the

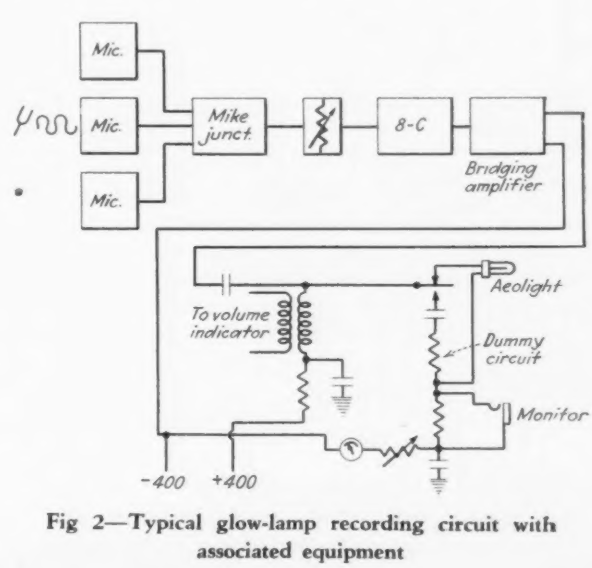

Fig 2—Typical glow-lamp recording circuit with associated equipment

glow-lamp through a control and ballast resistor, and a coupling condenser to the speech circuits which modulate this direct current flowing through the glow lamp. Additional means are provided for monitoring and also a dummy circuit so that the volume indicator will read correctly during such periods as it is desired to conserve the glow-lamp.

Operating characteristics of the lamp

In operation the value of a d.c. current flowing through the glow-lamp is determined by the light efficiency of the glow-lamp with respect to the film emulsion characteristics. This value is chosen so that the unmodulated transmission will fall midway on that portion of the film characteristic to be used.

Either "toe" or "straight line" characteristics may be used in processing film for glow-lamp recording. Both methods of processing are possible and have proportional linear characteristics, otherwise they would be unusable due to the loss of fidelity.

In general, the quality and quantity of light emitted by a glow discharge tube depends upon the electrode spacing, the type of gas, the pressure of gas, and the applied potential. From life and operating requirements it is usual to excite the glow lamp below maximum output. While this amount of light, when using positive emulsion, falls below that required for straight line *H* and *D* recording, it is more than ample for toe processing. When straight line *H* and *D* characteristics are desirable, it is usual to use a film having greater speed. In the last few months, so-called composite stocks have been developed by the film companies wherein the speed lies between that of the positive and negative emulsions, and is ample for straight line recording with glow discharge tubes. Negative stocks, such as orthochromatic, panchromatic and super-panchromatic, are capable of giving perfect straight line records with low light intensities. With the super-speed films, such as super-panchromatic, it is possible to work with very limited amounts of light and to fully modulate over the straight line *H* and *D* portion of the film.

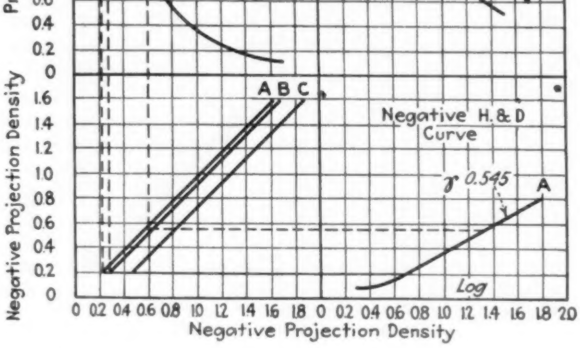

Fig. 3—Characteristic curves for exposures and processing with positive stock using glow-lamps for recording

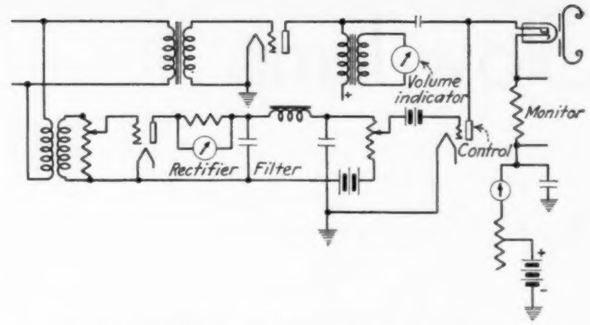

Fig. 4—Modification of circuit in Fig. 2 to meet special requirements of the biasing circuit

