We, LICENTIA PATENT-VERWALTUNGS-GmbH, of 6 Frankfurt Main 70, Theodor-Stern-Kai 1, Germany hereby apply for the grant of a standard patent for an invention entitled:

**VIDEO RECORDER WITH FAST MOTION AND/OR SLOW MOTION REPRODUCTION**

which is described in the accompanying complete specification.

Details of basic application:

- **Number of basic application:** P32 05 781.4
- **Name of Convention country in which the basic application was filed:** German Federal Republic
- **Date of basic application:** 18.2.82

Our address for service is:


Dated this eleventh day of February 1983.

LICENTIA PATENT-VERWALTUNGS-GmbH

by [Signature]

Agent for the Applicant.

TO:

The Commissioner of Patents.
A video recorder with fast motion and slow motion reproduction, in which two or more rotating video heads with differing azimuth angles alternately record a respective field in a slant track on a magnetic tape transported in its longitudinal direction at a normal speed, wherein during reproduction, during which the magnetic tape is transported in the longitudinal direction at a speed which differs from the normal speed, the scanning track followed by each video head is angularly displaced in the longitudinal direction of the tape by such an amount relative to the respective recorded track that each of the video heads scans the maximum surface area of the recorded track having the azimuth angle assigned to the respective head, wherein a picture carrier which is frequency modulated with the video signal and at least one sound carrier which is frequency modulated with a low frequency sound signal are

<table>
<thead>
<tr>
<th>Claim</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. A video recorder with fast motion and slow motion reproduction, in which two or more rotating video heads with differing azimuth angles alternately record a respective field in a slant track on a magnetic tape transported in its longitudinal direction at a normal speed, wherein during reproduction, during which the magnetic tape is transported in the longitudinal direction at a speed which differs from the normal speed, the scanning track followed by each video head is angularly displaced in the longitudinal direction of the tape by such an amount relative to the respective recorded track that each of the video heads scans the maximum surface area of the recorded track having the azimuth angle assigned to the respective head, wherein a picture carrier which is frequency modulated with the video signal and at least one sound carrier which is frequency modulated with a low frequency sound signal are</td>
</tr>
</tbody>
</table>

The following table applies:
recorded together by the video heads in the same slant tracks, and the frequency of the at least one sound carrier is chosen at a high frequency at which the azimuth losses due to the azimuth angle ensure adequate alternation of the cross talk between adjacent tracks during reproduction.
The following statement is a full description of this invention, including the best method of performing it known to us:-

- 1 -

are alternatingly evaluated from field to field by the change-
In a video recorder, for example using the VHS recording system, the signals of time-successive half frames (fields) are recorded by means of two rotating video heads in so-called slant tracks, which extend at an angle of approximately 60° to the edge of the magnetic tape. In this way each field is recorded in a respective slant track extending from one edge of the tape to the opposite edge. The successive tracks are recorded without a spacing between them, that is, without a so-called guard area.

To reduce the crosstalk between neighbouring tracks, it is known from German Federal Republic Offenlegungsschrift 3 011 635, to provide the two video heads, which in time-succession record a respective field and are then inoperative during the succeeding field, with differing azimuth angles. This means that the gap in the magnetic head relative to the direction across the tape would be changed to +60° for one head and -60° for the other head. Because of the so-called azimuth loss when there is a variation between the direction of the head gap and the direction of magnetisation, a high crosstalk attenuation is achieved between adjacent tracks when the first video head passes over the track assigned to it at the correct azimuth angle, it picks up practically no signal from the next-lying track with the other azimuth angle.

In this arrangement, in order for the video heads always to scan the slant tracks accurately, and also traverse the tracks with the correct azimuth angles, the tracks are marked by a 25Hz impulse train, which is recorded in a longitudinal track extending along one edge of the tape. By comparison of this impulse train scanned by a fixed head with an impulse train derived from the head wheel, the phase position can be assigned to the respective track on the tape to the normal fast motion signals tracks in the practical precede.

Longitudinal from the track arises. The amplitude of a track as opposed to the opposing tracks amplitudes. The amplitude difference between the corresponding signal due to the recorded signals is 20 tracks in the practice.

