June 24, 1969 D. HAFLER 3,452,161

STEREO SOUND RECORDING ON SUPER-8 MOTION PICTURE FILM

Filed Oct. 4, 1965 Sheet 1 of 2

FIG. 1

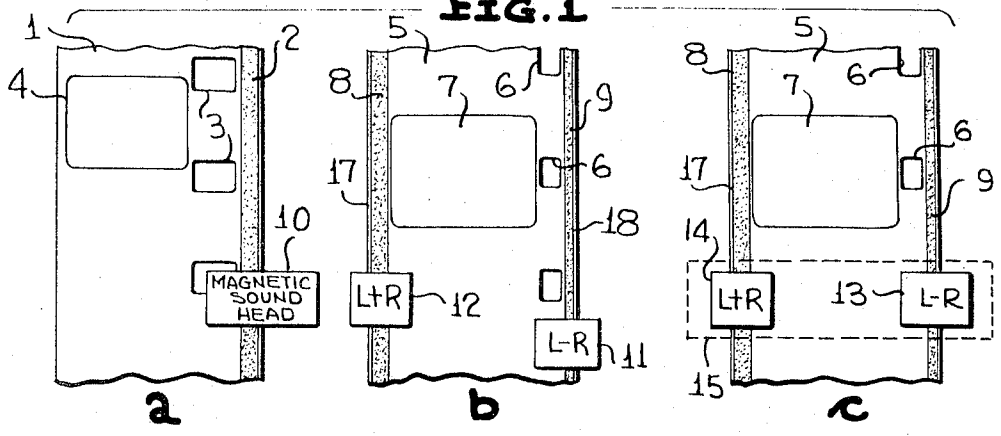
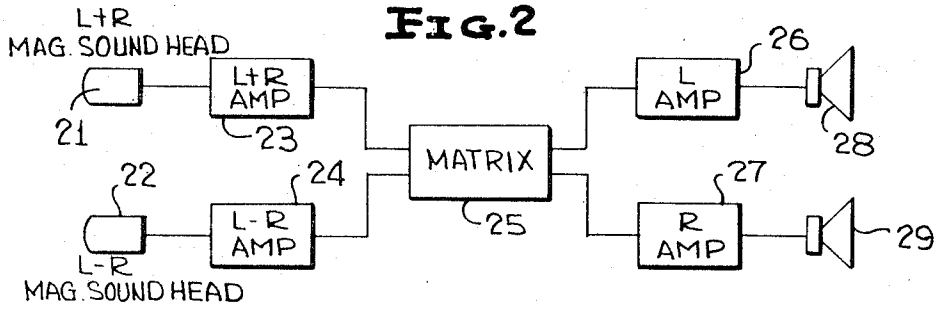


