

PATENT SPECIFICATION

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DRAWINGS ATTACHED

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(54) METHOD OF RE-PRODUCING STORED SIGNALS AND RECORD SUPPORT FOR USE IN THIS METHOD

(71) We, LICENTIA PATENT-VERWALTUNGS-G.m.b.H., of 1 Theodor-Stern-Kai, 6 Frankfurt, 70, Federal Republic of Germany, a German Body Corporate, do hereby declare 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 a method of reproducing signals stored on a record carrier, the surface of which comprises deformations corresponding to the behaviour of the signal value with respect to time, and with a pickup which, with its contact face, exerts a compressive force on the surface of the record carrier travelling past it, which force is so dimensioned that, with a suitable modulus of elasticity of the material of the record carrier used, the elastic change in shape of the support surface caused by the compressive force is considerably greater than the oppositely directed deflection of the contact face of the pickup due to the compression.

Such a method forms the subject of an earlier proposal (Patent Nos. 1,266,202 and 1,266,203) which, with its teaching of playing back a substantially resilient record carrier which yields elastically under the pickup pressure, with a pickup having a high contact pressure, was contrary to the view then held by those skilled in the art. The view held at that time was for the highest possible frequency limit of the reproducible bandwidth, the record carrier should be as hard as possible and the pickup should be sprung as softly as possible. The publication "Factors Affecting the Stylus/Groove Relationship in Phonograph Playback Systems" by G. R. Bastiaans in the Journal of the Audio Engineering Society, October 1967, Vol. 15, No. 4, pages 389 to 399 is a suitable example of this conventional view with regard to the extension of the

reproduction range towards even higher frequencies, because it contains a detailed representation of the theory of the relationships and gives values of the upper limiting frequencies which can be reached for the kind of gramophone-record play back usual up to then.

According to the results of experiments, the earlier proposal opened up the possibility of recording and reproduction in a suable range of up to some Mcps above the limiting frequency which was previously considered insuperable, using a pickup having a skid-shaped portion in engagement with the surface of the record carrier which executes only a very small amplitude of movement while the deformations in the surface of the record carrier containing the signal, on the other hand experience considerably greater compressions. Thus the possibility is afforded of recording and reproducing a broadband signal which may serve, for example, for the storage and reproduction of a television transmission. In this case, as mentioned, a skid-shaped pickup is used, the leading edge of which gradually approaches the surface of the record carrier while the trailing edge has a relatively sharp angle to the record carrier surface at which trailing edge the deformations rapidly pass out of range of contact with the pickup during play back whereas they move gradually into the range of contact at the leading side.

A frequency-modulated carrier oscillation is generally recorded, which has the advantage that the amplitude of the carrier oscillation remains unaltered and with a hill and dale recording, all hills of the recording which hills reproduces the peaks of the carrier oscillation, are alike so that the skid-shaped portion of the pickup, which always covers several wavelengths of the carrier oscillation, comes into contact with all hills, without any of the hills being omitted, as could occur, in amplitude modulation with hills of different

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SPECIFICATION AMENDED - SEE ATTACHED SLIP

heights. In this manner, the pickup records, in pressure pulses, the running of each individual hill out of its contact range at the "sharp" pickup edge. These remarks regarding the operation of the method according to said earlier proposal were considered necessary because there is not yet any printed publication available about this system of so-called "pressure playback".

In a method of the kind in the first paragraph of the specification, because of the broad working frequency band with an upper cut-off frequency of some Mcps, a number of narrow-band signals can be stored by the known multi-channel technique, or a broadband signal, for example a video signal, can be recorded and reproduced, which occupies the entire frequency range available. In the latter case, the need may arise to accommodate one or more further signals, for example a sound signal or colour information, in the same recording.

