piece of equipment to one of the intermediate stages. All other steps can be performed on conventional reduction priners. Practical tests have shown that a good print quality may be expected when using Mode 3, described above.

Original anamorphic image recordings made with the Cineavision system with a 16mm, super 8mm, or video camera will all have the same aspect ratio, identical with the image area aspect ratio standardized for 35mm Style B anamorphic recordings. The uniformity of the aspect ratios of anamorphic images in all these cases makes it possible to obtain reduction or enlargement prints without image area losses. The means for obtaining these results are extremely simple and can be achieved with little additional cost in existing equipment.

It is important to note that in all the given examples of dimensional image area variations, neither the incidence angle of the light beam on the camera, printing, and projection gates, nor the type of lens aperture used was considered. In practice, the tolerances of the image area dimensions depend on such factors as the *f*/stop and focal length of the camera lenses used, the distance between the emulsion and the physical gate aperture, and distance variations between the projector mask and the film during final projection.

All the dimensions given refer exclusively to the image area dimensions that should be obtained on the film in agreement with the respective standards (Table IV), or the corresponding screen image aspect ratios. They are not directly applicable to the mechanical camera, printer, or projector gate dimensions.

On request, the authors will gladly furnish detailed information about their actual experiences with camera, printer, and projector aperture tolerances found in practice. Also available is information about recommended splicing methods so that certain types of splices will not become visible in projection.

Readers should note that the Cineavision system is covered by patent applications in the U.S. and other industrially developed countries.

Table IV. Reference Standards and Recommended Practices.

Subject matter	Reference
35mm camera image areas, anamorphic and nonanamorphic	ANSI PH22.59-1974
16mm camera image area	ANSI PH22.7-1976
Super 8mm camera image area	ANSI PH22.157-1971, R1977
35mm projectable image areas, anamorphic and nonanamorphic	ANSI PH22.195-1977
16mm projectable image area	ANSI PH22.8-1969, R1975
Super 8mm projectable image area	ANSI PH22.154-1976
Image area, step optical reduction and enlargement printing 35mm-to-16mm and 16mm-to-35mm	SMPTE RP 65-1976, reduction SMPTE RP 66-1976, enlargement
Image area, reduction printing 16mm-to-super 8mm	ANSI PH22.153-1971, Note 1
Optical printing ratios for enlargement and reduction of motion-picture images	ISO 4238-1976

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Anamorphic Super-8 Wide-Screen Prints with Stereophonic Sound

By JOHANNES WEBERS

Initially, a short overview of the use of stereophonic sound in wide-screen pictures is given. The basics of obtaining a stereophonic soundtrack and its use in conjunction with a wide-screen film are briefly discussed. The basic sequence of printing steps for obtaining a print with magnetic sound are outlined. Next, the manufacturing steps for obtaining deanamorphosed reduction prints from anamorphic originals are discussed in detail. The image scanning process, necessary in this type of reduction printing, is analyzed, and an automatic scanning system for the optical reduction printer is described. A control tape for the automatic optical printer scanning is obtained by first scanning a workprint of the original anamorphic film by means of a video camera tube. Methods are described for producing an anamorphic super-8 print from an anamorphic original. Finally, methods are discussed for applying high quality stereophonic soundtracks to anamorphic super-8 prints.

The human eye covers a vertical angle of about 20° and its horizontal angle is about 40°. Over the years there have been many attempts by the motion-picture industry to develop wide-screen processes which simulate the field of view of the eye.

The effect of the panoramic picture can be greatly enhanced by adding stereophonic sound. Here, the capability of the ear to localize sound sources in space by their relative differences in time, intensity, and phase comes into play. In wide-screen projection, the content of the picture and the simultaneous acoustic source displacements are thus thoroughly intertwined. This gives the viewer an almost perfect illusion, in contrast to normal projection where only a single speaker is used.

