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(54) REPRODUCING OPTICAL RECORDINGS

(71) We, PHILIPS ELECTRONIC AND ASSOCIATED INDUSTRIES LIMITED, of Abacus House, 33 Gutter Lane, London, E.C.2, a British Company, do hereby delcare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The invention relates to an apparatus for reading a record carrier which record carrier contains a signal, recorded in optically coded form, which is read with the aid of a beam of optical radiation and light-sensitive detector, and which recorded signal comprises a combined video signal comprising a first signal component which consists of a first carrier wave which is modulated with the luminance information, and at least a second signal component which contains sound information as a modulation of a second carrier wave.

Consequently, the invention concerns the reading of record carriers on which the luminance information, normally provided with synchronizing signals, the sound information and, as the case may be, chrominance information are stored in a single common track, in particular in an optically coded manner. In this respect, first of all a disc-shaped record carrier is considered as for example proposed in Patent Specification No. 1,391,541, in which carrier the information is recorded in relief, i.e. in a sequence of recesses and intermediate areas. When such a structure is read with the aid of a beam of optical radiation and a single radiation detector, a signal is obtained which consists of a certain d.c. component, which corresponds to the average radiation level, and an a.c. component superimposed thereon, which component contains the information which is read from the record carrier.

During said reading operation problems occur owing to irregularities in the structure of the record carrier. Said irregularities may for example consist in the absence of one or more of the said recesses or the presence of inhomogeneities in the carrier, such as air bubbles etc. Said irregularities in the record carrier, and also disturbances in reading said record carrier, give rise to signal deviations in the signal which is supplied by the radiation detector, which signal may even become nil if the beam of radiation is interrupted completely. All these signal disturbances will be referred to as "dropouts" hereinafter.

In order to reduce the effect of said dropouts on the image eventually reproduced a multitude of compensation circuits are known. Said known compensation circuits are generally based on the fact that a television picture has a line-frequency structure and that the content of said television picture differs little from line to line. By delaying the luminance and/or chrominance signal by one line time it is therefore possible to utilize the signal that has been delayed by one line time instead of the disturbed signal during the occurrence of a dropout in the detected video signal so that the effect of said dropout on the reproduced image is reduced to a reasonable extent.

However, said method cannot be used for the sound information, because said sound information does not have said line-frequency structure. Consequently, dropouts remain very disturbing in the reproduced sound signal.

Therefore, it is an object of the invention to mitigate the effect of dropouts on the reproduced sound signal in a particularly simple manner. For this, the invention provides apparatus for reading a record carrier on which a combined video signal is recorded, in which record carrier the video signal is recorded in optically coded form, which apparatus comprises means for producing a beam of optical radiation, and a radiation sensitive read detector, which read detector produces an output which, during reading, comprises a first signal

component which consists of a first carrier wave which is modulated with the luminance information, and at least a second signal component which consists of a second carrier wave modulated with sound information, characterized in that the apparatus is provided with a dropout detector for the detection of dropouts in at least said first signal component and with a clamping circuit having a signal input connected to receive at least the second signal component, a signal output and a control input, which clamping circuit at its control input receives a control signal from the dropout detector and which as a function of said control signal, in the absence of a dropout, transfers the signal applied to the clamping circuit signal input unmodified to the signal output and during the occurrence of a dropout clamps said signal output at a fixed d.c. signal value which corresponds to the average value of the signal which is applied to the clamping circuit signal input.

The invention does not provide complete compensation of dropouts, but it has been found that the energy content of a signal disturbance which occurs in the time interval of a dropout is reduced in such a way that the disturbance which occurs in the eventually reproduced sound signal remains within acceptable limits.

Preferably, all of the combined video signal is subjected to the action of the clamping circuit. This preferred embodiment compared with all other embodiments that are possible, has the advantage that the time during which the clamping circuit should be active during the occurrence of a dropout is minimal. Because the second signal component, which contains the sound information, generally covers a frequency band below the frequency band which is occupied by the first signal component, it is necessary to employ low-pass filters or band-pass filters for extracting said second signal component. However, owing to the use of this type of filter a dropout of a certain duration in the combined video signal will appear as a dropout of a longer duration in the extracted second signal component. The extent to which said duration is prolonged naturally depends on the filters used.

