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(54) INFORMATION RECORD PLAYBACK SYSTEMS

(71) We RCA CORPORATION, a corporation organized under the laws of the State of Delaware, United States of America, of 30 Rockefeller Plaza, City and State of New York, 10020, United States of America 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 present invention relates generally to information records and recording/playback system therefor, and particularly to such apparatus establishing and employing capacitance variation effects in a novel manner permitting, for example, relatively inexpensive mass replication and simple playback of recordings of video signals for display in monochrome or color.

A variety of approaches to information recording exists in the prior art. A common phonograph system using a piezo-electric transducer is an example of an electromechanical system which has proven successful for limited bandwidth applications (for example, audio recordings).

Magnetic tape recording using a helical scan recording and playback mechanism has extended the bandwidth capabilities of prior linear scan magnetic tape systems so that video frequency recording is possible using magnetic tape as the recording medium.

Video signals have been effectively recorded on a phonograph record using bandwidth conversion techniques to allow the recording of lower frequency signals on a phonograph record. The recorded low frequency signals are detected and converted by means of a storage tube into video frequency signals for television display.

These and other similar systems suffer from one or more practical deficiencies, such as lack of adequate bandwidth capability

for video frequencies, insufficiently long playback time, high cost of mass replication or high cost of playback apparatus, et al. Magnetic tape, for example, remains a relative costly medium when employed for video recording. The necessary bandwidth conversion equipment required when using a low bandwidth phonograph record for video recordings remains too expensive for the general consumer public.

A recently developed video disc recording system utilizes a thin flexible disc and electromechanically records and retrieves signals from this video record. Playback requires revolving the record at speeds of the order of 1500 rpm, using a central hub drive, with the record rotating on an air cushion above a stationary platform. The resulting output signals are of sufficient bandwidth to provide a black and white television display. Although disc replication in such a system is relatively inexpensive, the playback time is limited by the relatively fast rotation of the record, and by the fact that only one side of the disc is recorded.

In copending application 13073/72 (Serial No. 1392201) and application no. 49430/74 divided therefrom (Ser. nos. 1392204) a video disc playback system and disc record are described wherein geometric variations in the bottom of a spiral groove on a disc record are relied upon to establish, in cooperation with a tracking stylus incorporating a conductive electrode, capacitance variations representative of video signals as the disc is rotated by a supporting turntable.

The present invention in one aspect thereof also includes a disc record which incorporates geometric variations in an information track in the bottom of a spiral groove in the disc surface, which variations, upon playback, cooperate with a tracking stylus electrode to establish information-representative capacitance variations. How-

ever, in the present case the grooved disc surface comprises conductive material overlaid with a thin coating of dielectric material of substantially uniform thickness. In the overall system, the tracking stylus includes a support element of insulating material tapering to a tip at one end thereof and supporting a conductive electrode terminating at said tip. The stylus tip and groove shapes are so correlated that during playback relative rotational movement can be effected between said disc and stylus with the stylus tip received in the disc groove. Electrically coupled to the stylus electrode is means for responding to variations in the capacitance exhibited between the stylus electrode and the conductive surface of the disc during such relative movement, thereby to develop an electrical signal representative of information recorded in the information track. In particular, circuitry responding to such capacitance variations may readily reconstitute the recorded information in electrical signal form with an acceptable signal-to-noise ratio. The existence of the coated conductive surface on the disc permits the presence of different recordings on both sides of the disc, with playback of one disc side substantially unaffected by the information recorded on the opposite disc side.

The present invention is applicable to wideband information storage and one may provide, for example, a video record/playback system for which the relatively inexpensive mass replication techniques associated with conventional phonograph record stamping may be used to advantage (supplemented by appropriate metallizing and coating techniques). The record medium base material may comprise a relatively inexpensive thermoplastic material, such as vinyl, and the playback apparatus may make use of turntable drive techniques and recording techniques associated with conventional phonographs. Moreover, in such application of the principles of the present invention, one may obtain adequate bandwidth for monochrome or color display with a disc rotation speed (e.g., 360 rpm) significantly less than that required for the above-mentioned air-cushioned, flexible disc system, with the consequence of a significantly greater playing time for a disc side of the same diameter and the same number of grooves per inch. The ability, to record on both sides of the disc provides a further, factor-of-two increase in playing time per record, relative to one-side-only recording systems, such as the aforementioned air-cushioned disc system.