FIG. 2



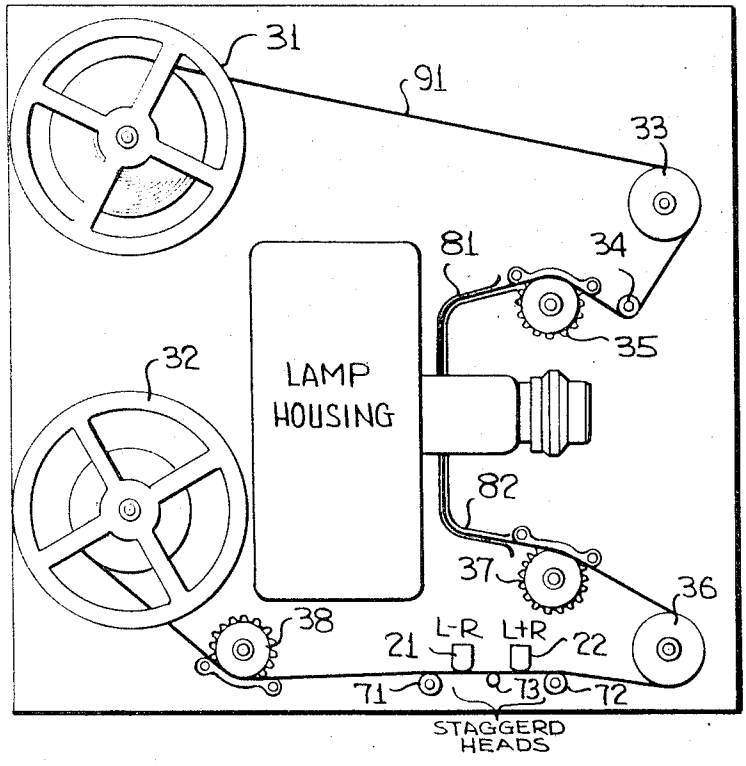


FIG. 3

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FIG. 4

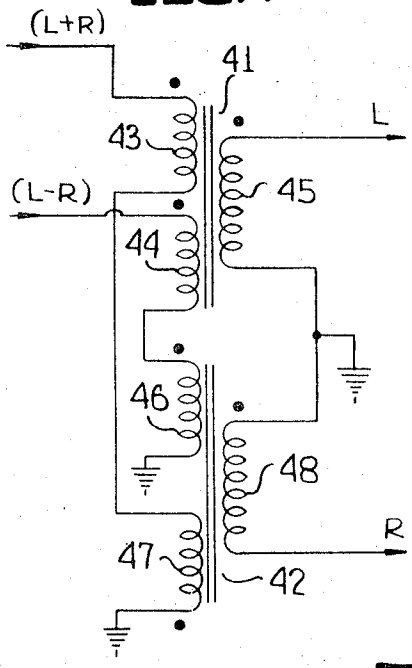


FIG. 6

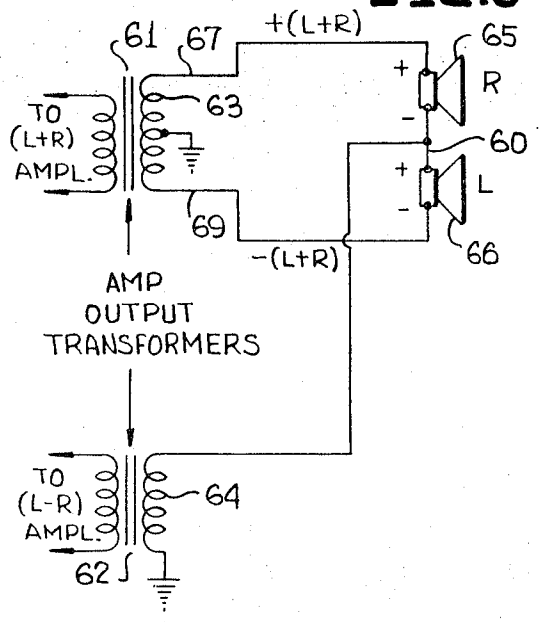


FIG. 5

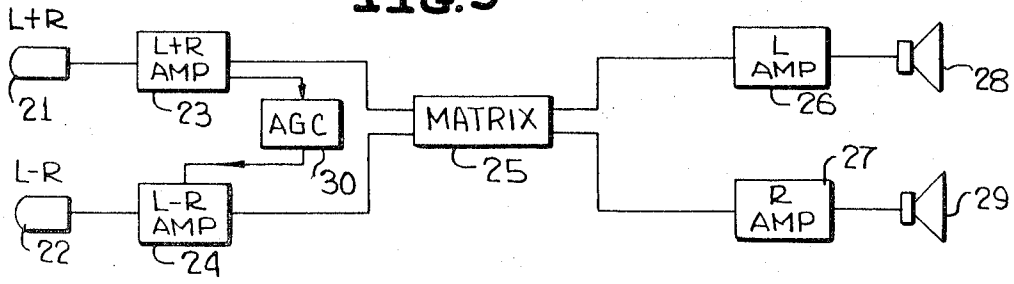
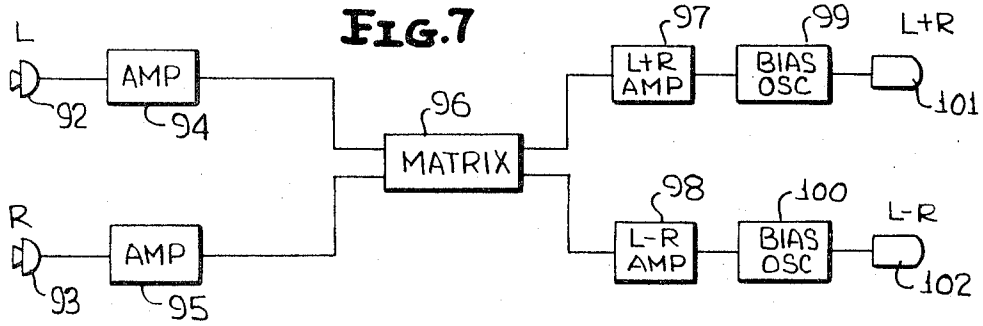


FIG. 7



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STEREO SOUND RECORDING ON SUPER-8 MOTION PICTURE FILM

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ABSTRACT OF THE DISCLOSURE

A stereophonic sound system employing Super-8 film. Such film includes a poor quality magnetic track intended solely for mechanical balancing required because of the presence of a high quality track. The high quality track is employed for L+R stereophonic signal, and the low quality track for the L—R signal, thus utilizing a track which would otherwise be unused.

The present invention relates generally to sound recording, and more particularly, to stereophonic sound systems for use with motion picture equipment.

Motion picture equipment, i.e., cameras and projectors, designed for the amateur, normally utilize a relatively small width film strip of either 8 mm. or 16 mm. size; the 8 mm. width being, by far, the most popular and most widely used for home movies. Because of the relatively small size of such film, the introduction of a sound recording medium thereon has generally presented certain design problems in providing the necessary sound track width in the limited space available.

Motion picture film of 8 mm. width, having a single magnetic sound track, is presently commercially available, and such film has a single track of magnetic material, generally composed of a magnetizable oxide, disposed between one edge of the film and the sprocket holes located therein. Such film has only sufficient space for said one sound track and the modification of such film to provide a second track for stereophonic sound reproduction would ordinarily pose extremely severe design problems.