The cla
position of the head wheel which carries the video heads can be so controlled that each head traverses the track assigned to it.

In the described slant track recording, it is also known by altering the longitudinal speed of the magnetic tape to effect a reproduction at a speed which varies from the normal speed, and thereby to reproduce the picture in fast motion or slow motion. This is possible because the signals of the time-successive fields in the mentioned slant tracks are directly adjacent and therefore the video heads in the transition from one track to the other encounters practically the same picture point in the following or the preceding field.

However, in the described scanning with altered longitudinal speed of the magnetic tape, a disadvantage arises. The video head only accurately follows the recorded track assigned to it, when the magnetic tape is moved longitudinally at the normal speed. When this speed differs from the normal speed, the video head must inevitably glide from one track to a neighbouring track. This means that, as opposed to the normal scanning, the video head also scans tracks having the incorrect azimuth angle. In this case the amplitude of the signals picked up will be practically nil. The amplitude of the signals picked up will thus fluctuate in dependence on whether the head is located on a track with the correct azimuth angle or on a track with the incorrect azimuth angle. These amplitude fluctuations can cause interference in the picture reproduction. In particular the signal to noise ratio during picture reproduction is reduced due to the amplitude fluctuations and the amplitude interr-

The claims defining the invention are as follows:
It is known from IEEE Transactions on Consumer Electronics, Vol. CE-26, February 1980, pages 121-128, during reproduction in which the magnetic tape is transported in the longitudinal direction at a speed which varies from the normal speed, angularly to displace the track traversed by the video head from the recorded track to such an extent in the longitudinal direction of the tape, that the video head scans the largest possible surface portion of the recorded track at the azimuth angle assigned to the video head.

By this displacement, the maximum amplitude of the scanned signal occurs essentially in the centre of a slant track, and therefore in the middle of the picture, where interference is most commonly perceived.

The object of this invention is to provide a video recorder of the last-described kind with provision also for a sound signal, in which a fast motion or a slow motion is also available for the sound, without the frequency of the sound signal being affected. This objective is realised in a video recorder with fast motion and slow motion reproduction, in which two or more rotating video heads with differing azimuth angles alternately record a respective field in a slant track on a magnetic tape transported in its longitudinal direction at a normal speed, wherein during reproduction, during which the magnetic tape is transported in the longitudinal direction at a speed which differs from the normal speed, the scanning track followed by each video head is angularly displaced in the longitudinal direction of the tape by such an amount relative to the respective recorded track that each of the video heads scans the maximum surface area of sound carrier(s) lie(s) in the range 1.9-2.2 MHz.
of the recorded track having the azimuth angle assigned to the respective head, wherein a video carrier which is frequency modulated with the video signal and at least one sound carrier which is frequency modulated with a low-frequency sound signal are recorded together by the video heads in the same slant tracks, and the frequency of the at least one sound carrier is chosen at a high frequency at which the azimuth losses due to the azimuth angle ensure adequate attenuation of the cross talk between adjacent tracks during reproduction.

The availability of fast motion and slow motion reproduction for the sound without altering the frequency of the sound signal will not be explained. Because the scanning of a slant track takes only 20ms, in practice the sound signal recorded in a single slant track is not a complete syllable such as "gone", but is only a vowel such as "o" or only a broken part of a vowel. Thus when such a slant track is scanned several times in succession, there arises during sound reproduction not a senseless or disturbing repetition of a whole syllable, but merely a repetition of a vowel or a consonant. This means, for example, that the vowel "o" in the syllable "gone" is scanned several times in succession and therefore the whole sound reproduction is stretched. The reproduction thus produces a slowed but understandable speech reproduction. Because the relative speed between the video heads and the slant tracks remains practically unchanged in spite of the alteration of the speed of the magnetic tape in the longitudinal direction, the frequency of the scanned carriers also remain practically unchanged, so that the frequency modulation of recorded carriers functions without change. Therefore the pitch of the sound content also
remains unchanged, and is not raised or lowered as happens in an audio tape recorder when scanning is speeded up or slowed down. Such a reproduction of the sound at increased or decreased speed with the correct pitch would otherwise involve a substantial circuit cost in the form of bucket chain circuits and the like. This slowed down or speeded up speech is advantageous in practice, for example, with too-rapid speech in the recorded sound signal, for speech analysis or for teaching purposes.