Therefore, if only the extracted second signal component is subjected to the action of the clamping circuit, said clamping circuit in the event of a dropout will have to clamp its signal output at said fixed signal value for a time which is longer than the duration of the original dropout. Although this is still acceptable in most cases, it will be obvious that it is more favourable when the time during which the clamping circuit clamps the signal which is subject to its action at a fixed signal value during the occurrence of a dropout is minimal. This is achieved by subjecting all of the combined video signal to the action of said clamping circuit, because said video signal has not yet been subjected to a filter action and the duration of the signal disturbances caused by the dropouts has not yet been extended.

For the detection of the dropouts the complete combined video signal may be applied to the dropout detector. The operation of said dropout detector is irrelevant for the principle of the invention. In principle, any suitable known dropout detector may be employed. However, since the invention does not compensate for dropouts, but reduces their influence on the eventually reproduced sound signal, there will generally be little need to detect comparatively small dropouts. therefore, the dropout detector may conventionally be of a type which only detects large dropouts, for example a so-called peak detector which detects the time intervals during which the applied signal exceeds a certain preset amplitude margin. In that case it may be useful to apply not the complete combined video signal, but the extracted first signal component to the dropout detector. Said first signal component generally consists of a frequency modulated first carrier wave and then has an essentially constant amplitude. It is therefore possible to determine the amplitude limit for the dropout detector which functions as a peak detector fairly accurately, so that an effective dropout detection is obtained.

Embodiments of the invention will now be described, by way of example, with reference to the accompanying drawings, in which:—

Fig. 1 shows a first embodiment,

Fig. 2 shows some waveforms for illustration purposes,

Fig. 3, by way of illustration, shows an example of a frequency spectrum of a combined video signal,

Fig. 4 shows a second embodiment, and

Fig. 5 shows a clamping circuit.

The embodiment shown in Fig. 1 comprises a read unit 1 for the combined video signal. The optical read system is represented by a radiation-sensitive diode 2. As the construction and operation of the read system are not essential for the principle of the invention said read system is only shown schematically. At the output terminal 3 of the read unit 1, which terminal is also the input terminal for the following signal processing circuit, the combined video signal V is consequently available.

Said combined video signal V by way of example may be as shown in Fig. 2*a* and

have a frequency spectrum as shown in Fig. 3. As is indicated in Fig. 3 the luminance information is frequency modulated on a first carrier wave, so that the luminance information covers the frequency band E_y. It is assumed that the modulated first carrier wave has a frequency sweep which extends from 5.2 MHz, which corresponds to a maximum black, to 6.5 MHz which corresponds to maximum white (shaded area). As for a correct signal transmission at least the first lower side band should be included, the spectrum of the luminance information E_y extends down to 2.5 MHz at the lower frequency end for a luminance bandwidth of 2.7 MHz.

The chrominance information of the colour television signal is contained in a frequency band E_c below the frequency band E_y, namely as a modulation of a carrier wave f_c. This may be achieved in known manner by transposing the chrominance signal present in the standard colour television signal to a lower frequency by mixing it with a suitable mixing frequency. In the Figure the frequency of 1.5 MHz is selected for the carrier wave f_c, whilst the bandwidth of the chrominance signal is 1.2 MHz.

Below the frequency band E_c two sound signals are included as frequency modulations of two carrier waves f_{g1} and f_{g2}, which sound signals occupy the frequency bands E_{g1} and E_{g2}. Said two frequency bands may for example contain a stereo sound signal which is added to the colour television signal. Moreover between said two frequency bands E_{g1} and E_{g2} a pilot signal E_p is included, which in known manner may be employed to eliminate phase errors owing to speed variations of the record carrier when the chrominance signal E_c is re-transposed to the standard chrominance carrier frequency associated with the standard colour television signal. The exact position of said pilot signal E_p relative to the two sound signals E_{g1} and E_{g2} is of no further interest.