Recently, a somewhat different format has become commercially available in 8 mm. motion picture film. Such film, and associated equipment for use therewith, has been sponsored by the Eastman Kodak Company and is termed "Super-8." This motion picture film is characterized, inter alia, in that the area of each frame, for visual presentation, is greater than that of the conventional 8 mm. film. Also, the orientation and size of the sprocket holes has been changed to provide a greater amount of usable width. Further, and most significant for the purposes of the present invention, a sound reproduction medium comprising a magnetic stripe is provided along one edge of the film; however, in this case, the magnetic stripe is disposed between the film edge and the visual frame, instead of between the opposite film edge and the sprocket holes. By so locating the sound track adjacent the edge of the film opposite the sprocket holes, it is then required to provide the film with mechanical balance for winding purposes. This is conveniently accomplished by coating a second stripe of material, similar to that used for the sound track, along the edge of the film adjacent the sprocket holes in the very narrow space there provided. The balance stripe width may be anywhere from approximately 20 to 65 percent of the width of the sound track and is coated generally in an inferior manner with respect thereto, so as not to be generally considered usable for satisfactory sound reproduction; the sole purpose of such stripe being for winding balance.

In accordance with the present invention, it has been discovered that both the normal sound track and the balance stripe found in the Super-8 format are capable of being used to achieve high fidelity stereophonic sound reproduction, heretofore not considered feasible, since even the Super-8 format has insufficient space to accommodate the two regular width sound tracks normally expected to be necessary.