In accordance with an illustrative embodiment, acceptable video displays are obtainable from playback of a disc of vinyl base material, having a conductive layer of

a metal, such as aluminum, vapor deposited on its surface to a thickness of the order of 500 Angstrom units ($\text{\AA}$), and a dielectric coating thereover, of such material as polystyrene, with a thickness comparable to that of the metal layer. For playback at a disc rotation speed of 360 revolutions per minute, the following groove parameters may, illustratively, be employed: groove pitch-1000 grooves per inch, groove width-11 micrometers, total groove depth-5 micrometers. The groove surfaces may be smoothly curved, with the pick-up stylus tip comparably conformed. Thus, the stylus may comprise a suitably shaped tapered support element (formed, e.g., of sapphire) supporting a conductive electrode (e.g., of such material as tantalum, vacuum sputtered on the support element) formed at the stylus tip with a groove bottom engaging surface having a dimension in a direction along the groove of approximately .3 micrometer, and a dimension in a direction transverse to the groove of approximately 5 micrometers.

Illustratively, the information track in the groove bottom may comprise a suitable information-representative pattern of relatively raised and depressed areas, the former constituting undisturbed regions of the groove bottom, while the latter comprise regions depressed below the normal groove bottom by a distance of the order of .4 micrometer. A variety of patterns set forth with greater or lesser particularity, in certain of the appended claims and in the claims of applications nos. 52206/74 and 52207/74 (Ser. Nos. 1392205 and 1392206) divided herefrom, are feasible for use, including: a baseband pattern wherein the video signals are directly represented by the relative widths of a central depressed area and adjoining raised areas in the bottom of the groove; an AM carrier pattern wherein a carrier frequency amplitude modulated by the video signals is represented by successive pairs of regions, a first region of each pair having the relative widths of a central depressed area and adjoining raised areas determined by video signal amplitude, and the succeeding region of each pair having the relative widths of a central raised area and adjoining depressed areas complementarily determined; and a FM carrier pattern, wherein depressed areas extending across the width of the groove bottom alternate with raised areas across the width of the groove bottom, and the spacing between successive areas of the same type (e.g., depressed areas) varies with video signal amplitude.

Initial recording of the video information on a master disc, from which replicas may be derived, may be achieved by a variety of techniques including electromechanical cutting and optical scanning. However, a particularly accurate recording technique,

that may be advantageously employed pursuant to the principles of the present invention, involves use of a scanning electron microscope to selectively expose a photoresist-coating in the grooves of a nickel recording master disc, in appropriate response to the information to be recorded. Subsequent steps to derive vinyl replicas may use techniques comparable to those employed in audio record replication. Final preparation of such replicas includes, pursuant to previously discussed principles of the present invention, application of the metal and dielectric coatings to the replica surface.

Upon playback of the replica disc, a variety of techniques may be employed to derive signals for display purposes from the capacitance variations exhibited between the stylus electrode and the disc's conductive surface. Illustratively, the variable capacitance provided thereby may be used to vary the resonance of a tuned circuit excited by an RF oscillator. A suitable detector circuit may convert the resonance changes to an amplitude varying output signal, which may then be processed in a manner appropriate to the modulation pattern employed on the disc to derive, for example, video output signals for application to a video input monitor, or, for another example, modulated RF signals for application to the antenna terminals of a television receiver.

The invention and its advantages may be more fully understood by those skilled in the art upon a reading of the following detailed description and an inspection of the accompanying drawings in which:

FIGURE 1 is a perspective view of a portion of a record disc groove and a section of the tip of a pickup stylus tracking in the groove thereof, pursuant to an embodiment of the present invention;

FIGURE 2 is a cut-away transverse view of the groove of FIGURE 1 showing the profile of the groove and the modulation contained therein and also illustrating the placement of the pickup stylus tip;

FIGURE 3 is a cut-away side view of the groove of FIGURE 1 illustrating the modulation elements located in the groove;