The principle of pressure playback of a frequency-modulated carrier wave, which has been outlined in its broad principles, appears at first to exclude the super-imposition of an additional signal oscillation or modulated carrier wave, because the advantage of equal heights in the oscillation to be played back would be lost by such a superimposition. As a result of the beat of two signals to be recorded superimposed, conditions resembling amplitude modulation with different positions of the hills would obviously result so that the skid-shaped pickup might no longer detect the (lower) hills situated in dips in the superimposed curve.

The invention seeks to provide a method which enables this difficulty to be overcome and enables one or more additional signal oscillations to be added without leading to the expected disturbances during the playback process.

According to the invention, there is provided a flexible record carrier having stored signals thereon in the form of hill and dale deformations which deformations consist of a broadband signal in the form of a frequency modulated carrier oscillation and at least one further signal of lower frequency than the lowest frequency of the broadband carrier oscillation superimposed on the broadband carrier oscillation, the amplitude of the lower frequency signal being selected such that when the recording is reproduced by a skid shaped pressure pickup operating by compression of the hills of the hill and dale deformations, even the lowest hills contact the sledge shaped member and are compressed thereby.

As a result of the limitation, according to the invention, in the amplitude of the further signal in proportion to the amplitude of the broadband signal, and taking into consideration the compression of the frequency-modulated deformations representing the broadband

signal caused by the pickup pressure, it is possible to hold the trailing edge of the pickup, which acts substantially as a pressure sensor, always in contact with each individual hill of the broadband signal travelling past. The occurrence of this effect is a simple criterion for the correct adjustment and selection of the variable parameters, namely modulus of elasticity of the record support, size of the deformations, length and shape of the pickup sledge and tracking force. A graph of the behaviour of the output voltage of the pickup can easily be recorded by means of an oscillograph, and it can be seen whether gaps in the play back of the higher frequency broadband oscillation occur in time with the lower-frequency additional signal oscillation, which would indicate an unsuitable selection of the parameter values, whereas with selection in accordance with the invention there are no such playback gaps.

Preferably, the component amplitudes of one or more further signals are preferably lower than half the component amplitude of the broadband signal. This condition merely states that the uninterrupted playing back of all the hills of the broadband signal achieved in the method according to the invention is achieved when the hills are compressed to half their amplitude, so that a complete levelling of the parts of the broadband oscillation which are high as a result of the superimposition is unnecessary.

In the pressure playback method according to the said earlier proposal, the compressive force exerted on the pressure pickup and originating from a deformation is obviously approximately proportional to the compression depth, if it is assumed that the changes in shape of the deformations takes place within the elastic range. In addition, however, the compressive force achieved is proportional to the supporting area and since this increases proportionately as the wavelength increases (with the width of the recording track remaining constant, for example, in a groove), the frequency response of the played-back signal proportional to $1/\omega$, in which ω signifies the angular frequency. Accordingly, lower frequency signals appear at the output of the pickup with a relatively high amplitude (see Patent Nos. 1,266,202 and 1,266,203). If it is desired to obtain substantially equal amplitudes signals for both or all the superimposed recorded signals during the playing back, then the amplitude of the lower frequency oscillation can be lowered in accordance with the ratio of the frequencies during the recording. This relationship is of great benefit for the continuous playing back of the hills of the broadband signal. A record carrier constructed in accordance with this embodiment of the invention is characterised in that the component amplitudes of one or more further

recorded signals are lower, in the inverse proportion of their wavelengths to the average Wavelength of the broadband signal, than the component amplitude of the broadband signal.

A further signal superimposed on the broadband signal may be a sound signal, control signal or colour signal. A modulated carrier oscillation, for example a sound signal in the form of a frequency-modulated carrier oscillation, is preferably used as such a further signal. A plurality of further signals, for example a sound signal, a control signal and a colour signal, may also be used with the broadband signal, bearing in mind the amplitude ratio necessary between the sum of the further signals and the component amplitude of the broadband signal.