The present invention provides a sound recording and reproduction system whereby the two signal channels required for stereophonic sound recording, i.e. the left and right channels, are so combined such that a first signal, representing the sum of the left and right channel signals, is recorded on the sound stripe of normal width and a second signal, representing the difference between the left and right channel signals, is recorded on the narrow stripe. Magnetic pickups are provided for each respective stripe whereby the separate sum and difference signals are amplified. After being amplified, each of the sum and difference signals are fed to a matrix arrangement which decomposes the sum and difference signals into the left and right channel components. Of course, the left and right channel components might, alternatively, be separated by a simplexing technique or any other technique known to the art. The left and right channels, after being optionally amplified, feed electroacoustic translating means, such as loudspeakers, spaced so as to provide the desired stereophonic effect.

The system of the present invention produces sound reproduction of high-fidelity quality, while achieving a stereophonic effect with a recording medium generally considered insufficient for this purpose.

In addition, the system, in accordance with the present invention, retains compatibility with monaural systems of the conventional type.

The recorded sum signal provides the signal components necessary for high fidelity reproduction, while the difference signal, even though recorded on an extremely poor reproduction medium, supplies the components essential for good stereophonic effect. The narrow balance stripe, when used for magnetic recording, is generally characterized by a limited and narrow range of frequency response and a low signal to noise ratio which renders a rather degraded quality of sound reproduction.

However, it is generally found that the low frequency acoustic wave components are relatively nondirectional. Further, these components of the left and right channel signals normally have amplitudes which are approximately equal. Thus, typically the difference signal of (L—R), at low frequencies, will have relatively small amplitudes as compared with the sum signal of (L+R), and some loss thereof in reproduction will not materially affect the fidelity, which will then depend almost entirely on the quality of the sum channel signal.

At the other end of the acoustical frequency spectrum, it is generally found that at frequencies above about 10,000 cycles, the wavelength of the sound is about equal to or less than the inter-ear spacing of the average listener and thus, at these frequencies, the location of the source becomes not readily ascertainable. Therefore, the loss of these high frequency components can also be tolerated, if this loss occurs only in the difference channels. Thus, the low and the high frequency components are not materially significant with respect to the subjective stereophonic effect on the listener.

The fidelity of the recording and reproduction is retained by the sum channel signal which is recorded on the normal sound track of the film and which supplies a left and right channel signal of good quality, including those frequency components which might be lost in the difference channel.

Because of the above-stated limitations of the difference channel, electrical components which have re-

stricted bandwidths and lower power ratings, as compared with those in the sum channel, can easily be accommodated, providing considerable economies in the system.

The use of the sum and difference channel technique additionally provides monaural compatibility, since the sum channel signal contains all of the components required for single channel high fidelity reproduction. Thus, the present invention is capable of use with either monaural or stereophonic motion picture equipment designed for the Super-8 format. In addition, the stereophonic sound system, in accordance with the present invention, is capable of use with dual motion picture equipment designed to be used with either the conventional 8 mm. or Super-8 film, as will hereafter be discussed.

A further feature, in accordance with the present invention, is the provision for dynamic expansion or contraction of the L—R channel. This feature provides greater enhancement of the fidelity of reproduction and comprises means for diminishing, or eliminating completely, the L—R signal whenever the L+R signal is at a relatively low amplitude level. When the L+R signal is at a relatively high, or normal level, the L—R signal is maintained at its normal level. In this manner, the effects of the inferior signal-to-noise ratio of the L—R channel can be diminished. Thus, for low level signals, the (L—R) signal would disappear, producing no stereo effect, but providing the system with an improved signal-to-noise ratio. The lack of stereophonic separation does not represent a serious disadvantage in this instance because it does not appear to be important at low signal levels.