FIGURE 4 is a top view of a portion of a groove of the general type shown in FIGURE 1, and shows the information track width and a variety of modulation elements therein;

FIGURE 5 is a perspective view of a stylus tip in accordance with a modification of the stylus tip construction illustrated in FIGURES 1 and 2;

FIGURE 6A is a top view of a portion of a groove in which information is recorded in the form of an amplitude modulated carrier signal, pursuant to a variation of the recording technique exemplified by the modulation pattern shown in FIGURE 1;

FIGURES 6B-6D are diagrams showing the capacitance variations detected by a pickup stylus which scans over the portion of the groove shown in FIGURE 6A;

FIGURE 7A is a top view of a groove in which information is recorded in the form of a frequency modulated carrier signal, pursuant to another variation of the recording technique exemplified by the modulation pattern shown in FIGURE 1;

FIGURE 7B is a diagram showing the capacitance variations which would be detected by a stylus tracking the portion of the groove shown in FIGURE 7A;

FIGURE 8 is a top view of a playback mechanism which may be employed in accordance with an embodiment of the present invention to play back a video disc of a form as described above, the view showing a pickup arm assembly and a portion of a player mechanism suitable for scanning the video record disc;

FIGURE 9 is a side view of the playback mechanism of FIGURE 8, showing the turntable and drive mechanism as well as the pickup arm assembly;

FIGURE 10 is a front view of the playback mechanism of FIGURE 8, showing the stylus and the stylus arm drive assembly;

FIGURE 11 is an enlarged front view of the pickup arm assembly of FIGURE 8, showing the placement of the stylus relative to the stylus arm and shield enclosure and the video disc;

FIGURE 12 is a detailed view of the pivot assembly shown in FIGURE 8; and

FIGURE 13 is a circuit diagram partially in schematic and block form of playback circuitry that may be employed to process the capacitance variations detected by the pickup electrode in the playback mechanism of FIGURE 8.

A description of and claims relating to a recording technique and manufacturing procedure for making the record discs will be found in divisional application No. 48664/74 (Serial No. 1392203).

Referring to FIGURE 1, a storage medium 10 comprises a disc having an elongated spiral groove 14 contained therein and, illustratively, fabricated from a thermoplastic material, such as vinyl, as is used in a phonograph record.

The playback mechanism may be somewhat similar to a phonograph player, with a turntable used to rotate the disc while a stylus 20 is suitably held in a position to track the spiral groove; such a playback mechanism will be described in greater detail subsequently. It is noted that only a section of the very tip of stylus 20 is shown in FIGURE 1, which is a greatly enlarged view showing the arrangement of the stylus 20 relative to the groove 14.

Viewing the groove portion of the disc

in detail, it is seen that the base material of storage medium 10 has a conducting surface layer 11 which may, illustratively, be vacuum deposited on its surface. This layer may be of a conductive metal such as aluminum, vapor deposited to a thickness of 500Å, for example. A dielectric coating 12 overlays the metallized layer 11. Layer 12 may, illustratively, be of a dielectric material such as polystyrene, also with a 500Å thickness.

Looking at the topology of the surface of the disc, FIGURE 1 shows a very small portion of the spiral groove 14 illustrating modulation elements 18 in the groove. The modulation system used in the FIGURE 1 example is a base band type in which the signal information is recorded directly without the use of a carrier signal. Other modulation systems which may be alternatively employed will be discussed subsequently. Elements 18 appear as protrusions in a signal information track 16. The elements 18 provide capacitance variations between the pick-up stylus 20 and the metallized layer 11.

As the electrode 23 scans over the modulation elements 18, the area of the metallized layer 11 which is immediately adjacent to the electrode 23 varies in accordance with the recorded signal information. The signal information track 16 covers a substantial amount of the groove area to maximize the difference between maximum and minimum detected capacitance. The remaining area in the groove comprises the groove walls 15 which support stylus 20. The area between successive grooves comprises the land areas 19. It is noted that for the most efficient use of the total disc surface, it is desirable to reduce the land areas to a minimum amount; the relative land area dimensions are exaggerated in FIGURE 1 for ease of illustration.