Because of the positioning of the sound carrier(s) relative to the azimuth losses in accordance with this invention, a cross talk attenuation of around 40-60dB is achieved. The one or more sound carriers advantageously have a frequency of the order of 1.9-2.2MHz. These frequencies also have the advantage that the one or more sound carriers then lie in a frequency range in which the frequency response of the video heads exhibits a maximum, whilst the frequency response in the region around 0.5-1.0MHz shows a sharp fall off. The mentioned frequency range of the carriers is also advantageous, because the one or more sound carriers are in general recorded with an amplitude which is only about 10% of the amplitude of the picture carrier. The choice of a frequency in the range 1.9-2.2MHz thus also realises a better signal to noise ratio for the one or more sound carriers.

For sound reproduction, the following advantage arises. The scanning of the slant tracks takes place alternatingly by the two video heads. With head alternation, interference arises during sound reproduction, because the signal scanning is changed over from one head to the other, and during this scanning an unavoidable phase transition occurs.
in the FM carrier. The scanning in accordance with this invention takes place in such a way that the minima in the amplitude of the scanned sound carrier occurs at the transition from one field to another, that is, where the heads change over. At a time which is critical with head alternation, the scanned FM sound carrier has its minimum amplitude, so that phase transitions in this carrier have a small effect on the demodulated sound signal. The longitudinal speed of the magnetic tape can, for example, be varied from a minimum value of 5mm/S through the normal value of 23.39mm/S to a maximum value of 46.8mm/S. The relative speed between the video heads and the tape thereby remains in an advantageous manner constant at around 4.8mm/S, so that the frequency modulation of the picture carrier and the sound carrier remains practically uninfluenced.

The recording and scanning of the slant tracks advantageously takes place with two video heads in accordance with the current practice in video recorders. Essentially however, scanning with more than two video heads is possible.

An example of this invention will now be explained with reference to the accompanying drawings. These show in Fig. 1 the arrangement of the slant tracks for recording, reproduction, and r-production at an increased longitudinal speed, in Fig. 2 a diagram to explain the scanning of the slant tracks in Fig. 1, in Fig. 3 an example of the displacement of the scanning track, in Fig. 4 a circuit for amplitude control during reproduction, in Fig. 5 a diagram to explain the operation of Fig. 4, and in Fig. 6 a block circuit diagram of the reproduction circuit for carrying out the invention.

In Fig. 1, slant tracks 2 are recorded on the
magnetic tape 1, the tracks extending from one side of the tape to the other. Longitudinal tracks which are used in practice for the additional recording of a sound signal or a synchronising signal are not shown. In practice the slant tracks extend across the tape at a small angle of the order of 6°. The beginnings and ends of the recorded slant tracks are indicated in the drawing by the points numbered 0-20. The slant tracks are alternatingly traversed by two video heads 3a and 3b. The position and kind of scanning of the slant tracks 2 will be explained in conjunction with Fig. 2. It must first be assumed that the longitudinal speed \( V \) of the magnetic tape 1 in the direction 4 is zero. The video head 3 traverses by its rotation within a head drum the track 1-0. The position of this track arises from the geometrical relationship produced by the encirclement of the head drum by the magnetic tape. With the stationary condition of the tape, that is, with \( V = 0 \), this track 1-0 will be repeatedly scanned. The scanning of a track lasts 20mS, that is, the duration of one field of the television signal. Now let it be assumed that the magnetic tape 1 is moved at the normal speed \( V_0 \) in the direction 4. During the scanning of the track beginning at 1, the tape 1 has covered a path width in the direction 4, which is determined by the time of 20mS and \( V_0 = 23.39 \text{mm/S} \). The video head traverses therefore at the normal speed \( V_0 \) not the track 1-0, but the track 1-2. This scanning is shown in Figs. 1 and 2 by the hatching between points 1 and 2. During the next 20mS the video head 3a does not contribute to the scanning, but moves unused around to the other edge of the tape again. This return movement also takes 20mS, so that the video head after 40mS is again at
distance 2a in the time of 40mS. There then commences again the scanning, this time of the track 5-6 in a further period of 20mS. In a similar way the video head 3b scans the intermediate tracks 3-4, 7-8, 11-12, etc., which are not hatched in the drawings. From a longitudinal track (not shown) on the magnetic tape 1, the impulse train 5 at 25Hz is recorded, which marks the tracks 1-2, 5-6, 9-10, etc. This impulse train ensures that the video head 3a always scans these (marked) tracks and the video head 3b always scans the interlying tracks.