The combination of the signal components E_y, E_c, E_{g1}, E_{g2} and E_p to one combined video signal may be effected in a manner as described in Patent Specification No. 1,433,904. The signal components E_c, E_{g1}, E_{g2} and E_p are added to the signal component E_y, after which the combined signal is limited. Thus, a signal is recorded in optically coded form on the record carrier as a sequence of marks and spaces, which allows a favourable recording. When such a signal is read a waveform as shown in Fig. 2a is obtained. The signal V obtained after reading comprises the first signal component E_y, which consists of a frequency modulated first carrier wave on which the signals of a lower frequency E_c, E_{g1}, E_{g2} and E_p are superimposed. Said signals

$$(E_c+E_{g1}+E_{g2}+E_p)$$

which are superimposed on the signal component E_y generally have a comparatively low amplitude (for example maximum 20%) relative to the amplitude of the first signal component E_y. When reading is effected by means of a single diode 2, said signal components are superimposed on a d.c. component $V_=$, which corresponds to the average radiation energy at the diode. When said signal is amplified, employing a.c. coupling between consecutive amplifiers, said d.c. component obviously becomes nil.

It has been assumed that in the time interval t_1—t_2 a dropout occurs. In the case of a disc-shaped record carrier which is read with the aid of an optical read system such a dropout may for example be caused by a surface flaw, by the absence of one or more recesses or by an irregularity in the record carrier, for example an air bubble. The read detector, in this case the radiation-sensitive diode 2, will then receive a difference amount of radiation, the magnitude of the difference of course depending on the magnitude and nature of the flaw and/or irregularity. It has been assumed that the disturbance is such that the video signal V supplied by the read system 1 assumes a value which differs substantially from the signal values normally assumed by said video signal. It will be evident that if said video signal is not further processed there will also appear a signal disturbance in the individual signals E_y, E_c, E_{g1}, E_{g2} and E_p, which disturbance begins at the instant t_1.

As stated previously a compensation of said signal disturbances with respect to the luminance signal and the chrominance signal can be achieved by utilizing the line-frequency structure of a television picture, for which purpose during a signal disturbance by means of a delay line the information contained in the preceding line is used to replace the disturbed information of the instantaneous line. However, said method cannot be used for the sound information, so that the dropout remains very disturbing in the reproduced sound.

In order to improve this, the video signal V in the apparatus shown in Fig. 1 is applied to the signal input 9 of a clamping circuit 8 *via* a delay means 7. Further, said video signal V is applied *via* an amplifier 4 to a dropout detector 5, whose output signal D *via* an amplifier 6 is fed to a control input 11 of the clamping circuit 8. The video signal V_c which has been processed by said

clamping circuit is eventually available at a signal output 10 of said clamping circuit.

The operation of said circuit is as follows. The dropout detector 5 detects the appearance of the dropout at the instant t_1. For this, said dropout detector 5 may be of any arbitrary known design. A known embodiment of such a dropout detector is constituted by a peak detector. Such a peak detector detects the time intervals within which the amplitude of the applied signal exceeds a certain value. In order to detect both dropouts which cause a negative spurious pulse, as is the case in Fig. 2*a*, and dropouts which cause a positive spurious pulse, it is evident that said peak detector should be of the full-wave type (or absolute value-type). By way of illustration two threshold values are indicated in Fig. 2*a* by means of dotted lines, which are disposed at a distance R above and a distance R below the average value V_- of the video signal V, assuming that the detection circuit supplies a detection pulse when the signal V exceeds the margin $V_- \pm R$ defined by said threshold value which margin is generally $\pm R$, because after the amplifier V_- has generally become nil. It will be evident that for a correct dropout detection the two said threshold values should lie beyond the signal spacing normally occupied by the video signal V.

As previously stated, the dropout detector 5 when thus designed each time supplies a pulse-shaped output signal D when and as long as the applied video signal V assumes a value which lies beyond the signal spacing $V_- \pm R$. Said output signal D, shown in Fig. 2*b*, of the dropout detector 5 is applied to the control input 11 of the clamping circuit 8 *via* the amplifier 6. Said clamping circuit 8 is designed so that normally the video signal which is applied to its signal input 9 is transferred (unimpeded) to its signal output 10, but that in the event of a control pulse at its control input 11 said signal output 10 is clamped at a signal value which corresponds to the average value V_- of the applied video signal V. The video signal V_e at the signal output 10 of the clamping circuit 8 therefore will be as shown in Fig. 2*c*.