The indented portion of the information track (i.e., between modulation elements 18) is of nearly uniform depth as shown by the depth dimension 17 of the information track 16 in FIGURE 2. Pursuant to an illustrative set of track dimensions, the depth 17 of track 16 may be about 0.4 micrometer, the groove depth approximately 5 micrometers, and the groove width approximately 11 micrometers.

The pickup stylus 20 illustrated in FIGURE 1 includes first and second dielectric support members 21 and 22, respectively, between opposed faces of which a conductive electrode 23 is embedded. Illustratively, the electrode 23 is approximately 0.3 micrometers in thickness and approximately 5 micrometers in width at the bottom of the stylus at the point where it contacts the groove 14.

The stylus assembly 20 may be fabri-

cated, for example, by vacuum sputtering a conducting material such as tantalum on a sapphire base 21, to form the electrode 23 thereon. The base material can be masked to provide a suitable electrode profile, and the sputtering process suitably controlled to provide a uniform coating of tantalum of the desired thickness. The second support member 22 may then be bonded to the electrode 23, using, for example, a sputtered glass layer 24 as a bonding agent, to form a sandwich structure in which the conducting electrode is embedded. The stylus assembly may then be lapped in a groove including a fine abrasive material to generally conform the tip of the stylus to the shape of the groove 14. An alternative form for the stylus 20 is shown in FIGURE 5 and described in detail subsequently.

FIGURE 2 shows an end view of the groove 14 of FIGURE 1 and the relative position of the stylus 20 with respect thereto. In FIGURE 2, the parts identical to those shown in FIGURE 1 are labeled with the same reference numbers. It is seen that the groove 14 is generally arcuate in cross-section, and the tip of stylus 20 substantially conforms to, and comes into contact with, the groove. By utilizing a dielectric coating 12 over the metallized disc, the exposed surface of the electrode 23 of stylus 20 can be brought into contact with the dielectric coating 12 thereby increasing the maximum-to-minimum capacitance ratio between the electrode 23 and the metallized layer 11 as the electrode scans the disc. When a uniform dielectric coating is employed, the distance between the electrode 23 and modulation elements 18 is maintained relatively constant so that different size styli or worn styli will still provide satisfactory performance. A polystyrene dielectric coating has a relatively low coefficient of friction, thereby reducing stylus wear.

The motion of stylus 20 relative to the groove 14 in FIGURE 2 is transverse to the plane of the drawings. As the electrode 23 scans over the modulation elements 18, the area of the metallized disc immediately under the electrode varies, forming a capacitor which varies in accordance with the recorded signal information. It is noted that, for the illustrative parameters, the metal surface of the depressed regions of the information track 16 which surround the modulation elements 18 is spaced more than .4 micrometer from the electrode 23, whereas the metal surface 11 of the modulation elements 18 is only separated from the electrode 23 by approximately 500Å. Thus, while the total surface area 11 below the electrode 23 is constant, the metal area which presents the significant capacitance to electrode 23 is that portion associated with the modulation elements 18. The capacitance

thus formed is a function of (1) the area of the fixed electrode, which forms one plate of the capacitance and is constant; (2) the thickness of dielectric coating 12 which is also constant, and (3) metallized area 11 of the varying modulation elements 18 in FIGURE 1.

FIGURE 3 is a side view of the groove 14 of FIGURE 1 showing the modulation elements 18 as they appear in the cut-away side view. It is noted that, since the disc has a conductive surface, the electrode of the pickup stylus is effectively shielded from extraneous sources of capacity variations such as signal information or surface defects on the opposite surface of the disc (not shown) which may also be employed for recording, or from defects in the storage medium 10 itself. A relatively constant capacitance exists between the metallized layer 11 and ground which is in series with the signal capacitance (i.e., the capacitance between the pickup electrode 23 and the metallized layer 11). This capacitance can be relatively large and may be formed, for example, between the metallized layer 11 and a conductive turntable base which is grounded, or other grounded conducting objects in proximity to the metallized layer 11.