The original CinemaScope film uses four channels — three channels for the left, center, and right speakers and an extra channel. The Todd-AO system employs six-channel recording and in projection uses speakers in left, half left, center, half right, and right positions. A special sound space effects channel is used.

The initial sound input for the release printing of magnetic striped stereophonic films is a master tape. It is the end result of the final post production sound mixing operation. This is one of the most important post production procedures. Of all the divers phases of film production, where only one or two sound tapes can be played synchronously with the picture, the final mix is the opportunity at which the director and his artistic collaborators can judge for the first time the image and the sound of a film as a whole. It opens multiple possibilities for further creative work.

In stereophonic sound recording, all sounds, except the music, are normally single-channel recordings. The reason for this practice is that, within a motion-picture studio hall, true stereophonic sound recording simultaneously with the shooting of the picture would be extremely difficult. In Todd-AO, for example, five microphones would be needed, creating a difficult problem of multiple microphone shadows. Furthermore, most studio scenes show only single sound sources, and thus true stereophonic sound recording would be economically unjustified.

Hence, in most cases, single sound sources are recorded in single-channel fashion. They are then distributed across the screen in a premixing step by means of a pan pot. With its help, the audio signal is routed between three or four front channels, so that their relative intensity corresponds with the apparent screen location of the visual sound

A contribution received on 11 January 1979 from Johannes Webers, Bavaria Kopierwerk GmbH, Bavariafilmplatz 7, 8022 Geiselgasteig, German Federal Republic.

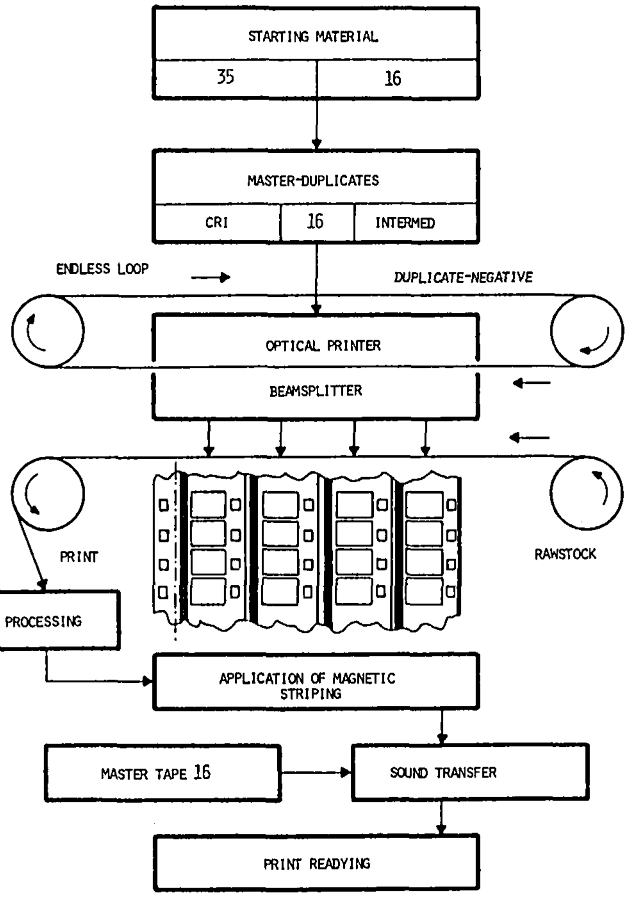

Fig. 1. Manufacturing steps for the quantity printing of super-8 reduction prints with magnetic sound.