Instead of an arbitrary signal disturbance in the time interval t_1—t_2, as shown in Fig. 2*a*, said video signal V_e now contains a signal disturbance during said time interval, which is constituted by the video signal V_e remaining at a constant value V_- during said time interval. It has been found that said residual signal disturbance is far less disturbing than the original signal disturbance. This is explicable because the energy contents of the residual signal disturbance is substantially lower than the energy contents of the original signal disturbance. In particular with respect to the sound signals which are eventually obtained this yields a substantial improvement. When said sound signals are extracted, use is made of filters which may be readily br brought into a resonant mode, though damped, by a signal disturbance with a relatively high energy content. As a result of this, the eventually obtained sound signal is wholly determined by said dropout during a time interval which may be substantially longer than the time interval of the original dropout, which results in a clearly audible disturbance of the sound signal.

The invention, which results in a limitation of the energy contents of the signal disturbance first of all ensures that the magnitude of the disturbance in the eventually reproduced sound signal is limited. Moreover, the time is reduced within which said signal disturbances in the sound signal have a value within the audible range, because the filters are excited less strongly and the disturbance decreases sooner to an insignificant value owing to decay. In this respect both aspects are significant because the disturbing effect of a signal disturbance in the reproduced sound signal depends both on the magnitude of said disturbance and on its duration. Signal disturbances in the eventual sound signal which have a duration below one or a few microseconds are for example hardly audible.

The delay means 7 should provide a delay which corresponds to the delay caused by the amplifiers 4 and 6 and the detector 5, so that the input signal at the signal input 9 and the control signal at the control input 11 of the clamping circuit are in agreement with respect to time. Said time delay has already been allowed for in Fig. 2, so that the pulse of the detector signal D covers the time interval t_1—t_2.

Fig. 4 shows a second embodiment of the invention, in which corresponding elements are denoted by the same reference numerals as in Fig. 1. The combined video signal V is again applied to an input terminal 3. Connected to said input terminal 3 are a high-pass filter 12 for extracting the luminance signal E_y, a low-pass filter 13 for extracting the two sound signals E_{g1} and E_{g2} and the pilot signal E_p, and a band-pass filter 14 for extracting the chrominance signal E_c.

The luminance signal is demodulated with the aid of an FM demodulator 17. Moreover, said luminance signal E_y is delayed by one line time by a delay means 15, for example an ultrasonic delay line, and subsequently demodulated with the aid of an FM demodulator 16. Said delayed and undelayed demodulated luminance signal

are applied to the two inputs of a switch 18, which *via* an amplifier 19 is actuated by the dropout detector 5, which detects dropouts in the extracted luminance signal E_y. In this known manner a compensation of dropouts in the luminance signal is achieved, which luminance signal is available at the output terminal 27.

The extracted sound signals E_{g1} and E_{g2} together with the pilot signal E_p are applied to the signal input 9 of the clamping circuit 8 *via* the delay means 7. Said clamping circuit 8 receives a control signal from the dropout detector 5 at its control input 11 *via* a pulse shaper 20. Thus, a signal appears at the signal output 10 of the clamping circuit 8, which signal is clamped at its average value during a dropout. As the sound signals E_{g1} and E_{g2} together with the pilot signal E_p have already been subjected to the filter action of the low-pass filter 13, the duration of the dropout in the signal which is applied to the clamping circuit 8 is generally longer than the duration of the dropout in the original combined video signal V and is also longer than the duration of the dropout in the extracted luminance signal E_y. The dropout which is detected by the dropout detector 5 consequently has a duration which is not in accordance with the dropout in the sound signals. Accordingly, in order to obtain a clamping action of the clamping circuit 8 for the full duration of the dropouts, the shown pulse shaper 20 is provided. Said pulse shaper may be designed so that it supplies a pulse of a fixed duration as soon as a pulse appears at the output of the dropout detector 5. The pulse duration of the pulse which is supplied by the pulse shaper 20 should then be selected so that at least the majority of at least the gross dropouts in the sound signals is fully covered by said pulse. On the other hand, said pulse duration should be minimised so as not to affect correct portions of the sound signals. In this respect, it is therefore necessary to compromise between a high degree of dropout limitation, also of dropouts of very long duration, and minimal impairment of correct signal portions. The eventual choice then depends of course on the type of dropout which occurs in the detected video signal.