FIGURE 4 is a top view of a portion of a FIGURE 1 type record groove, illustrating two different recorded signal conditions. The left end (18) of the groove is modulated with both low and high frequency information whereas the right end of the groove (18') is modulated with relatively low frequency information only. When the electrode 23 is over the portion of the groove illustrated as 18'A, the capacitance is at a minimum. When the electrode is over the position 18'B, however, electrode 23 is in close contact with a larger area of the metallized surface 11 and a greater capacitance is detected. At point 18'C in groove 14 it is seen that the information track 16 is completely closed over; thus, a maximum capacitance will be detected. This point may, for example, be a synchronization pulse in a composite television signal. As the pickup scans along the groove 14, capacitance variations corresponding to the modulating information occur between the electrode 23 and the layer 11. These capacitance variations can be electrically detected and converted to form video signals suitable for display by a television monitor.

FIGURE 5 is a greatly enlarged perspective view of a stylus assembly 30 employing a single sapphire mounting structure, pursuant to a modification of the previously described stylus assembly. The sapphire mounting structure has a front surface 31 with a beveled edge 33 leading down to a

second beveled edge 35. A rear surface 34 of the sapphire mounting structure has a conducting element 38 deposited thereon to form the conductor for detecting capacitance variations. The surface 32, between the front and rear faces 31 and 34, respectively, is beveled inwardly toward the front surface 31 to allow the stylus some freedom of motion in the groove 14 of the disc 10. A corresponding beveled surface is not shown but is understood to be formed on the opposite side of the generally trapezoidal shaped stylus tip. Thus, the front surface 31 of the stylus has a triangular cross section, similar in shape to the electrode 38 cross section, but somewhat smaller due to the beveled side surfaces. The disc motion is from the left to right as indicated by the arrow in the drawing. The mounting structure may be fabricated from sapphire which is originally shaped to have a peak portion 37 (shown in dotted lines in the drawing) which is removed by lapping, as explained above in conjunction with FIGURE 1, to conform the stylus tip to the shape of the groove 14. As illustrated, the conducting element 38 may cover the entire rear surface 34 of the stylus assembly 30, deposited to a depth (39) which may be, for example, .3 micrometers.

FIGURE 6A is a top view of groove 14 including an information track 16 whose width substantially covers the width of the groove 14, illustrating recording in the form of an amplitude modulated carrier, pursuant to a variation of the baseband recording technique previously described. The left portion of the illustrated groove, indicated as the portion 42, shows the unmodulated carrier which comprises alternate areas of signal elements 41 and depressed areas 43 (latter indicated by shading in the drawing). Thus, as the pickup stylus (not shown) scans along the groove, the modulation elements 41 will be in contact with the conducting element of the pickup stylus, whereas the depressed areas 43 will be spaced at least .4 micrometer from the pickup stylus. The capacitance between the conductive element and the modulation elements 41 (which are understood to include a metallized surface having a dielectric coating thereon) is shown diagrammatically in FIGURE 6B by the pulses 41' which correspond in location to the signal elements 41 in FIGURE 6A. FIGURE 6C indicates the capacitance in the intervals corresponding to the depressed areas 43. Over the interval 42, no appreciable capacitance exists between the conducting element of the pickup stylus and the metallized surface at the bottom of the depressed areas. FIGURE 6D represents the total capacitance detected by the pickup stylus as it moves along the groove 14. This figure may also represent, for example, an

output signal from electrical pickup circuitry shown in FIGURE 13.

As the carrier signal is modulated by signal information at the right end of the groove (shown by the interval 44), the information track in the groove is selectively cut away in the pattern illustrated in the figure. Successive locations 45-50 are shown which provide capacitance contributions illustrated in FIGURE 6B by the elements 45', 47' and 49' and in FIGURE 6C by the elements 46', 48' and 50'. It is seen that the modulation element locations (41 at the left end of the groove) may have portions of the narrow areas depressed in greater or lesser amounts, while the previously completely depressed areas (43 in interval 42) may be more or less completely depressed during the modulation interval 44. One feature of such a modulation system is that corresponding pairs (i.e., 45-46, 47-48, and 49-50) provide a substantially constant support area of the pickup stylus as it moves along the groove. Although providing a substantially constant support area, the modulation format varies the detected capacitance in accordance with recorded signal information. The boundaries between the unshaded and shaded portions are drawn in heavy lines to indicate the modulation. FIGURE 6D illustrates the combined detected capacitance due to each interval 45-50 of the remaining elements shown. It is seen that during the interval 52 included in the modulation interval 44 the capacitance remains constant as shown by FIGURE 6D. Considering FIGURE 6D as also illustrative of the output signals from an electrical pickup circuit (as shown in FIGURE 15, to be later described), such a signal will remain at a constant level (zero) during the interval 52.