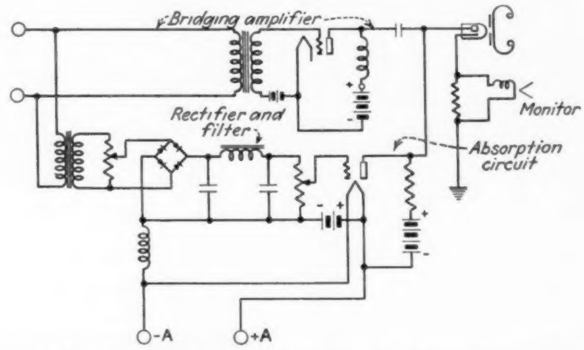

Fig. 5—Simplified circuit using a full wave contact rectifier in place of thermionic rectifier

The question of cost, however, must be considered. In the major studios, where from 50 to 75 productions a year are to be made, it is roughly estimated that approximately one hundred thousand feet of sound negative will be required per production for recording. In the case of the 50 production per year company, five million feet of sound negative are required. The price differential between positive and negative stocks is in the ratio of four to one. There is also an advantage in the use of positive stocks, due to their lower speed having greater stability and ease of handling, and this, in addition to the yearly saving, makes it desirable to employ that type of emulsion.

In the making of studio productions, it is common practice to use the double system of photography and recording, that is, a separate sound and separate picture negative. In the case of a single system, such as employed in newsreels, wherein sound is simultaneously recorded with the picture, the question of emulsion is necessarily determined by the photographic requirements. This usually calls for the panchromatic and super-panchromatic types. The requirements of photographic processing determine that of sound, and is necessarily straight line.

Referring again to the common practice in studio production work, positive stock is utilized generally, necessitating the toe method of processing when using glow-lamps for recording. The characteristic curves of such exposures and processing are shown in Fig. 3. The lower right-hand quadrant shows the negative characteristics of dynamic glow-lamp current plotted against negative projection density. The lower left-hand quadrant represents printer points, and the upper left-hand quadrant shows the characteristic of the printer curve having the negative projection density plotted against the print transmission. The upper right-hand quadrant shows the overall recording characteristics, and this

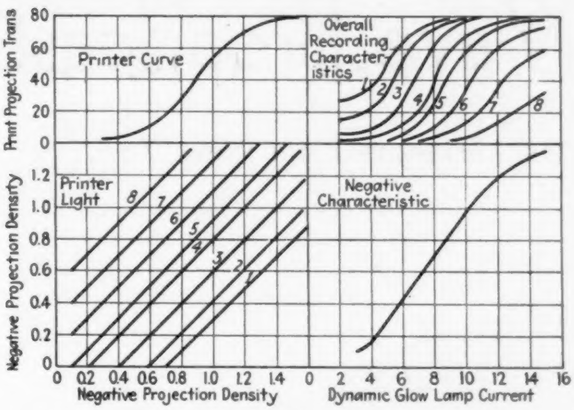

Fig. 6—Film characteristics when using straight line recording and processing

should be chosen so that the original requirement of proportionality is carried out. In normal toe practice a print having an unmodulated transmission of between 40 and 45 per cent is specified.

Operating limits for film exposure

The design and operation of biasing circuits, in connection with glow-lamp recording, depends upon the film characteristics to be utilized. It is obvious that the increase of opacity in the negative must not be carried beyond a point where there is film curvature. An examination of the negative characteristic in Fig. 3 shows that the straight line region extends from approximately 65 per cent transmission to 15 per cent transmission. In practice then we would place the unmodulated exposure half way between these peak limits, or aproximately 40 per cent. At this point we can swing the film transmission with our signal 50 per cent without incurring noticeable deterioration of fidelity. This representing our highest modulating level, it is now necessary to pick a point further down the scale where a minimum signal will not overswing into the curved region of the emulsion. Allowing 10 per cent for this minimum swing, we pick a point wherein the unmodulated transmission for this value of signal will be 20 per cent. This minimum operating point, allowing a swing of 5 per cent plus or minus, is well within the safety zone and permits sounds of increasing intensity and flat wave front to be recorded without distortion. This is necessary due to a characteristic of the biasing circuit, which will be pointed out later, wherein a requirement of time for operation is essential.

It is now necessary that we change our fundamental circuit, as shown in Fig. 2, to one similar to Fig. 4, the requirement of our biasing circuit being that for a minimum signal transmission of approximately 20 per cent unmodulated value shall be increased to a transmission of 40 per cent for our fully modulated signal. It is, therefore, necessary to make the control of the d.c. current flowing through the glow-lamp automatic and vary with the strength of the impressed speech signal. In Fig. 4, the d.c. path through the glow-lamp is controlled by the plate filament resistance of the control tube which is in series to ground. This control tube in turn has its grid potential varied by the output of a rectifier tube, and this rectifier tube in turn is energized by diverting a part of the speech current used to modulate the glow lamp.