It is now assumed that the speed Vo is increased to twice that value, 2Vo. At the speed Vo, the video head 3a has a time of 80mS to cover the section of the tape from point 1 to point 9. Because the speed V is now 2Vo, the video head 3a must now cover this section in half the time, that is in 40mS. This means that as opposed to a speed Vo, the displacement of the track from one edge of the band to the other no longer corresponds to a=20mS, but to 2a=40mS. The video head 3a thus describes in Fig. 1 the track 1-4 and after the unused period the track 9-12, these tracks being shown by chain dotted lines in the drawing. The video head 3a thus commences the scanning of the track 1-2 under the control of the impulse train 5 at the correct azimuth angle and therefore the full amplitude of the scanned signal. As shown by the track 1-4 indicated by the chain dotted lines, the video head however in following the track 1-4 is moving continuously away from the correct track 1-2, and then moves over the track 3-4 at an incorrect azimuth angle, where the
amplitude of the scanned signal is practically zero. This produces for the scanned carrier an amplitude curve according to Fig. 2b.

Now in Fig. 3, the position of the scanning track, that is, the track followed by the video head, indicated by the chain dotted lines is shifted towards the left by a distance a/2=10mS. It will be seen that the scanning track with the chain dotted lines is better arranged relative to the track 1-2 at the correct azimuth angle. For one thing, the optimum position over the correct track 1-2, and therefore the maximum amplitude of the scanned signal, is shifted into the middle of the slant track. For another thing, the signal amplitude at the beginning and end of the track is not zero, but has half the maximum value, whilst at both the end positions the correct track 1-2 is covered. By means of this now improved scanning, the amplitude curve of Fig. 2c is produced. This shift of the maximum amplitude into the centre of a field has the advantage during picture reproduction, that the optimal position with the greatest signal to noise ratio now lies in the centre of the picture and not at the upper edge of the picture. Because the main events and the centre of picture observation lie by experience in the middle of the picture, and less at the edges of the picture, this has an advantage in picture reproduction. For the sound reproduction there is the advantage, that at the end of the slant tracks, that is, with head alternation where phase shifts in the scanned sound carrier can lead to interference, the amplitude has a lower value.

The shifting of the chain dotted scanning track shown in Fig. 3 is achieved in a simple manner during reprodu-
uction. It is known that the rotation of the head is so controlled by comparison of the impulse train 5 from the longitudinal track of the magnetic tape 1 with an impulse train derived from the head wheel, that the magnetic heads accurately follow the recorded tracks. By intervention in this control circuit therefore, a desired shift of the scanning tracks can be achieved, for example by the value a/2 in Fig. 3. For this purpose only one of the impulse trains applied to the phase comparator needs to be shifted by the desired amount.

The head wheel control circuit will then simulate a position other than that indicated by the impulse train 5 on the tape 1, and thereby the position of the scanning track is geometrically shifted in the longitudinal direction of the tape.

Fig. 4 shows a circuit by means of which the amplitude variation according to Fig. 2c in a picture carrier or sound carrier can be controlled. The carrier is applied to the amplifier 6. The output of the amplifier 6 is rectified in the rectifier 7 and passed to the low-pass filter 8. A control voltage $U_R$ is derived at the output of the filter, which is dependent on the amplitude of the carrier, and so controls the amplification of the amplifier 6 that a carrier of constant amplitude is available at the output terminal 9. This amplitude stabilisation can also be achieved by means of other regulating circuits, control-circuits or limiters.