FIGURE 7A is a top view of a portion of a groove 14 including a signal information track 16 which substantially covers the width of groove 14. Illustrated in the groove is a frequency modulation type of recording format in which a carrier signal represented by the elements 53 and 54 at the left end of the groove portion may be frequency modulated by signal information. The depressed areas (54, for example) are indicated by shading in the drawing. At the left end of the illustrated groove, the depressed areas 54 and the interleaved signal element areas 53 represent an unmodulated carrier. As with the amplitude modulation scheme described in conjunction with Figure 6, the capacitance pickup stylus will detect a maximum capacity between the conducting element in the pickup stylus and the metallized surface of the disc (of which groove portion 14 is a part) when the conducting element is centered above a modulation element and comes into contact

therewith. When the conducting element is aligned with a depressed area, the distance between the conducting element and the metallized surface of the disc is increased and the capacitance decreases. FIGURE 7B shows diagrammatically the accompanying capacitance variations and is drawn to a line the capacitance variations 55', 56', 57' and 58' with the corresponding signal elements 55, 56, 57 and 58 of FIGURE 7A. As the pickup stylus scans over the modulation information, it is seen that the negative going capacitance portions of FIGURE 7B correspond to the constant width depressed areas interleaved with the elements 55, 56, 57 and 58 of FIGURE 7A. The spacing between successive depressed areas is varied by the signal to provide the signal information recording. Although FIGURE 7B is a graph of the capacitance changes, it may also represent an electrical signal provided by the pickup circuitry shown in FIGURE 15. As indicated, a method by which information can be recorded on the video disc is described in detail in divisional application No. 48664/74 (Serial No. 1392203) the method there described for exposing a photoresist on a recording master employs a scanning electron beam microscope, but it is possible in some applications to alternatively utilize an optical scanning source for exposing the photoresist. With certain types of modulation systems, such as the described FM system, it is also possible to mechanically cut the recording master by employing a cutting stylus which has its position modulated with signal information.

A description of a playback mechanism and electrical circuitry which may be employed to detect the recorded signal information and convert the detected capacitance variations into usable electrical signals is now presented.

FIGURE 8 is a top view of the record player mechanism on which a video disc 100 is placed. Disc 100 includes a spiral groove 14 on the top surface of the disc and, as shown in the figure, a spiral groove 14' on the under side of the disc. Groove 14' likewise contains signal information for playback by the player mechanism. The mechanism includes a turntable mounting board 102 which has a drive motor and drive mechanism not shown in the FIGURE. A shield enclosure 104 contains a stylus arm 106 which rests on a stylus arm centering bracket 107, when the machine is not operating. The stylus 20 is attached to the stylus arm 106 by means of a stylus mounting cap 108. An aperture 109 in shield enclosure 104 permits the stylus 20 to pass through the shield enclosure and contact the disc 100. The electrical connection to the electrode imbedded in the stylus is made by means of a flexible conductor 130

110 which may be fabricated from beryllium copper, for example. The stylus arm 106 is attached to a groove velocity error correction drive mechanism 125 by means of a flexible pivot assembly 120 which allows the stylus arm 106 to move in a lateral as well as vertical direction during operation.

The shield enclosure 104 and stylus arm 106 are driven to allow the stylus 20 to track the groove 14 by means of a drive shaft 130 (FIGURE 9) which is engaged by an engaging mechanism, coupled to the shield enclosure 104 containing the stylus arm shield enclosure 104 by means of a shield shield enclosure 104 containing the stylus arm 106 is moved transversely across the record by means of the drive shaft 130 to provide approximate tracking with the groove 14. The flexible pivot 120 as well as the flexible conductor 110 allows the stylus arm 105 to float on the disc 100, thereby permitting the stylus 20 to track surface deviations in the disc such as warping. The relative groove velocity error correction drive mechanism 125 is an electromechanical transducer driven by electrical signals by the circuitry shown in FIGURE 13 to compensate for velocity errors due to turntable speed variations, record eccentricity or other velocity errors. The operation of the groove velocity corrector 125 is described in detail in concurrently filed copending application No. 13074/72 (Serial No. 1383336).