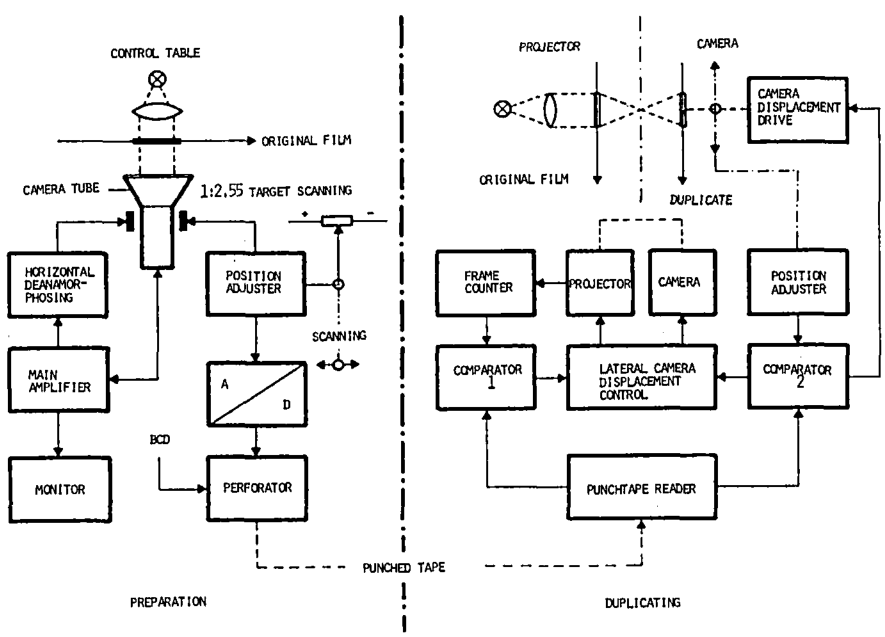

Fig. 3. Working steps for the manufacture of a deanamorphosed reduction duplicate from an anamorphic original, using image scanning.

sources. In the subsequent final mixing, all multi-channel soundtracks are then re-recorded by means of a mixing console on a final perforated magnetic master tape.

As a last step, the picture is printed first, and then the sound from the master tape is recorded on the print's magnetic stripes. For this purpose, the master tape will be recorded from a playback head or sound reader. This is best carried out by means of a film projector equipped with recording and playback heads. This facilitates recording and the simultaneous control of picture and sound synchronism.

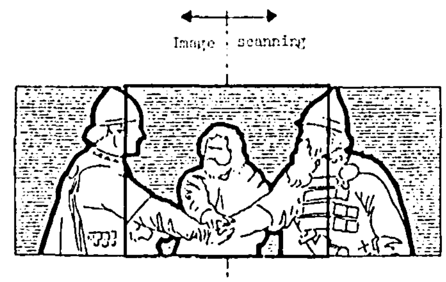

Fig. 2. Loss of image area when wide-screen originals are cropped to the normal 1:1.37 image aspect ratio.

Wide-Screen Films in the Super-8 Format

Up to present, wide-screen films with stereophonic sound only were available in the 35mm or 70mm formats. The wider use of the super-8 format led to increased offerings of programs in the small format, the original versions of which were on stereophonic 35mm or 70mm films. First we shall now discuss the customary methods for quantity printing of such super-8 films.

Figure 1 shows the quantity printing procedure for super-8 films with magnetic sound stripes. The initial 35mm or 16mm originals are first duplicated. As the master duplicate negative, either a 16mm CRI (color reversal intermediate) negative or an intermediate 16mm negative will be used. The dupe negative thus obtained is run as an endless loop through an optical printer, equipped with a beamsplitter which reproduces the 16mm negative as four identical side-by-side copies on 35mm positive stock which has four rows of super-8 perforations and a separate row of auxiliary perforations which will be discarded during print finishing. The exposed rawstock is first processed, and then the magnetic stripings are applied. Next, the audio information from the 16mm master sound tape is transferred. After the sound transfer step, the final print separation (slitting) and winding on 8mm spools takes place.

The manufacture of the dupe negatives is very expensive. It is carried out exclusively on optical printers, because only by this means can correct frame dimensions be obtained, as the frame aspect ratios of the 35, 16, and super-8mm image areas do not coincide exactly. If wide-screen films with aspect ratios of 1:1.66, 1:1.85, 1:2, 1:2.35, or as wide as 1:2.55, must be reprinted, the problems are compounded.