In Fig. 5, the amplitude curve 10 of Fig. 2c is changed into the amplitude curve 11 by the circuit of Fig. 4. It will be seen that the carrier now has a substantially constant amplitude over the whole 20mS duration of the field.

The amount of the shifting of the scanning track, $a/2$ in Fig. 3, can be dependent on the order of the slow
motion or fast motion. With twice the longitudinal speed, $2V_0$, the amount of this shift is advantageously $10\mu s$. With speeds $V$ which are less than $V_0$, it is appropriate to alter the speed in the following stages:

<table>
<thead>
<tr>
<th>Speed ($V$)</th>
<th>Shift (mm/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$0.2V_0$</td>
<td>4.678 mm/s</td>
</tr>
<tr>
<td>$0.4V_0$</td>
<td>9.356 mm/s</td>
</tr>
<tr>
<td>$0.6V_0$</td>
<td>14.034 mm/s</td>
</tr>
<tr>
<td>$0.8V_0$</td>
<td>18.712 mm/s</td>
</tr>
</tbody>
</table>

For these values of the longitudinal speed $V$, it is appropriate to shift the scanning track by an amount which corresponds at the normal speed $V_0$ to a time of $5\mu s$. It can be seen that then an optimal co-ordination is achieved of the scanning track to the track with the correct azimuth angle according to Fig. 3. This also ensures that this optimal co-ordination persists, that is, it remains the same from field to field, without variation over a long time period. The alteration of the longitudinal speed $V$ between the values mentioned is achieved in that the impulse train of (say) 225Hz derived from the tachometer (head wheel) for the longitudinal speed $V$ is doubled in frequency to 450Hz, and then divided down. In this way there is derived the desired reference impulse for the different speeds, required for the control of the longitudinal speed $V$. The impulse train 5 from the longitudinal track on the magnetic tape 1 is now at a different frequency with a change in the speed $V$, and serves in the known way for correcting the scanning phase, that is, the co-ordination of the paths of the heads to the tracks.

For the already mentioned different speeds $V$, ...
the following Table applies:-

<table>
<thead>
<tr>
<th>Value of V</th>
<th>Tachometer Frequency</th>
<th>Dividing Factor</th>
<th>Divided Tacho. Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.0Vo</td>
<td>450Hz</td>
<td>9</td>
<td>50Hz</td>
</tr>
<tr>
<td>0.2Vo</td>
<td>450Hz</td>
<td>90</td>
<td>5Hz</td>
</tr>
<tr>
<td>0.4Vo</td>
<td>450Hz</td>
<td>45</td>
<td>10Hz</td>
</tr>
<tr>
<td>0.6Vo</td>
<td>450Hz</td>
<td>30</td>
<td>15Hz</td>
</tr>
<tr>
<td>0.8Vo</td>
<td>450Hz</td>
<td>22</td>
<td>20Hz</td>
</tr>
<tr>
<td>1.0Vo</td>
<td>450Hz</td>
<td>18</td>
<td>25Hz</td>
</tr>
</tbody>
</table>

The impulse train 5 from the longitudinal track on the magnetic tape 1 similarly has for the respective speeds V the frequency given in the right hand column of the above Table. This impulse train can then in the known manner be compared in phase and used for controlling the rotational phase of the head wheel which carries the video heads, in the sense that the heads respectively follow the desired tracks according to Fig. 1 or Fig. 3.