It is possible upon the proper calibration of such a circuit, to vary the impedance in the glow lamp circuit in such a way as to change the d.c. component in accordance with the speech level impressed upon this circuit. It is necessary that means be provided so that the control tube will not modulate the d.c. component in accordance with low frequency speech currents. This is provided for in the filter timing circuit between the rectifier tube output and the grid of the control tube. The period of this timing depends upon the values of the tuned filter circuit, and is usually between one-fiftieth of a second, and one-hundredth of a second, which permits the control tube to function only in relationship to the envelope of the speech current.

Variation in circuits used

There are many variations in the type of biasing circuit to be used, and just so that they contain the three essential units, i.e. rectifier, filter timer, and control tube, properly adjusted, the results will not vary. Fig. 5 shows the circuit that has been simplified by the introduction of a full wave contact rectifier in place of the thermionic rectifier. In addition, in place of the control tube being in series with the glow lamp, it is shunted across the resistor, supplying the d.c. current to the glow lamp, and provides an absorption control in place of series. One advantage of this method is that saturation may be properly controlled. Saturation is a double safeguard against overrunning the film limiting characteristic.

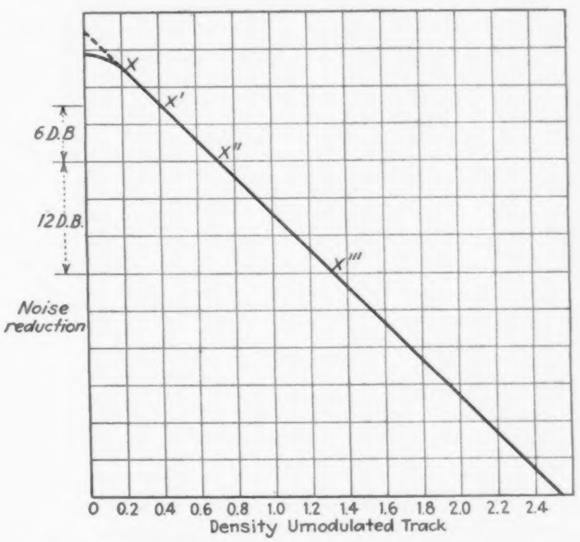

Fig. 7—Density of the unmodulated sound track plotted against relative noise reduction

Fig. 6 represents film characteristics when employing straight line recording and processing. It will be noted that the negative characteristic is such that the optimum unmodulated transmission for full modulation is approximately 20 per cent. This value inherently gives this type of processing a reduction of 6 db. in ground noise over normal toe processing due to the halving of the unmodulated transmission. It will be further noted that it is possible to increase the print density to values as low as 4 per cent and 5 per cent.

In order to fully understand the effect of noise reduction in relationship to toe and straight line processing, reference is made to Fig. 7. In this the density of the unmodulated sound track is plotted against relative noise reduction. It will be noted that in the upper regions of

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transmission, noise reduction is not linear with decrease of transmission, curving off at a point approximately 65 per cent. As this value falls in the fog region it is of little importance. The amount of noise reduction is based on the ratio between maximum signal unmodulated track and minimum signal unmodulated track. In the case of toe recording, normally this is the ratio of 40 per cent X′ to 20 per cent X″, or theoretically 6 db. reduction. In the case of the straight line print, it will be the ratio of 20 per cent X″ to 5 per cent X‴, or approximately 12 db. It will be found in practice, however, that the actual observed reduction is not quite as great. While the modulation value of toe recording is inherently higher, the net reduction of surface noise and signal-to-noise ratio is greater when using straight line methods.

It is the contention of the author that the reduction of surface noise is not the advantage to be gained by biasing methods, but rather it is the increase in range between signal and noise. At the present time the average auditorium background noise, which consists of audience movement, ventilation, etc., is approximately —15 db. Any reduction of film surface noise below this value will be wasted, it should, however, be applied to the other end of the volume spectrum.

In the average theater, having a capacity of approxi-2,000 seats, +20 db. level into the horns is sufficient to create the illusion of a large orchestra, and +30 db. is sufficient to create a natural illusion of gunfire. It is, therefore, desirable that the maximum range of 45 db. between surface noise and peak signal be attained. This is greater than is at the present time attainable with the existing systems. It is believed, however, that with the adoption of methods producing sound tracks similar to the ideal, as represented in Fig. 1, that ranges of 60 db. on the film will be possible.