Because most super-8 projection lenses yield only linear magnification in both axes, the projected image will be cut off or cropped considerably on both sides if the original wide-screen ratios were 1:1.66 or 1:1.85 (Fig. 2). If the originals had been taken with an anamorphic lens, deanamorphosing of the stored image must first take place. The loss of important parts of the image area presents a problem, because at the 1:1.37 screen aspect ratio of the projected

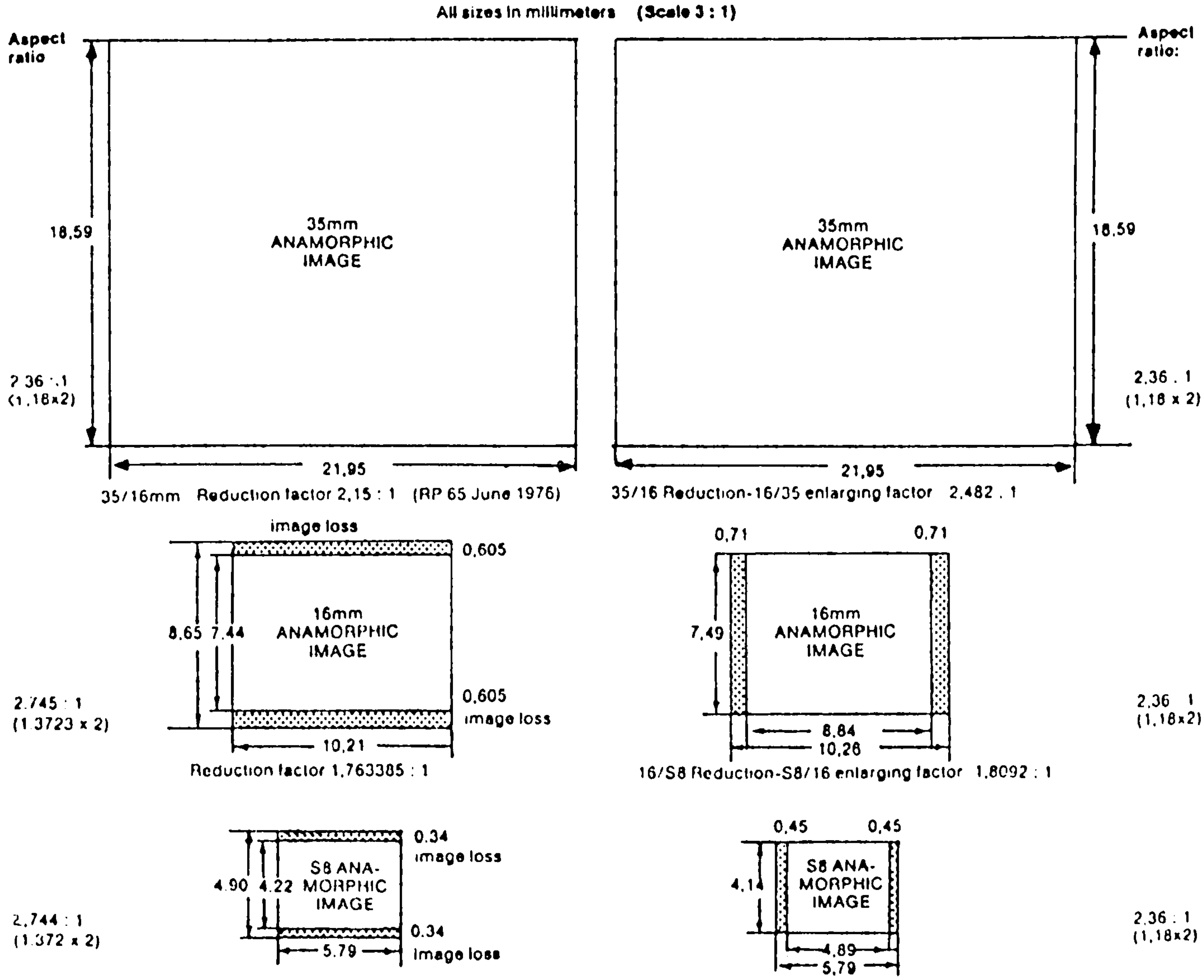

Fig. 4. Comparison of procedures for obtaining an anamorphic reduction print from an anamorphic original. Left, the customary production steps; right, the Cineavision method.

