A Proposed 8mm Sound Film System

By JOHN A. MAURER

A perforator and printing equipment have been built to produce film in accordance with the proposed 8mm sound film standard shown on page 623 of the SMPTE Journal for August, 1961, which uses perforations 0.050 in. square and provides for a variable-density soundtrack 0.050 in. wide. Prints have been made on Eastman Color Print Film, Type 7383. Design and performance aspects are discussed.

This paper is a report of a practical test of the proposed changes in the perforation and sound record dimensions of 8mm film first published on page 623 of the *Journal* of the SMPTE for August, 1961.

Figure 1 is an enlargement of a strip of 8mm film made in accordance with the proposal. The perforations are 0.050 in. wide and 0.050 in. high. The distance from the perforations to the nearer edge of the film is 0.058 in. The soundtrack is 0.050 in. wide; of this 0.040 in. is scanned.

Rationale of the Proposal

The dimensions given above were arrived at on the basis of the following considerations:

(1) The perforations of the present ASA Standard 8mm film are wider than necessary, and this excess width wastes space that might otherwise be used to improve the quality of the picture or of the sound record or both.

(2) It was believed, however, that the industry would not accept a change which would make existing films obsolete, and that therefore the part of the film reserved for the picture must be left unchanged.

It should be noted that the proposal did not say anything about the size of the frame to be projected to the screen. There have been other proposals for enlarging this area without changing the perforations. One of these proposals which is of particular interest would make the height and width of the projected area exactly one half of the corresponding dimensions for 16mm film. This would facilitate the production of 8mm release prints by continuous optical reduction from 16mm negatives. It would increase the projected area over the present standard area by about 20%. The projector could still be used with existing films; all that would happen would be that nearly the entire image on the film would be projected, and in a very few cases part of the boundary of the camera aperture might appear on the screen. The proposal just outlined, if adopted, would not conflict with the one which is the subject of this paper.

(3) It was obvious that a greater record area would benefit both magnetic and photographic soundtracks. In the case of the magnetic record, previous experience had made us aware of the problem of head contact discussed by Walter Bach in his paper, "The Azimuth Plateau Effect," in the *Journal* of the SMPTE for March, 1962, and it was believed that the coating of a wider stripe would result in a greater fraction of the width of the stripe being flat enough to make effective contact with the head.

(4) It was thought to be a good idea to specify an 8mm photographic track of such dimensions that optical reduction from 16mm sound negatives could be done at a ratio of 2 to 1 laterally as well as longitudinally. This would permit the use of optical systems made up entirely of spherical lenses, avoiding the complications of anamorphosing systems such as are required when reducing 35mm soundtracks to 16mm.

The last stated consideration leads to the choice of the track width that was proposed. A one-half size reduction of a 16mm variable-area soundtrack would be 0.030 to 0.032 in. wide. A scanned area 0.040 in. wide would allow a tolerance of ±0.004 to 0.005 in. for film weave. A variable-density track, to provide the same tolerance should be 0.050 in. wide. 16mm variable-density negatives recorded for reduction to 8mm could easily be made 0.100 in. wide — the space is available on the film without changing the centerline distance.

Once this desired value of 0.050 in. for the width of the variable-density soundtrack and of the magnetic stripe had been arrived at it was noted that a perforation 0.050 in. square with its edge on the side next to the picture at the original distance of 0.108 in. from the guided edge of the film would leave a space of 0.058 in. in which we could place the 0.050-in. sound record. This completed the set of dimensions in the proposal.

Presented on April 30, 1962, at the Society's Convention in Los Angeles by John A. Maurer, JM Developments, Inc., 116–118 West 29 St., New York 1.
(This paper was received on July 10, 1962.)

Equipment Used to Produce the Film

In order to be able to produce film in accordance with this proposal we built a perforator, an optical reduction picture printer, and an optical reduction soundtrack printer. We also made appropriate modifications in our 8mm photographic sound recorder.