Still another feature, in accordance with the present invention, is the provision of a matrix system for decomposing, or separating the sum and difference signals into the left and right channels, wherein the loudspeakers are brought into, and made directly a part of the system resulting in the elimination of the additional transformers normally employed in conventional matrix arrangements and thus, producing even greater economies in the system.

Accordingly, it is an object of the present invention to achieve stereophonic sound reproduction utilizing the limited recording medium characteristic of amateur motion picture film.

It is another object of the present invention to utilize a motion picture film having magnetic stripes of unequal width for compatible stereophonic sound reproduction.

It is a further object of the present invention to provide a system whereby the sum and difference of two stereophonic sound signals are recorded and reproduced on separate sound tracks of different widths.

It is still another object of the present invention to utilize the magnetic balance stripe on motion picture film for sound reproduction in a high fidelity stereophonic sound system, not heretofore achieved.

Still another object of the present invention is to provide a sound motion picture system which is compatible for monaural and stereophonic sound reproduction in addition to being capable of use with motion picture equipment designed for use with 8 mm. motion picture film having either the conventional or Super-8 format.

Still a further object of the present invention is to provide a reliable, compatible stereophonic sound recording system capable of high fidelity reproduction and being economical to manufacture.

The above and still further objects, features and advantages of the present invention will become apparent upon consideration of the following detailed description of several specific embodiments thereof, especially when taken in conjunction with the accompanying drawings, wherein:

FIGURE 1 shows the various motion picture film formats and pickup head locations in accordance with the present invention;

FIGURE 2 illustrates, in block diagram form, a sound system in accordance with one embodiment of the present invention;

FIGURE 3 illustrates the general environment of the present invention;

FIGURE 4 illustrates one example of a matrix arrangement usable in the present invention;

FIGURE 5 illustrates, in block diagram form, a sound system in accordance with a second embodiment of the present invention;

FIGURE 6 illustrates a second matrix arrangement in accordance with another embodiment of the invention; and

FIGURE 7 illustrates the block diagram of a general recording system in accordance with the present invention.

Referring now to FIGURE 1, there is shown a comparison of the conventional 8 mm. film format with that of the Super 8 and the arrangement of sound pickup heads in relation thereto. The conventional 8 mm. film is shown in FIGURE 1(*a*) having a total width of nominally 0.315 inch. A magnetic stripe **2** of about 0.03 inch is coated on the film base **1** between edge **16** and sprocket holes **3**. The conventional motion picture sound system provides a certain lag between the visual information of a particular frame and the corresponding sound portion on the magnetic stripe. The magnetic sound head **10**, which may be of any conventional type, is thus located at a certain predetermined distance along the transport path from the projector (or camera) aperture.

FIGURES 1(*b*) and 1(*c*) show the format of the Super 8 film which has the same nominal width as the conventional type. Each frame **7**, for presenting the visual information, has a larger area than the frame **4** of the conventional film, the sprocket holes being reoriented in order to provide more usable width. The sound track **8**, corresponding to sound track **2** of FIGURE 1(*a*), is shown relocated on the opposite side of the film between film edge **17** and the frame **7**, where edge **18** of the Super 8 format corresponds to edge **16** of the conventional format. A space of about 0.020 inch remains between the sprocket holes **6** and the edge **18**. Because the magnetic sound stripe **8** is located at a relatively large distance from the sprocket holes rather than, as heretofore, being adjacent thereto, an additional stripe may be applied in the aforementioned space between the holes **6** and the edge **18** to mechanically balance the film and to provide uniform winding. The balance stripe **9** is deposited for this reason, and primarily for manufacturing convenience consists essentially of the magnetic oxide material of which the sound track **8** is composed. However, the width of the stripe **9** may range from only 0.006 to 0.018 inch and the care with which application is made is generally less than that for the normal sound track **8**. Consequently, if the balance stripe **9** is used as a recording medium, the sound reproduction will be of a degraded nature having a relatively low signal-to-noise ratio. However, by using the balance stripe **9** in conjunction with the sound track **8** in the system of the present invention, high fidelity sound reproduction may be achieved in addition to providing a stereophonic effect for the reasons previously stated.