super-8 film, only about 54% of the original width remains on the screen. Thus, only by sacrificing some of the picture height can an increased image width be accommodated. An aspect ratio ranging from 1:1.66 to 1:1.85 represents, at present, the usual practice for super-8 reduction printing of anamorphic originals in order to avoid too great a loss of image information.

Image Scanning in Reduction Printing

The lateral scanning method represents a means for retaining the most important parts of the original scene. With this method, the camera aperture (that is, the optical printer camera as a whole) moves horizontally as required relative to the projected negative image in the optical printer. In this way, the image area carrying the principal action appears always within the camera aperture. The manual execution of this scanning maneuver presents great difficulties for the operator of the optical printer. Therefore, this reduction process has been improved to the point where it is now fully automatic.

With the improved system, a workprint of the original to be reduced is run through a special editing or control table (Fig. 3). Here, the picture to be scanned during reduction printing is projected on the target of a camera vidicon or plumbicon tube, the horizontal deflection of which can be decreased or increased (adjusted) according to the original film's aspect ratio — in our example 1:2.55. The electronically deanamorphosed picture appears on a control monitor with an image aspect ratio of 1:1.37 as would normally be obtained during reduction printing. By applying to the camera-tube deflection system an adjustable negative or positive bias voltage (obtained from a positioning adjuster), the electronically scanned area can be shifted laterally in the camera tube. This moves the image on the control monitor sidewise as desired so as to show on the monitor always the most important part of the scene action. The positioning adjuster yields an analog positioning signal which depends on the deviation from the desired position of the cropped image area. This signal, after passing through an analog-to-digital converter, is BCD-encoded and stored on a punched paper control tape.

A supplementary mechanical drive unit on the optical printer permits changing of the lateral position of the camera so as to rephotograph the desired image area section of the projected picture. The drive unit is activated by the program stored on the punched tape, which converts the digital information into the exact lateral true image positions of the camera. In the automatic printing mode, the optical-printer camera will stop at a certain frame number and change to the desired lateral position. Once the chosen position is reached, the printing continues automatically until the program calls for a new camera position.

Anamorphic Prints in the Super-8 Format

The best method for anamorphic super-8 wide-screen projection is, of course, to have an anamorphic expander lens on the super-8

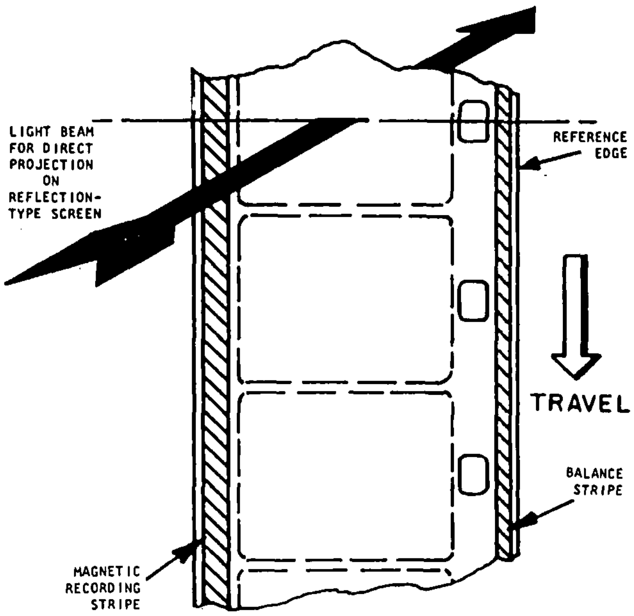

Fig. 5. The super-8 film and its magnetic sound stripe and balance stripe.