Fig. 6 shows a circuit by means of which the described shifting of the scanning tracks during reproduction can be achieved. The drawing shows the magnetic tape 1, the slant tracks 2, the direction 4 of the longitudinal speed V, the track 12 for the impulse train 5 which is scanned by the synchronising head 13, an impulse shaping circuit 32 for the impulse train 5, the phase comparison stage 14 for the head wheel control, the head drum 15 together with the video heads 3a and 3b as well as two permanent magnets 16, 17, the scanning head 18 for scanning the head wheel impulse train 19 at a frequency of 25Hz generated by the magnets 16, 17, an amplifier 20 for the control voltage $U_R$ generated in the phase comparison stage 14, and a motor 21 for driving the
head wheel 15. The impulse train 5 at 25Hz scanned by the head 13 from the synchronising track 12, and the impulse train 19 generated in the head 18 by the magnets 16, 17, are compared in the phase comparison stage 14. The control voltage \( U_R \) thus derived controls through the amplifier 20 the rotational phase of the motor 21 and thereby the head wheel 15, so that during reproduction the video heads 3a and 3b accurately follow the tracks 2, in particular so that they respectively scan the tracks with the correct azimuth angles. The delay stage 22 is provided in the path of the impulse train 5. This delay stage produces an impulse of which the position in time of the trailing edge is adjustable. The trailing edges of the output impulses from the stage 22 generate the impulses at the output of the impulse shaping stage 32. By this means the phase comparison stage 14 thus simulates ("sees") another position on the magnetic tape along the direction 4, so that the head wheel 15 during scanning is correspondingly electrically shifted along the direction 4. Thus in this way the shifting according to Fig. 3 can be adjusted to the extent required. The stage 22 cannot advance in time an impulse of the impulse train 5, for example by the mentioned 5 or 10mS. However, because the impulse train 5 is continuous, a desired advance in time of an impulse can be effectively achieved by correspondingly delaying the preceding impulse. With a period duration of 40mS in the impulse train 5, a delay of 35mS is the equivalent of an advance of 5mS. By adjustment of the delay in the stage 22, the optimal relationships according to Figs. 1 and 3 can be adjusted. This impulse delay can similarly take place in the path of the impulse train 19.

The signals from the two video heads 3a and 3b
are alternatingly evaluated from field to field by the changeover switch 23. The recorded sound carrier is extracted by the band filter 24, amplified in the limiter stage 25, and demodulated in the FM demodulator 26. The output of the demodulator is applied to a loudspeaker 27 through a further amplifier (not shown). The recorded picture carrier with its sidebands is extracted by the filter 28, and applied through the limiting stage 29 to the FM demodulator 30. This demodulator delivers at the terminal 31 the video signal for picture reproduction.
comparison of this impulse train scanned by a fixed head with
an impulse train derived from the head wheel, the phase

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The claims defining the invention are as follows:

1. A video recorder with fast motion and slow motion reproduction, in which two or more rotating video heads with differing azimuth angles alternately record a respective field in a slant track on a magnetic tape transported in its longitudinal direction at a normal speed, wherein during reproduction, during which the magnetic tape is transported in the longitudinal direction at a speed which differs from the normal speed, the scanning track followed by each video head is angularly displaced in the longitudinal direction of the tape by such an amount relative to the respective recorded track that each of the video heads scans the maximum surface area of the recorded track having the azimuth angle assigned to the respective head, wherein a picture carrier which is frequency modulated with the video signal and at least one sound carrier which is frequency modulated with a low frequency sound signal are recorded together by the video heads in the same slant tracks, and the frequency of the at least one sound carrier is chosen at a high frequency at which the azimuth losses due to the azimuth angle ensure adequate alternation of the cross talk between adjacent tracks during reproduction.

2. A video recorder according to claim 1, wherein a circuit is provided which processes at least one of the scanned frequency modulated carriers to provide a constant-amplitude carrier.

3. A video recorder according to either of the foregoing claims, wherein the frequency or frequencies of the
sound carrier(s) lie(s) in the range 1.9-2.2MHz.

4. A video recorder according to any one of the foregoing claims, wherein the frequency or frequencies of the sound carrier(s) lie(s) in a frequency range which substantially corresponds with the maximum of the frequency response of the video heads.

5. A video recorder according to any one of the foregoing claims, wherein the attenuation of the cross talk between two or more recorded sound signals lies in the range 40-60dB.

6. A video recorder according to any one of the foregoing claims, wherein the amplitude of the recorded sound carrier(s) is approximately 10% of that of the recorded picture carrier.

Dated this eighth day of February, 1983.

LICENTIA PATENTVERWALTUNGS GmbH
DRAWINGS
scanning is changed over from one head to the other, and during this scanning an unavoidable phase transition occurs.

Fig. 1

Fig. 2
Fig. 3

Fig. 4

Fig. 5
END