The perforator was used to place a row of 0.050-in. square perforations at the proper distance from the previously unperforated edge of a strip of 16mm singly perforated film stock. This edge has no latent image printing in it, so that both the picture and soundtrack areas are available for tests. Picture printing, sound recording, and processing are done in the 16mm width. After slitting to 8mm, the half of the film carrying the 16mm perforations is discarded. This is obviously not a commercial procedure, but it serves very well for experimental work.

The Picture Printer

We built a small step picture reduction printer which is mainly noteworthy for the time that was spent in trying to provide it with the best possible printing lens system.

Lenses of the focal lengths commonly employed in 35mm and 16mm optical printing cannot provide the standard of definition that we need in 8mm release prints because their longitudinal color errors (secondary spectrum) amount to several times the focusing tolerance. The best possible compromise focus with such a lens, arrived at simultaneously somewhere in the blue-green

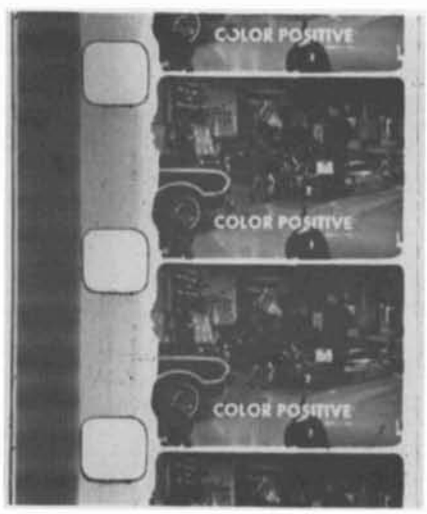

Fig. 1. An enlargement (× 6.75) of film made in accordance with the proposal.

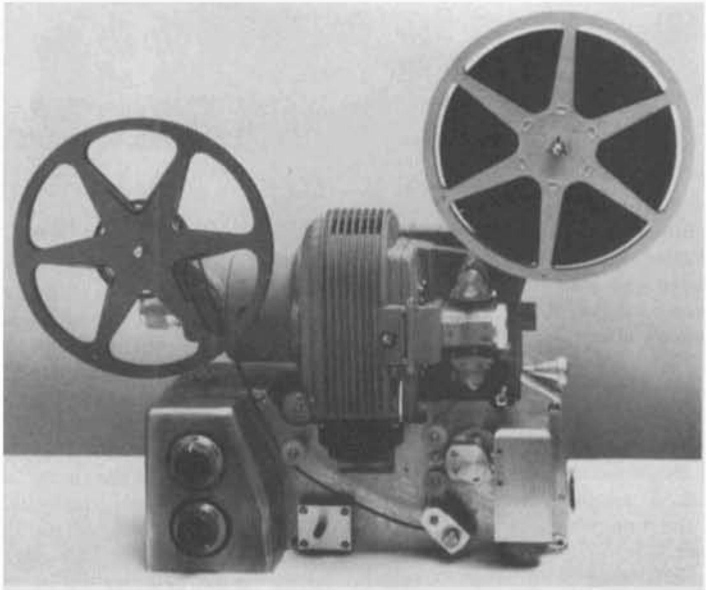

Fig. 2. 8mm projector with added soundhead.

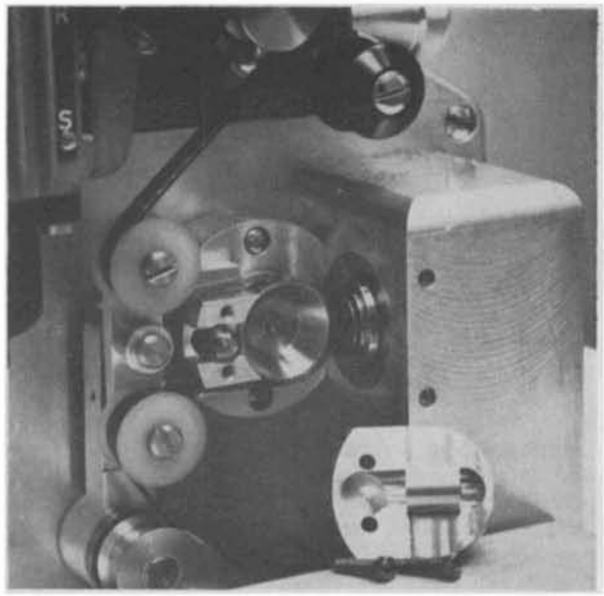

Fig. 3. Closeup of construction at sound reproducing point.

and in the orange-red, leaves yellow, blue and deep red quite noticeably out of focus, and the overall effect is considerably less sharp than the best images of which the color print stock is capable.