Referring to FIGURE 1(*c*), a signal which contains the sum of the Left and Right channel signals is recorded on the regular magnetic sound track **8**, while another signal which contains the difference between the Left and Right channel signals is recorded on the narrow balance stripe **9**.

Magnetic pickup heads **13** and **14** are located adjacent each respective stripe and at a given predetermined distance along the transport path from the aperture, corresponding to the amount of lag required. The motion picture equipment designed to utilize the Super 8 format requires a shorter lag than the equipment designed for use with the conventional sound film of FIGURE 1(*a*), and thus the heads **13** and **14** are illustrated as being in a relatively higher position, assuming the film is to move toward the bottom of the figure.

Alternatively, instead of two separate pickup heads, a single head **15** with two in-line magnetic gaps might be used. This, of course, simplifies the construction of the

unit and also the adjustment of the required lag for each stripe.

FIGURE 1(*b*) shows a modification of the arrangement of FIGURE 1(*c*) which adapts the system of the invention to a dual projector capable of handling either of the two aforementioned film formats. A first magnetic pickup **11** is provided and arranged so as to respond to the sound track of the conventional 8 mm. film of FIGURE 1(*a*) with the proper lag between the visual and audio information therefor. A second magnetic pickup **12** is provided opposite the first head and in staggered relation thereto in order to respond to the sound track of the Super 8 film which has a shorter lag and is disposed on the opposite edge of the film. Now, by utilizing the head **12**, normally associated with the Super 8 format, for the sum signal and the head **11**, normally associated with the conventional format, for the difference signal recorded on the narrow or balance stripe of the Super-8 format, a dual projector of the type described may be incorporated into the system of the invention. Of course, it is required that a suitable lag and stagger be used in the recording arrangement for each stripe. Generally, an adjustment of the heads would be necessary in order to bring about the proper relative stagger.

A sound system, in accordance with the present invention, is shown in FIGURE 2 comprising magnetic pickup heads **21** and **22**, each responsive to the (L+R) and (L—R) stripes, respectively. Each head is electrically connected to an audio amplifier, the outputs of which are fed to a matrix **25**. The function of the matrix is to separate the sum and difference input signals and provide Left and Right channel outputs which are amplified by amplifiers **26** and **27**. Various simplexing circuits might also be used to perform the same function and the particular circuits disclosed are not to be considered in a limiting sense. The output signals from the Left channel and Right channel amplifiers are each fed to the loudspeakers **28** and **29** which are arranged to provide a stereophonic separation.

The amplifiers **23**, **24**, **26** and **27** may be of any conventional type, however, since the (L—R) signal has a narrower bandwidth requirement, amplifier **24** may have a correspondingly narrower bandwidth and a lower power rating.

The matrix **25** may comprise any of the arrangements known in the art, an example being that shown in FIGURE 4. The particular prior art circuit of FIGURE 4 is merely included as exemplary in the description of the system of the present invention and is shown to comprise two transformers **41** and **42**, each having double primary windings **43**, **44**, **46** and **47** and single secondary windings **45** and **48**. The primary windings **43** and **44** of transformer **41** are both wound with the same sense, while the primary windings of transformer **42** are wound with opposite senses. The secondary windings **45** and **48** are connected in series and a ground connection is provided therebetween. Then, if the (L+R) signal is applied to winding **43** and the (L—R) signal is applied to winding **44**, the output of the transformers will provide separate signals proportional to the Left and Right components of the sum and difference inputs.

