



OPTICAL END-OF-TAPE DETECTION DEVICE.

The invention relates to an optical end-of-tape detection device for use in a magnetic recording and/or playback apparatus.

Such devices are used in inter alia cassette recorders and
5 serve to ensure that the tape drive stops when the end of tape is reached so as to preclude tape breakage. The device generally comprises a light source, a light-sensitive element which cooperates with said source, and a detection circuit which is coupled to said light-sensitive element. A disadvantage of this
10 type of device is that the cassette and the apparatus must be light-tight to a very high degree to prevent the device from being influenced by ambient light (artificial light or daylight), which may lead to the cassette recorder being switched off erroneously. Apart from the constructional complexity entailed by this
15 light-tightness, this also has the disadvantage that the freedom of designing the cassette is restricted. For example, the use of transparent cassettes is then impossible. Moreover, a separate transparent window must be provided in the cassette in order to check the amount of tape which is still available. All in all this
20 renders the use of the inherently attractive optical end-of-tape detection unattractive.

It is known, for example from patent specification 1465579, to provide an end-of-tape detection device in which the influence of ambient light is reduced substantially. More particularly that
25 patent specification discloses an optical end-of-tape detection device for use in a magnetic recording and/or playback apparatus, which device comprises a light source, a light-sensitive element which cooperates with said source, a detection circuit which is coupled to said light-sensitive element, and a modulator for
30 modulating the light emitted by the light source to enable the detection circuit to distinguish the light emitted by the light source from ambient light.

As it is desirable to operate the light-sensitive element in such a device as a current source, because the output current then
35 has a linear relation to the incident light and the amplitude of

the current pulses produced by the pulsating light source is not influenced by the ambient light, as in the case of an element operated as a voltage source, a problem arises because the currents of comparatively low frequency, which will be direct currents for daylight and currents of a frequency equal to twice the mains frequency for artificial light, will saturate the detection circuit.

In order to solve this problem the invention is characterised in that the light-sensitive element has the nature of a current source and the detection circuit comprises a current-voltage converter the input of which is coupled to the photo-sensitive element and the output of which, via a low-pass filter with a cut-off frequency which is lower than the frequency of the light-source modulation, is coupled to the input of a voltage-current converter the output of which, in order to compensate for the low-frequency current component, is connected to the current-voltage converter, so that the low-frequency component of the current received by the current-voltage converter is reduced.

If desired the modulator may be adapted to cause the light source to pulsate with a predetermined frequency and the detection circuit detects said light pulses synchronously.

In such a case the detection circuit may comprise a differential amplifier having one input to which a signal to be detected is applied and having another input to which said signal is applied via a switch operated in synchronism with the light-source modulation and a hold capacitance, so that the difference between the applied signals is amplified in alternate phases of the light-source modulation.

The present invention will now be described in more detail, by way of example, with reference to the single figure of the accompanying drawing, which figure is a schematic circuit diagram of an embodiment of the invention.

The Figure shows a light source, in particular a photo-diode 1, whose emitted light can be detected by a photo-sensitive

element, in particular a photo-transistor 2. Such a combination is used for detecting the transparent end of an otherwise opaque magnetic tape in a magnetic tape recorder, for example a video cassette recorder. The photo-transistor 2 supplies to an output 3 (the emitter) a photo-current I_F which is proportional to the amount of light received. The output 3 is connected to a current-voltage converter 4, which converts an input current I_{HF} into an output voltage on an output 7. This current-voltage converter comprises an operational amplifier 8 having a resistor 9 of a value R_1 arranged between its output and its inverting input and having its non-inverting input connected to a point at a reference voltage V_R . As a result of this the voltage on output 3 of the photo-transistor is maintained at the voltage V_R . Thus, the output voltage on point 7 is equal to $V_R - I_{HF}R_1$.

Without special shielding steps the photo-transistor 2 also receives ambient light in addition to the light emitted by the photo-diode. Therefore, without special measures it is not readily possible to distinguish a variation of the light received from the photo-diode 1 by the photo-transistor 2 from an ambient light variation. Since optical shielding of the photo-transistor 2 from the ambient light may pose a problem, this problem is overcome by the optical end-of-tape device made in accordance with the present invention wherein the light emitted by the photo-diode 1 is modulated by means of a source 10 which in the present example generates a pulse-shaped signal, although in principle it is alternatively possible to select a different signal waveform. As a result of this, in addition to a component caused by ambient light, which component is a direct current in the case of daylight and a low-frequency current of a frequency equal to twice the mains frequency in the case of artificial light, the photo-current contains a pulsating component when the photo-transistor 2 receives light from the photo-diode 1 (in the case of end-of-tape), whilst this pulsating component is not present if the photo-transistor 2 does not receive light from the photo-diode 1. Therefore, the end-of-tape can be detected by detecting said pulsating component.

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For this several possibilities are available, such as narrow-band filtration for the frequency of the pulsations or synchronous detection.