A well corrected anastigmat lens of any of the types commonly made for 16mm cameras, if stopped down to about $f/4.0$, has a region of substantially uniform and very high definition extending from its axis to between 3 and 5 degrees away from the axis, that is, extending over about $\frac{1}{8}$ of the angular field over which the lens is commonly used. Within this region the errors of astigmatism and coma are completely negligible; at slightly greater field angles the uncorrected residuals of these aberrations may be seen on an optical bench, and the quality of definition drops to a level of about $\frac{1}{4}$ that seen in the central region. This assumes that the workmanship is perfect. We are talking here about a standard of performance higher than is necessary for any other purpose. Even when we have lenses of a suitable type of construction it is necessary to select the very best individual examples by careful study on an optical bench.

We need a lens of short focal length in order to keep the longitudinal secondary spectrum to the order of one or two thousandths of an inch, and at the same time we need a lens in which the region of very high central definition is large enough to cover the 8mm frame. This means that the most suitable focal lengths are in the range from 25 to 40 mm. Only a few of the 25mm types are suitable.

In the present case we have used a carefully selected 40mm lens on the 8mm head of the machine and a specially designed 80mm Petzval-type lens on the 16mm head. The 16mm lens is used at about $f/8.0$, which makes the requirements in its case less critical. Each of these lenses is focused on infinity by the aid of an autocollimator. One of the advantages of this type of lens system is that it is not necessary to adjust the overall distance between the two printer gates to any exact value. The reduction ratio is determined by the focal lengths (actual, not marked) of the two lenses. One of the advantages of the Petzval type of lens is that it is possible to adjust its focal length over a range of a few per cent without impairing its performance. To set up a system in this way it is, of course, necessary to have an optical bench on which focal lengths can be measured accurately.

The lens system of this printer, constructed as above described, surpasses the resolution and fine detail contrast capabilities of the film by a factor of three over almost the entire area of the 8mm frame. This is necessary in order to make prints that are as sharp as can be obtained on color print film. The system may be used at any aperture from $f/4.0$ to $f/8.0$ on the 8mm side. At larger openings image contrast begins to deteriorate; at smaller openings the finest detail is lost because of diffraction.

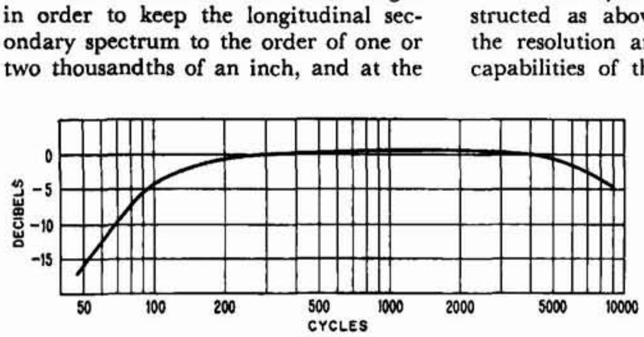

Fig. 4. Frequency response of photo-diode and projector amplifier — constant modulated light.

The Optical Reduction Sound Printer

The sound reduction printer consists of the film driving mechanisms of two 16mm sound recorders mounted on a single $\frac{1}{2}$-in. thick metal plate, one of them being driven at half speed. The optical system is set up on the same basis as the picture printing system described above. In this case, since the area to be imaged is comparatively small, lenses of the Petzval type are used on both ends of the system. As is well known, the Petzval lens has a somewhat reduced secondary spectrum as compared with other types of highly corrected lenses.