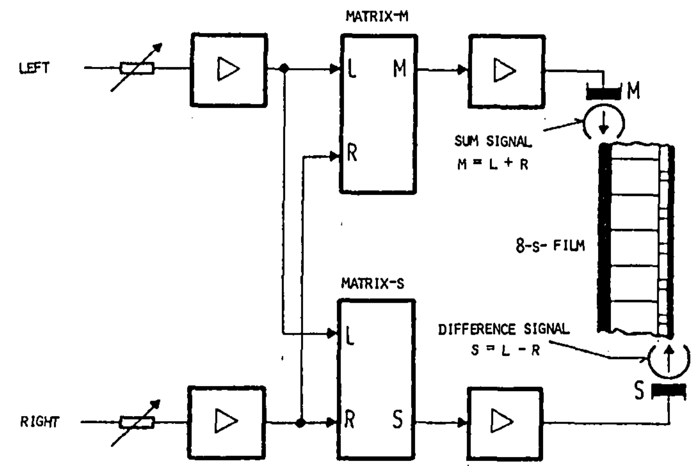

Fig. 6. Stereophonic sound recordings using the *M/S* system.

projector. This will eliminate excessive cropping in reduction printing. The image content of the 35mm original can be transferred almost completely to the duplicate negative. Starting with a classical CinemaScope-style original, the reduction printing procedure will leave on both sides of the super-8 image transparent zones which would appear white in projection. If the Cineavision system of the Animex Corporation is used, this drawback is avoided (Fig. 4). This system will create black side strips which will disappear with the use of a black screen masking.

A specially equipped optical printer is used with the Cineavision system. Here, the exact height of the original anamorphic image is transferred to a 16mm internegative, and on both sides 0.71 mm wide strips without information will then appear. By means of a special exposure matte or through an extra preexposure step, the side strips of the internegative are kept transparent so that they will appear as two dark zones on the print.

If the Cineavision procedure is not employed and the full width of the original anamorphic picture is reproduced within the super-8 aperture a loss in picture height will result in the form of two narrow strips, each 0.34 mm wide, which will be cropped off at the top and at the bottom of the image.

Stereophonic Sound Records on Super-8 Films

The widely employed super-8 film has two magnetic stripings, one for the recording of the sound and the other originally intended as a balance stripe only for proper reel winding (Fig. 5). Nowadays many projectors use the balance stripe as a second sound recording track. On account of their different widths (0.8 and 0.4 mm respectively), the two tracks are not of equal value. In consequence, for equal magnetization, the weighted and unweighted SNRs of each track will differ from one to the other. Good projectors will give 50 and 36 dB respectively for the left track, and only 46 and 32 dB respectively for the right track. (It should be noted that American National Standard PH22.161-1968, R1973 states that the balance stripe may be magnetic or nonmagnetic.)

Both these sound stripes are only infrequently used for the recording of stereo sound; instead they are used mostly for the storage of different acoustic events, for instance, one for the music and the other for speech. This permits the serious amateur who owns a synchronizable cassette recorder to carry out the mixing of the prerecorded sounds almost as professionally as in a sound studio.

As could be seen at the 1978 *photokina*, this technique has been perfected to a high degree. Already, many projectors are equipped with automatic mixing devices which depend on program cues for the mixing of sound frequency signals. This takes care of the needs of the sound film amateur.