For matching to existing television standards, the colour signal may be a standardised chrominance carrier signal of the PAL, NTSC or Secam systems, namely with a carrier frequency lowered by downward mixing so that it is below the range of frequency deviation of the broadband signal. For a chrominance signal with amplitude modulation, its maximum amplitude is preferably 3 to 4 times smaller than the corresponding maximum amplitude of the wider luminance signal. According to experiments, a suitable frequency for the chrominance carrier may be between 300 and 1000 Kcps.

The invention will now be described in greater detail, by way of example, with reference to the drawing, in which:—

Figure 1 represents an arrangement for pressure playback in accordance with said earlier proposal, wherein the method according to the invention can be used;

Figure 2 is a greatly enlarged representation with a longitudinal section through a groove of a record carrier, provided with deformations, with two superimposed signals dimensioned according to the invention;

Figure 3 is a graphic representation for the case of uninterrupted playing back of the hills of the higher frequency signal oscillation with playback voltages plotted in ordinates against the time axis; and

Figure 4 is a graphic representation corresponding to Figure 3 of the (faulty) case, avoided by the invention, of playing back the higher frequency signals with gaps.

In Figure 1, a portion of a record carrier 1 is illustrated in section and corresponds, in its strength characteristics, to the conditions of the earlier proposal, that is to say is softer than grooved records otherwise used for sound recordings; that part of the record carrier carrying the deformations may have a modulus of elasticity below 20,000 kp/cm², preferably even at or below 10,000 kp/cm². The record carrier may be in the form of a circular disc like a conventional gramophone record or may be in the form of a tape or strip. Contained in a groove 12 in the surface

of the record carrier 1 are the deformations which contain the signal and which may be produced by a stamping, injection-moulding or casting process as with a gramophone record hill-and-dale recordings. The part of the carrier illustrated is displaced in the direction of the arrow shown, in relation to a skid-shaped portion 3 of a pickup which also comprises the mechanical-electrical transducer 2, for example a piezo-ceramic body, and a damping member 5 of a material absorbing oscillations. The output voltage supplied is taken off from the lateral electrical coatings of the transducer 2, to lines 11. The pickup as a whole is secured to the flattened end 7 of a guide arm 6, the other end of which is secured, by means of a resilient joint 9, to a carriage not illustrated which, for example when a record support in the form of a disc and a spiral groove are used, is guided to follow the radial advance of the pickup. As a result of the feed of the record carrier 1 in the direction of the arrow, deformations come under the skid at the left-hand side of the sledge-shaped portion 3 of the pickup, but no pulse-like pressure signal is produced in the course of this as a result of the gradual rise in pressure when the deformations are pressed down. Such a pulse-like signal appears, however, when a deformation appearing as a hill leaves the range of contact of the pickup again at the right-hand side provided with a sharp edge

In Figure 2, a section through the record carrier 1, taken in the longitudinal direction of the grooves, is illustrated greatly enlarged. The relative motion between the record carrier and the pickup skid 3 is again indicated by an arrow. The pickup edge 4 is situated at the left-hand side, while the gradually rising portion of the skid is situated at the right-hand side.

It will be seen that, on feed of the record carrier 1 in relation to the pickup skid 3, the hills 13 of a frequency-modulated broadband signal gradually come into engagement with the skid, which covers a relatively large number of wavelengths, at the right-hand side. The hill 13 on the extreme right is still not in contact with the skid, the hill second from the right has just come into contact, and all the hills further to the left are already pressed in to different extents. At the edge 4, a hill is just passing out of range of the skid so that, in consequence there will be an abrupt decrease in the pressure on the skid. The double amplitude of the broadband component signal is designated by 2b and is constant.

From Figure 2, it can further be seen that, superimposed on the higher frequency broadband signal is a further lower frequency signal, the behaviour of which is represented by the sinusoidal chain line with the dales 14 and the hill 15 situated in the middle of the

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figure. The superimposition leads to the fact that the chain line becomes the centre line of the broadband oscillation and the hills of the broadband oscillation now no longer assume the same level in relation to the pickup. The amplitude of the lower frequency signal is designated by a .