The corrected signal at the signal output 10 of the clamping circuit is split up by means of filters 21, 22 and 23 into the sound signals E_{g1} and E_{g2} and the pilot signal E_p. The two sound signals E_{g1} and E_{g2} are demodulated with the aid of FM-demodulators 25 and 26 and are available at the output terminals 28 and 29. The extracted pilot signal E_p is employed, in known manner, for the compensation of phase errors in the chrominance signal, for example as described in United States Patent 3,580,990. The chrominance signal E_c which is extracted with the aid of the bandpass filter 14 is transposed to the standard chrominance band *via* the transposing means 24, which may be of any known type, and is available at output terminal 30.

Fig. 5, by way of example, shows one practical form of the clamping circuit 8. However, it will be evident that the scope of the invention is by no means limited by this clamping circuit. In Figure 5 the signal input 9 of the clamping circuit 8 is connected to the base of an npn transistor T_1 which functions as an emitter follower, which transistor has an emitter resistor R_1. The emitter of said transistor T_1 is connected to the emitter of a pnp-transistor T_2, whose base, *via* a resistor R_2, is connected to the control input 11 of the clamping circuit. The collector of said transistor T_2 is connected to the series connection of the capacitor C_1 and resistor R_3, whose connection point constitutes the signal output 10 of the clamping circuit. When transistor T_2 conducts the signal, which is applied to the signal input 9, is transferred to the signal output 10. However, when transistor T_2 is cut off by a control signal at terminal 11, the signal output assumes a potential which equals the potential level to which the resistor R_3 is connected. In this case it is assumed that the average value of the applied signal is nil, which is usually, so, so that the resistor R_3 is connected to earth.

Although so far only the reduction of the influence of dropouts on the sound signals has been mentioned, the apparatus of Fig. 1 may also yield an improvement of the luminance and/or chrominance signal. However, with these signals there is less need for such processing, because many other dropout compensation circuits for these signals are known in the art.

WHAT WE CLAIM IS:—

1. Apparatus for reading a record carrier on which a combined video signal is recorded, in which record carrier the video signal is recorded in optically coded form, which apparatus comprises, means for producing a beam of optical radiation and a radiation-sensitive read detector, which read detector produces an output which, during reading, comprises a first signal component which consists of a first carrier wave which is modulated with the luminance information, and at least a second signal component which consists of a second carrier wave modulated with sound information, characterized in that the apparatus is equipped with a dropout detector for detecting dropouts in at least

are applied to the two inputs of a switch 18, which *via* an amplifier 19 is actuated by the dropout detector 5, which detects dropouts in the extracted luminance signal E_y. In this known manner a compensation of dropouts in the luminance signal is achieved, which luminance signal is available at the output terminal 27.

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* C L M S *

said first signal component and with a clamping circuit having a signal input connected to receive at least the second signal component, a signal output and a control input, which clamping circuit at its control input receives a control signal from the dropout detector and which as a function of said control signal, in the absence of a dropout, transfers the signal applied to the clamping circuit signal input unmodified to the signal output and during the occurrence of a dropout clamps said signal output at a fixed d.c. signal value which corresponds to the average value of the signal which is applied to the clamping circuit signal input.

2. Apparatus as claimed in Claim 1, characterized in that the clamping circuit signal is connected to receive both first and second signal components.

3. Apparatus as claimed in Claim 1 or 2, characterized in that the dropout detector detects dropouts in only the first signal component.

4. Apparatus as claimed in any of the preceding Claims, characterized in that the dropout detector comprises a peak detector which detects the instants at which the magnitude of the signal applied thereto differs from the average value of the signal applied thereto by a predetermined threshold amount.

5. Apparatus substantially as herein described with reference to Figures 1 to 3 and 5, or Figures 2 to 5 inclusive of the accompanying drawings.

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