We have not completed the work planned for the optical reduction sound printer, and must defer a complete report on it until a later occasion.

The Sound Recorder

The sound for these films was recorded on a 16mm recorder which had been previously modified to produce 8mm variable-density direct playback tracks 0.030 in. wide. This recorder has now been equipped with a 32-tooth 8mm sprocket made to suit the new perforation size and position, and the optical system has been adjusted to give a recording image 0.00009 in. wide and 0.050 in. long, with its center 0.029 in. from the edge of the film. A new series of sensitometric tests was made on

Eastman Color Print Film, Type 7383, and a recording mask was made to suit this film. A mask made for Eastman Fine Grain Release Positive Film, Type 7302, (black-and-white) was already available. Frequency films as well as practical soundtracks were recorded on both types of film.

The Projector

We had available an 8mm projector made by the Japanese firm of Canon which had impressed us by its quietness of operation, by its uniform screen illumination, and by the quality of its *f*/1.4 projection lens. We built a new base for this machine, increasing the height enough to incorporate an adequate flywheel and motion filtering system and a small sound amplifier. The resulting experimental sound projector is shown in Fig. 2. The construction at the sound reproducing point is shown in Fig. 3, in which the front plate of the sound gate, which forms one side of the film guiding channel, is removed and turned over to show a mount attached to it which contains two small plano-convex lenses. These pick up the scanning beam after it has passed through the film and relay it in reduced size to an RCA type 4420 germanium photo-diode.

This photo-diode is operated with 30 volts bias and coupled by a 200,000-ohm resistor to a type 7025 tube which in turn drives a 6BQ5 output tube. The circuit of this amplifier is not complicated; on the contrary, it is almost the simplest circuit possible with these tube types.

The amplifier has approximately 20 db more gain than is needed, but it is stable and extremely quiet and the gain control is good enough to permit using it with our films. The excessive gain could easily be eliminated by a slight redesign.

We have measured the frequency characteristic of the combined amplifier and photo-diode by the use of a device in which a recording galvanometer produces constant modulated light. The constancy of modulation at different frequencies can be monitored visually with the aid of a microscope with a ruled glass eyepiece scale to an accuracy better than $\frac{1}{4}$ db. The response curve is given in Fig. 4.

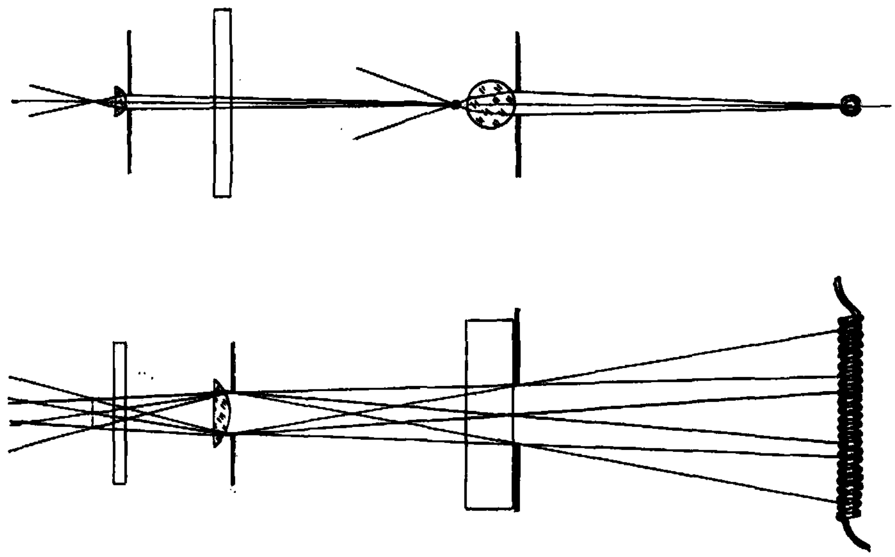

Fig. 5. Accurate scale drawing of the reproducing optical system: (top) vertical section; (bottom) horizontal section. This drawing is to a scale of 4 ×.