Meanwhile, an agreement has been reached with regard to stereophonic sound recording in that the customary 0.8 mm replay track be reserved for the left channel and the 0.4 mm wide balance track be used for the right channel. This seems a rather

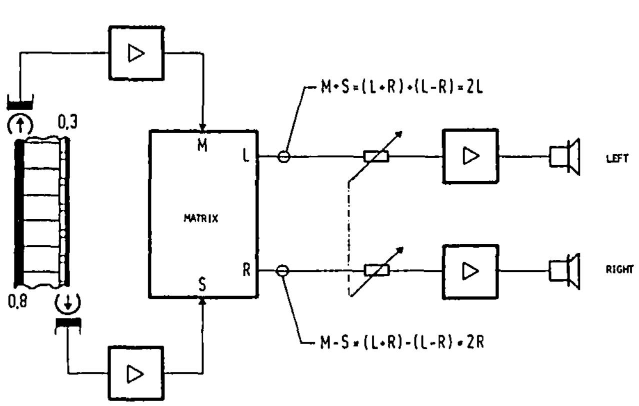

Fig. 7. Reproduction of stereophonic sound recorded with the *M/S* system.

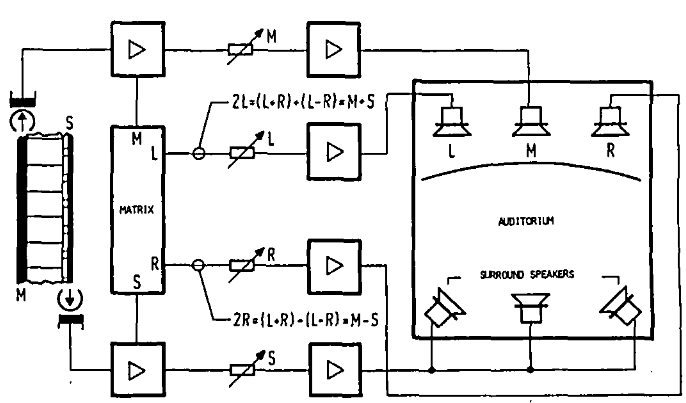

Fig. 8. Quasi-quadraphonic reproduction of the *M/S* audio signal from a super-8 film.

arbitrary agreement. In this author's opinion, this arrangement does not make much sense because the electroacoustic transfer conditions are, perforce, quite different in both channels.

If it is planned to offer high quality stereo programs on super-8 films, exploiting for the purpose first class stereophonic wide-screen films, the use of two soundtracks of equal value is a precondition. An additional problem is given by the fact that it would not be worthwhile for the distributor or retail outlet to have in stock a monophonic version in addition to the stereophonic one.

Therefore, stereophonic super-8 films should be compatible with the monophonic replay (Fig. 6). This is already a condition customarily in use for stereo disks and stereo broadcasting. In practice, this means that the stereophonic signals for left (L) and right (R) must be converted, before actually recording on the super-8 film, into a sum (or center) signal (M), known as ($M = L + R$), and a difference (or side) signal (S), known as ($S = L - R$). In this way, no information will be lost if the film is played on a monophonic projector.

The original stereo signals (L) and (R) will be recovered in stereophonic replay (Fig. 7) by using the relations

$$M + S = (L + R) + (L - R) = 2L$$
$$M - S = (L + R) - (L - R) = 2R$$

In other words, in analogy to stereo broadcasting, a monophonic sum information record (M) can be stored on the 0.8 mm main track of the super-8 film, and on the 0.4 mm balance track the side-to-side difference information (S) is stored. Defects in the balance stripe will then only influence the space information output.

Pursuing this principle further, it is possible to arrive at a quasi-quadraphonic reproduction system (Fig. 8). For this purpose, the (M) and (S) signals are decoded for the left (L) and right (R) speakers as described above. For the center speaker (M) a special amplifier branch will be used, fed directly by the (M) signal. The surround speakers must be fed by a fourth amplifier channel, using as their input the difference or side signal (S) from the balance stripe. Each of the four separate reproduction channels needs a separate fader for volume control. When properly adjusted, this arrangement yields astonishing stereo effects.