As a result of the tracking force of the pickup skid 3, the hills 13 of the broadband signal are compressed to the greatest extent where they coincide locally with a hill 15 of the lower-frequency signal and assume the highest level in relation to the pickup skid. As a result of the selection of the co-operating parameters, this compression, in the sense of the invention, is so great that even the hill on the extreme left, which is close to the pickup edge 4 and which is in the middle of a dale of the lower frequency signal and therefore assumes the lowest level still experiences a compression which is sufficient for the derivation of a pressure pulse.

This maintenance of contact or of a slight compression even with the hills 13 coinciding with a dale of the lower-frequency signal oscillation is achieved, in particular, by the selection of a sufficiently low amplitude a of the lower-frequency oscillation and of the tracking force of the skid 3 with conditions which are otherwise predetermined. A numerical example may explain the conditions found useful in practical experiments. Let it be assumed that a luminance signal with a bandwidth of 8.5 Mcps for example, a chrominance signal with a bandwidth of 300 Kcps and a sound signal with a bandwidth of 10 kcps are to be recorded. Then the luminance signal can be frequency-modulated first, in a manner known *per se*, for example with a deviation of 1 Mcps in the range from 3 to 4 Mcps. The geometrical amplitude b of this FM recording on the record carrier may amount to 1 μ m. Assuming a chrominance carrier frequency of about 500 Kcps, the geometrical amplitude of the corresponding recording can be reduced in the ratio of 500 Kcps to 3.5 Mcps (average FM carrier oscillation). Thus, in the present case, it amounts to 1/7 μ m. If a sound carrier frequency of 100 Kcps is selected, this geometrical amplitude could actually be lowered to 1/35 μ m. With the sheets of conventional plastics material, for example polyvinyl chloride, which have been tested for the purpose of pressure playback, these reductions in the additional signals are sufficient to ensure a continuous play back of the higher frequency signal in each case. The amplitude ratios given in the example apply for the case where electrical output signals which are equal in magnitude to one another are to be obtained.

In many cases, for example, in order to achieve a higher signal-to-noise ratio, it may be logical to obtain a different magnitude for

one of the signals during play back. In this case, the amplitude ratio must be appropriately modified during the recording. Nevertheless, the conditions applying for uninterrupted mechanical play back, with regard to the depth to which the pickup sledge skid presses into the hills of the FM oscillation must always be adhered to.

The chrominance signal mentioned in the example may be a standardised colour signal (PAL, NTSC, Secam) reduced in the chrominance carrier frequency. During the reproduction, the signal is raised again to the standardised chrominance carrier frequency value by mixing with an auxiliary signal.

Figure 3 shows, in graphical form, the behaviour of the electrical output quantity $S(t)$ of the mechanical-electrical transducer 2, at the leads 11, against the time axis t , when the invention is used. The curve 16 is covered when the pickup edge 4, in Figure 2, travels from its position at the left-hand edge of the drawing towards the right-hand edge of the drawing. When a hill 13 in Figure 2 leaves the pressure range of the pickup skid, there is a sudden reduction each time in the total compressive force exerted on the skid, with a voltage pulse at the transformer 2. These pulses are designated individually by 13'. Their height corresponds to the particular extent of the pressure relief, that is to say, to the extent of the previous compression. Therefore, the pulse train with the lower frequency signal of the curve 14—15—14 in Figure 2 is amplitude-modulated so that the pulse train 16 also has a corresponding amplitude modulation and passes from a dale 14', through a hill 15' back to a dale 14', like the curve of the lower frequency signal in Figure 2. The course of the curve shows that no gap occurs in the playing back of the higher frequency signal. The two oscillation can therefore be separated by means of limiters and filters and reproduced completely in their original form.