The undistorted output of the amplifier is of the order of $2\frac{1}{2}$ watts.

Scanning System

The scanning system of this projector uses a 6-volt 1-amp exciter lamp supplied with direct current from a small filament transformer and a resistance capacity filter. With more time available this power supply could have been built into the projector base, using a power transformer with an added winding to supply the exciter lamp current, but for the present, as a matter of convenience, we are using a separate power supply.

The scanning optical system is shown accurately to scale in Fig. 5. The three cylindrical lenses are all held in a mount 0.500 in. in diameter by 0.485 in. long. This is attached to a ring which can be adjusted for azimuth by the two screws seen in the front of the lamphouse in Fig. 3, and focused by the outer ring seen around the lens mount in the same figure. The scanning image is 0.00025 in. wide and 0.040 in. long.

Protection of the Soundtrack

A detail of construction that will be significant to engineers conversant with projector design is the lateral profile of the sprockets and guide rollers used in this projector.

The original sprockets and guide rollers were replaced by the parts shown in Fig. 6, in which the film width and thickness are also drawn accurately to scale. The cross sections of the picture aperture plate and the opposed pressure plate at the gate are similar. It may be seen that both the picture area and the sound-record area are well protected against scratches. In practice we have not experienced any trouble from scratches although we have run certain films through the projector a great many times.

Overall Performance

The quality of the pictures placed on the screen by this system is such that in practically all scenes it is possible

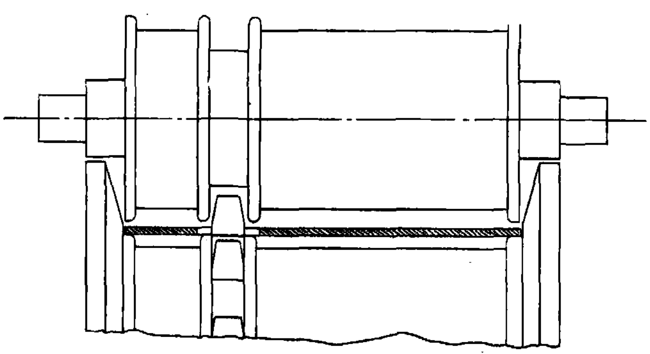

Fig. 6. Flanged sprocket and guide roller as used in the projector, with film in cross section. This drawing is to a scale of 6.52 ×.

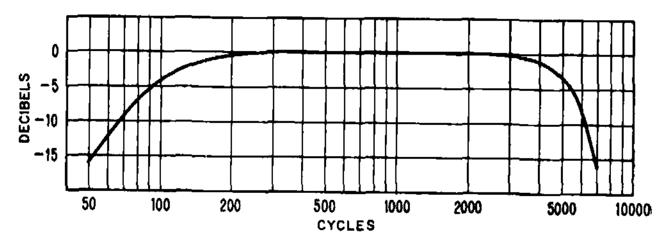

Fig. 7. Reproduced frequency characteristics of black-and-white and color soundtracks using practical values of recording equalization and the reproducing characteristic shown in Fig. 4.

for an observer standing near the screen to tell exactly on what plane of the subject the lens of the original 16mm camera was focused; in other words, very nearly all the detail that was present in the 16mm internegative has been transferred to the 8 mm print.

The steadiness of the picture when using the new perforation is as good as when standard 8mm film with an image reduced from the same negative is used. It was necessary to remove only a small amount of metal from the original pulldown claw of the projector to prevent interference with the smaller perforation.

The flutter content of sound reproduced by this projector is 0.08% as measured with 3000-cycle film made by our 8mm photographic recorder. The "wow" content is higher, of the order of 0.5%, clearly due to the fact that the sound system is driven through the entire original gear system of the projector instead of by a more direct drive such as would be used in a well-designed sound projector.

The frequency characteristics of black-and-white and color soundtracks are shown in Fig. 7. They do not differ enough to make it meaningful to draw two curves. The noise level of unmodulated black-and-white track made without noise reduction is 37 db below the output level of an 80% modulated 400-cycle tone. The corresponding figure for color print stock is 38 db. Our normal practice is to use 12-db noise reduction.