In order to ensure that the output-signal amplitude is independent of the amount of ambient light the photo-transistor 2 is operated as a current source, so that the photo-current I_F is largely proportional to the amount of light received. However, this has the drawback that the current I_F has a low-frequency current component which may be comparatively strong depending on the ambient light, which component, in contradistinction to voltage components, cannot be isolated simply so that it is not unlikely that the input stage 4 of the circuit, which is coupled to the output 3 of the photo-transistor 2, is saturated by said low-frequency current component. In order to solve this problem the output 7 of the amplifier 4 is connected to a voltage-current converter 6 via a low-pass filter 5 comprising an RC-network with a resistor 21 and a capacitor 22, which converter comprises an operational amplifier 23, arranged as a voltage follower, in series with a resistor 24 of the value R_2 . The voltage current converter 6 supplies a current I_{LF} to output 3 of the photo-transistor 2. If the component $V_R - V_0$ on the output 7, which as already stated is equal to $V_R - I_{HF}R_1$, has a low frequency, this component is applied to the resistor 24 via the follower 23, the other end of said resistor being connected to the output 3 carrying a voltage V_R . The current I_{LF} then complies with $I_{LF} = \frac{R_1}{R_2} I_{HF}$ or $I_{HF} = \frac{R_2}{R_1 + R_2} I_F$. If $R_1 \gg R_2$, the low-frequency component of the current I_F from photo-transistor 2 is reduced by a factor $\frac{R_1}{R_2}$ and transferred to the current-voltage converter 4, thereby preventing saturation.

In the Figure the output 7 of the current-voltage converter 4 is connected to the inverting input of operational amplifier 17 via resistor 11 of a value R_3 , which input is connected to the output 18 of said operational amplifier via a resistor 12 of the value R_4 . Via a switch 16, which is operated via a synchronous source 10, and a resistor 14 of the value R_3 , the output 7 is also connected to

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the non-inverting input of the operational amplifier 17, which non-inverting input is connected to the point of reference voltage V_R via a resistor 13 of the value R_4 . The point between switch 16 and resistor 14 is connected to a sampling capacitor 15.

When the photo-diode 1 does not emit light the switch 16 is closed. A signal $V_R - V_0$ then appears on output 7, V_R being the aforementioned reference voltage and V_0 being a component as a result of the ambient light. This voltage then also appears on the capacitor 15. The same signal then appears on both inputs and the signal on output 18 is equal to V_R . If the photo-diode 1 emits light, switch 16 is open. The signal $V_R - V_0 - V_S$ then appears on output 7, V_R being the aforementioned reference voltage, V_0 the aforementioned component as a result of the ambient light, and V_S being the component caused by the light received from the photo-diode 1 by the photo-transistor 2. Since the signal $V_R - V_0$ appears on capacitor 15 the difference, i.e. the signal V_S , is amplified and the signal $V_R + \frac{R_4}{R_3} V_S$ appears on output 18. Thus, the influence of the ambient light is eliminated.

A further circuit 19 which processes the pulsating output voltage on output 18 may be connected to output 18, which circuit may be for example a low-pass filter, a sample-and-hold circuit or a gate circuit which is clocked in synchronism with the source 10 and which detects whether or not light is received from the photo-diode 1 depending on the value of the signal $V_R + \frac{R_4}{R_3} V_S$, which is substantially equal to V_R if an opaque magnetic tape is present between the photo-diode 1 and the photo-transistor 2 and which is comparatively high at the end of the tape where a transparent portion of the tape is situated.



CLAIMS:

1. An optical end-of-tape detection device for use in a magnetic recording and/or playback apparatus, which device comprises a light source, a light-sensitive element which cooperates with said source, a detection circuit which is coupled to said light-sensitive element, and a modulator for modulating the light emitted by the light source to enable the detection circuit to distinguish the light emitted by the light source from ambient light, wherein the light-sensitive element has the nature of a current source and the detection circuit comprises a current-voltage converter the input of which is coupled to the photo-sensitive element and the output of which, via a low-pass filter with a cut-off frequency lower than the frequency of the light-source modulation, is coupled to the input of a voltage-current converter the output of which, in order to compensate for the low frequency current component, is connected to the current-voltage converter so that the low-frequency component of the current received from the current-voltage converter is reduced.

2. An optical end-of-tape detection device as claimed in Claim 1, wherein the modulator is adapted to cause the light source to pulsate with a predetermined frequency and the detection circuit detects said light pulses synchronously.

3. A device as claimed in Claim 2, wherein the detection circuit comprises a differential amplifier having one input to which a signal to be detected is applied and having another input to which said signal is applied via a switch operated in synchronism with the light-source modulation, and a hold capacitance whereby the difference between the applied signals is amplified in alternate phases of the light-source-modulation.

4. An optical end-of-tape detection device for use in a magnetic recording and/or playback apparatus, constructed and arranged to operate substantially as hereinbefore described with reference to and as shown in the accompanying drawing.



5. A magnetic recording and/or playback apparatus including the optical end-of-tape detection device as claimed in any one of Claims 1 to 5.

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