The conditions are different in the corresponding illustration in Figure 4. There it is assumed that, as a result of an erroneous selection, not made in accordance with the teaching of the invention, of the parameters essential for the effect, the pickup edge 4 does not retain any contact with hills 13 of the broadband oscillation for the periods of time t_2 and t_3 so that corresponding playback gaps occur in which there are no pulses 13' present. The signals cannot be completely recovered from the resulting output of the pickup, because information is only obtained therefrom during the interval of time t_1 .

The method according to the invention and the record support intended for use in this method are particularly suitable for the recording or reproduction of a complete colour television programme with luminance

signal, chrominance signal and sound signal, but the possibility of accommodating a plurality of further signals beside a broadband signal also exists.

5 WHAT WE CLAIM IS:—

1. A flexible record carrier having stored signals thereon in the form of hill and dale deformations which deformations consist of a broadband signal in the form of a frequency modulated carrier oscillation and at least one further signal of lower frequency than the lowest frequency of the broadband carrier oscillation superimposed on the broadband carrier oscillation, the maximum amplitude of the lower frequency signal being selected such that when the recording is reproduced by a skid shaped pressure pickup operating by compression of the hills of the hill and dale deformations, even the lowest hills contact the skid shaped member and are compressed thereby.

2. A record carrier as claimed in Claim 1, wherein the wavelength of said at least one further signal is longer than the longest wavelength of the broadband signal corresponding to the lower frequency limit of the range of deviation in the broadband signal.

3. A record carrier as claimed in Claim 1 or 2, wherein the component amplitude (a) of said at least one further signals are lower than half the component amplitude (b) of the broadband signal.

4. A record carrier as claimed in Claim 1 or 2, wherein the component amplitude (a) of said at least one further signal is lower in the intense proportion of its wavelengths to the average wavelength of the broadband signal than the component amplitude (b) of the broadband signal.

5. A record carrier as claimed in any one of Claims 1 to 4, wherein the broadband signal comprises a video luminance signal and said at least one further signal comprises a sound signal, control signal or colour signal.

6. A record carrier as claimed in Claim 5, wherein said at least one further signal comprises a modulated carrier oscillation.

7. A record carrier as claimed in Claims 5

or 6, wherein said at least one further signal comprises a colour signal in the form of a standardised chrominance carrier signal (PAL, NTSC or Secam) with a carrier frequency which is lowered to such an extent that it is below the deviation frequency range of the broadband signal.

8. A record carrier as claimed in Claim 7, wherein the chrominance carrier frequency is between 300 and 1,000 kcps.

9. A record carrier as claimed in Claim 6, wherein the carrier frequency is frequency modulated.

10. A record carrier as claimed in Claim 7, wherein for a standardised chrominance signal with amplitude modulation, its maximum amplitude is 3 to 4 times smaller than the corresponding maximum amplitude of the video luminance signal.

11. A method of producing a record carrier with stored signals thereon comprising applying to a flexible record carrier hill and dale deformations, which deformations consist of a broadband signal in the form of a frequency modulated carrier oscillation and at least one further signal of lower frequency than the lowest frequency of the broadband carrier oscillation superimposed on the broadband carrier oscillation, the maximum amplitude of the lower frequency signal being selected such that when the recording is reproduced by a skid shaped pressure pick-up operating by compression of the hills of the hill and dale deformation even the lowest hills contact the skid member and are compressed thereby:

12. A method of producing a record carrier with stored signals thereon substantially as described herein with reference to the accompanying drawings.

13. A flexible record carrier having stored signals thereon substantially as described herein with reference to the accompanying drawings.

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2. A record carrier as claimed in Claim 1, wherein the wavelength of said at least one further signal is longer than the longest wavelength of the broadband signal corresponding to the lower frequency limit of the range of deviation in the broadband signal.

3. A record carrier as claimed in Claim 1 or 2, wherein the component amplitude (a) of said at least one further signals are lower than half the component amplitude (b) of the broadband signal.

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