The sound quality of synchronized combined prints which we have had the opportunity of making has been rated as highly satisfactory by all who have heard it, including both educators and experienced members of the non-theatrical industry.

In summary, up to this point we have found nothing difficult or impractical in the use of film made in accordance with this proposal.

We wish to thank Movielab, Inc., of New York City, and Calvin Productions, Inc., of Kansas City, who at various times have processed color prints for us and have gone to the trouble of making the soundtrack application fit the unusual dimensions of both standard 8mm film and our specially perforated film. Without their help we could not have done any effective work on 8mm color sound films.

A Nonstandard Use of 16mm to Meet the 8mm Print Cost Challenge

By HENRY C. MENGERINGHAUSEN and WILLIAM R. WITHERELL, JR.

The use of 16mm sound release prints for large-scale business and educational film distribution has been challenged by the apparent savings offered by 8mm release prints with magnetic soundtracks. The authors propose a nonstandard use of 16mm, compatible with most existing sound and picture equipment, to effect considerable economies in shooting and printing. The proposed method retains the full 16mm frame and the standard width photographic track and achieves its savings by using an established slower projection speed.

A NEW factor has arisen on the non-theatrical motion-picture scene. Its name is *8mm*. It arrives with the promise of cheaper prints, smaller prints, lighter weight prints. It holds the lure of equipment that is cheaper, smaller, lighter in weight.

But this miniature size also brings with it many technical liabilities. It's soundtrack passes over the sound drum at a much slower speed. Its amplifiers have less power. It puts less light and one *quarter* the picture information and definition on the screen. *8mm* is about to turn professional largely because of an insistent demand on the part of industry and education for less costly distribution and projection.

Is there another answer to this demand for more economy? The authors think there is: 16mm at silent speed with sound. From a technical standpoint it is definitely superior to 8mm. From an economic standpoint it is not only competitive, but in some cases is far less expensive than 8mm magnetic release prints. Above all, it is compatible with much equipment already in use in the field.

It is one thing to assume a hypothetical situation and examine advantages and disadvantages. It is another to prepare samples made under controlled conditions. But the true test of a non-standard approach intended for wide usage is to put the idea on the screen using standard production equipment and techniques.

16 at 16

For the SMPTE Lake Placid meeting in October, the authors produced a six-minute 16-frames per second (fps) color subject entitled *16 at 16* with a photographic soundtrack including music, narration and sync sound sequences. It proved immensely valuable in pin-pointing both the advantages and disadvantages of such a system and it may well be the first film of its type produced in this country. In England and on the Continent, sound at 16 fps has been available for some time for post-recorded productions, both professional and amateur.

In fact, lest the 24-fps speed be revered too highly by virtue of long usage in this country, it puts things in better perspective to remember that the 24-frames/sec standard was originally adopted for the primary purpose of improving the *sound*, *not* the picture. Since then, much progress has been made in the quality of film emulsions, recorder optics and projector sound-systems. And, as John Maurer contended at the SMPTE Toronto convention, sound reproduction at slower speeds still can be improved considerably with present materials (*Jour. SMPTE, 70:* 618–624, Aug. 1961).

The production of *16 at 16* involved several steps. First, the script was written to emphasize the feasibility of the procedure and to provide answers to most of the questions that might arise in the minds of a technical audience. Because image clarity and brightness and freedom from flicker would be self-evident on the Lake Placid Club's 13-ft high screen, the narration was to concentrate on the sound recording and sound transfer capabilities and procedures.

Music, in two sections of the film, was to be used so the viewer could make a comparison with music on other optical tracks he might have heard. In addition, scenes and sounds of a frequency signal generator were included to document more accurately

Presented on October 6, 1961, at the Society's Convention at Lake Placid, N.Y., by Henry C. Mengeringhausen and William R. Witherell, Jr. (who read the paper), Video Films, Inc., 1004 East Jefferson Ave., Detroit 7.
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