FIGURE 7 shows a simple exemplary system for recording the appropriate signals on the motion picture film. Left and Right stereophonic channel microphones **92** and **93**, respectively, receive the program material to be recorded, which is amplified by amplifiers **94** and **95**. The outputs of these amplifiers are fed to a matrix **96**, which may be similar to that used in the system of FIGURE 2, and which, in turn, feeds the separate sum and difference amplifiers **97** and **98**. Recording bias is provided by the bias oscillators **99** and **100** which is applied to the amplifier outputs. Each signal is then fed to the magnetic recording heads **101** and **102**, which, of course, may be two in-line gaps of a single head, if desired.

The recording system may be located at the camera site and/or at the site of projection for program recording, correction and narration. In this respect, means for magnetic erasure may additionally be provided as is well known in the art.

FIGURE 3 shows a motion picture projector incorporating the features of the present invention and is merely intended to illustrate one example thereof. Film **91**, which is wound on reel **31** is threaded over guide rollers **33** and **34**, and over sprocket wheel **35**, through loop formers **81** and **82**, and over sprocket wheel **37**. The film then runs on guide rollers **36** and **72** over the magnetic pickup heads **21** and **22**, on roller **71** and over sprocket wheel **38**. The film is then taken up on reel **32**. The rollers **71** and **72**, together with the guidepost **73** retain the magnetic stripes against the heads with the proper pressure by means well known in the magnetic recording art.

The heads **21** and **22** are illustrated in the aforementioned staggered arrangement shown in FIGURE 1(*b*). Head **22** is positioned to respond to the (L+R) signal recorded on the wide magnetic stripe and head **21** is positioned to respond to the (L—R) signal recorded on the narrow magnetic stripe. The relative distances of each head from the projection aperture must correspond to the relative distances of the respective magnetic heads of the recording device so that the same head displacement exists for recording and playback.

FIGURE 5 shows another embodiment in accordance with the present invention. The system shown in FIGURE 5 is similar to that shown in FIGURE 2, like elements being identified by the same numerals, however, the system of FIGURE 5 includes the further feature of dynamic expansion and contraction of the (L—R) signal for the reasons aforesaid. This is accomplished, for example, by utilizing an automatic gain control circuit (AGC) **30**, of any well known construction which, in response to a decrease in the amplitude of the (L+R) amplifier **23** output, produces a signal which reduces the gain of the (L—R) amplifier **24**. Further, the amplifier **24** may be biased such that it is completely cutoff when the output of amplifier **23** is below a predetermined level. In this manner, the effect of the low signal-to-noise ratio of the (L—R) signal is substantially reduced, resulting in an improvement in the signal-to-noise ratio for the overall system.

FIGURE 6 shows a further embodiment in accordance with the present invention wherein transformers **51** and **62** represent the output transformers of the (L+R) and (L—R) amplifiers, respectively. The secondary winding **63** of transformer **61** has a centertap therein which is electrically connected to a reference potential, for example, ground, as shown in the figure. Lead **67** from the secondary **63** is connected to loudspeaker **65**, which, in turn, is connected in series with loudspeaker **66** and the secondary **63** through leads **60** and **69**. The secondary **64** of transformer **62** has one end connected to ground and the other end connected to lead **60** interposed between the two speakers **65** and **66**. In this manner, lead **67** carries a signal of +(L+R); lead **69** carries a signal of —(L+R); and winding **64** carries a signal of —(L—R). Thus, by algebraically combining the signals, it is easily seen that speaker **65** receives only the Right channel signal and speaker **66** receives only the Left channel signal.

The need for the additional matrix transformers **41** and **42**, as shown in the circuit of FIGURE 4, is thus eliminated and the matrix is achieved by merely incorporating the two speakers into proper circuit arrangement with a centertapped output transformer of the sum channel amplifier. This results in a final unit construction which has the advantages of being extremely compact, relatively easy to assemble, and relatively economical to manufatcure, while still maintaining compatible stereophonic high fidelity reproduction.