If one intends to obtain a two-channel master sound tape for the manufacture of

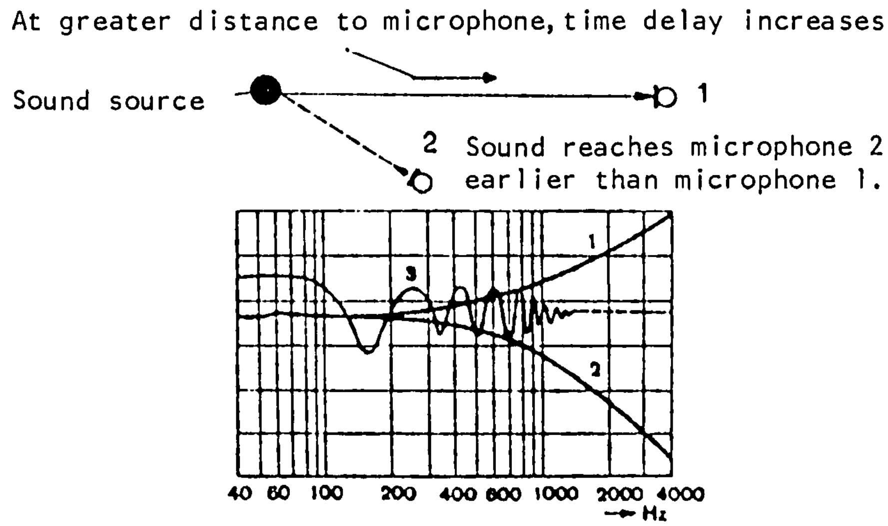

Fig. 9. Appearance of linear distortion when combining stereo signals.

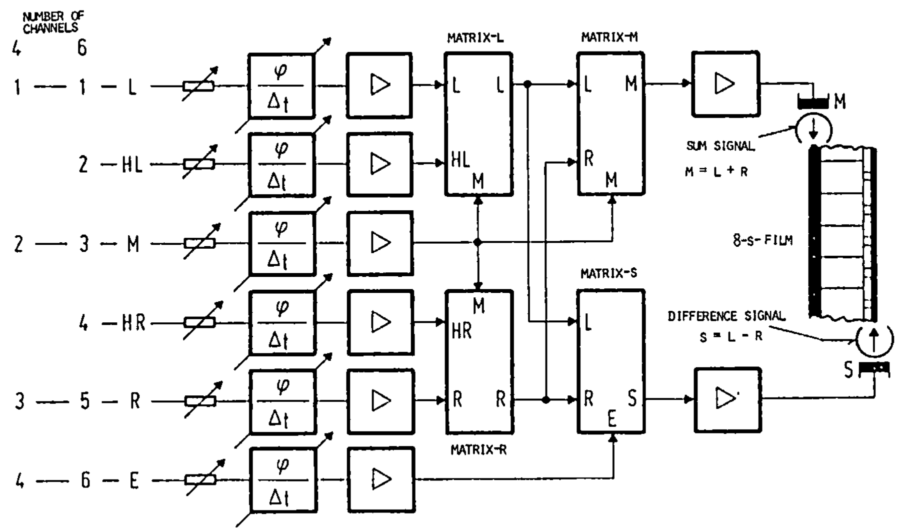

Fig. 10. Mixing of multi-channel stereo signals for sound recording on super-8 film.

stereophonic super-8 prints, an assembly of the original four- or six-channel master recordings must first be made. Stereo signals, however, often contain information that depends on time delay or time lag. Thus, depending on the phase relation, disturbing changes in output volume may occur during their mixing (Fig. 9). Simple omnibus circuits will seldom give proper results.

The principle shown in Fig. 10 has proven to be advantageous. In this arrangement, each channel incorporates a phase rotating or time delay device. The acoustic effect of the final mix is then evaluated by the sound engineer, and the tonal quality can be optimized by compensating critical phase conditions. Further mixing into right and left signals is carried out over corresponding matrix circuits which convert the input signals as already described into center and side output signals.

Conclusion

Several methods for the manufacture in quantities of super-8 prints have been described. It has been demonstrated that useful methods are now available for obtaining anamorphic super-8 prints with stereophonic sound.