Thus, there has been described a novel system for providing stereophonic sound recording on narrow width mo-

tion picture film having two magnetic stripes, one of which has a narrow width as compared to the other. The system also provides for monaural sound recording and reproduction, and may be incorporated in motion picture equipment designed to accommodate both Super 8 and conventional 8 mm. formats.

Although it has been suggested that the difference signal be recorded on the balance stripe of Super 8 motion picture film, it is also contemplated that a stripe of similar width might be coated on other motion picture film in the corresponding location, but provided in such a manner as would augment the recording qualities thereof and also function to provide balance.

While I have described and illustrated several specific embodiments of my invention, it will be clear that variation of the details of construction which are specifically illustrated and described may be resorted to without departing from the true spirit and scope of the invention as defined in the appended claims.

I claim:

1. A compatible stereophonic sound system for motion pictures utilizing a photographic motion picture film having relatively wide and narrow magnetic strips disposed along the length thereof, said film including sprocket holes adjacent one edge thereof, and wherein the relatively wide magnetic stripe is disposed along the opposite edge of said film and wherein said relatively narrow magnetic stripe is 20–65% as wide as said relatively wide magnetic stripe and is provided solely for mechanical balance of said film for winding purposes and is of inadequate quality for normal sound recording and reproduction and is located intermediate said sprocket holes and said one edge of said film, comprising: first means magnetically responsive to a first signal recorded on the wide stripe of said film, said first signal comprising the sum of a first and a second stereophonic signal, second means magnetically responsive to a second signal recorded on the narrow stripe of said film, said second signal comprising the difference between said first and second stereophonic signals; and means responsive to said sum and difference signals for conversion to said first and second stereophonic signals therefrom.

2. The system of claim 1 wherein said first means comprises a first magnetic pickup head spaced so as to define one lateral side of a film transport path, and said second means comprising a second magnetic pickup head spaced so as to define the opposite lateral side of said film transport path.

3. The system of claim 2 wherein said first and second magnetic pickup heads are directly oppositely disposed along the lateral direction of said film transport path.

4. The system according to claim 1 wherein said means responsive to said sum and difference signals comprises a matrix having two outputs, each output corresponding to one of said two stereophonic signals, and means responsive to each of said stereophonic signals comprising an electroacoustic translator.

5. The system according to claim 1 wherein said means responsive to said sum and difference signals comprises amplifier means; said amplifier means comprising transformer means having a centertapped secondary winding for providing said sum signal with one and opposite polarity; two loudspeaker means serially connected in circuit relation with said winding and having a connection therebetween; means applying said difference signal between the connection of the two series connected loudspeaker means and said centertap whereby said difference signal is combined with said sum signal of one and opposite polarity to produce an input of said first stereophonic signal to one loudspeaker means and said second stereophonic signal to the other loudspeaker means.

6. A compatible stereophonic sound system for motion pictures utilizing a motion picture film having relatively wide and narrow magnetic stripes disposed along the length thereof, said narrow stripe being of insufficient width to provide high fidelity sound reproduction, said film including sprocket holes adjacent one edge thereof, and wherein the relatively wide magnetic stripe is disposed along the opposite edge of said film and wherein said relatively narrow magnetic stripe is 20–65% as wide as said relatively wide magnetic stripe and is provided solely for mechanical balance of said film for winding purposes and is of inadequate quality for normal sound recording and reproduction and is located intermediate said sprocket holes and said one edge of said film, said system comprising first means magnetically responsive to a sum signal recorded on the wide stripe of said film, said sum signal comprising the sum of a first and a second stereophonic signal; second means magnetically responsive to a difference signal recorded on the narrow stripe of said film, said difference signal comprising the difference between said first and second stereophonic signals, means responsive to the amplitude of said sum signal for diminishing the amplitude of said difference signal whenever the amplitude of said sum signal is lower than a predetermined value; and means responsive to said sum and difference signals for decomposition into said first and second stereophonic signals.

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U.S. Cl. X.R.

179—1; 352—37