In some applications, picture jitter caused by velocity errors can be substantially reduced by modifying the horizontal automatic frequency control (AFC) system of the television receiver used to display the video signal. In such an application, the time constant of the AFC filter is changed to allow the controlled horizontal oscillator to follow the frequency variations of the detected sync pulses due to the velocity errors.

The shield enclosure 104 may also house some of the electrical circuits of FIGURE 13 to minimize stray capacitance and electrical interference by placing the detecting circuits in close proximity with the pickup stylus 20. An inductor 245 to which the electrode 23 is coupled can be mounted on a circuit board 140 without affecting the tracking weight of the stylus 20, since the stylus arm 106 is free floating and independent of the weight of the stylus shield enclosure 104. The other circuit components enclosed within the dashed rectangular box 104 in FIGURE 13 may also be mounted on circuit board 140. A typical tracking force on the stylus 20 is approximately .5 grams.

FIGURE 9 shows a side view of the turntable mechanism showing the arm feed drive motor 150 which is coupled to the drive shaft 130 by means of a drive belt 155 and drive pulley 133. The speed of

motor 150 is selected such that the shield enclosure 104 moves radially and over the disc 100 in proper time relationship to the rotational speed of the disc 100. Thus instead of relying on the spiral groove to pull the stylus arm assembly across the disc, the shield arm enclosure 104 is positively driven by motor 150. FIGURE 9 also shows the turntable drive motor 160 which is a synchronous motor which drives the turntable 101 (illustratively at a rotational speed of 360 r.p.m.) by means of a friction drive wheel 161 coupled to the shaft of motor 160. The disc 100 is centered on turntable 101 by means of a spindle 80 which fits through a centering hole (not shown) in the disc. The components shown in FIGURE 9 (and likewise in FIGURE 10) which are identical to those shown in FIGURE 8 have identical reference numerals. Also shown in FIGURE 9 are the engaging plate 135, the arm slide bar 165, the stop bar 170 and the arm height adjustment mechanism 175, the functions of which are described below in the description of FIGURE 10.

FIGURE 10 shows a front view of the mechanical means for driving the shield enclosure 104 across the disc 100. Referring to this FIGURE, it is seen that the drive shaft 130 has a threaded lead screw portion 131 to which the shield arm enclosure bracket 136 is coupled by means of an engaging mechanism 138. The length of the threaded lead screw 131 is selected so that before the pickup stylus is placed in a groove in the video disc, the engaging mechanism 138 will lie to the right of and thereby not engage the threaded portion 131 of shaft 130. As the innermost groove segment of the disc is reached during playback, the engaging mechanism reaches the end of the threaded lead screw 131 and the pickup arm stops.

The shield enclosure bracket 136 in FIGURE 10 is pivotally mounted on an arm slide bar 165 by means of slide bearings 166 and 166' on either end of the bracket 136. The engaging plate 135 is mounted to the shield enclosure bracket 136 by means of a leaf spring 167 which provides a bias pressure to plate 135. The engaging plate 135 includes a split nut type engaging means 138 which in a preferred embodiment was a pad of Teflon (Registered Trade Mark). An adjustment screw 139 is provided to insure the engaging means 138 disengages the lead screw 131 when the shield enclosure 104 is lifted after playback and returned to its rest position.

A height adjustment mechanism 175 is mounted to the shield enclosure bracket 136 by means of an anchor bolt 176. The height adjustment mechanism 175 engages a stop bar 170 as shown in FIGURE 9 to limit

the travel of shield enclosure 104 in the vertical direction. A height adjustment screw 177 is provided to set the proper limits of travel for shield enclosure 104.

5 In operation, as power is applied to the player mechanism, the drive shaft 130 is rotated by means of the drive belt 155 and drive pulley 133. The shield enclosure 104 is manually lifted and placed in the lead groove of the disc. When so placed, the engaging mechanism 138 will be located over the lead screw portion 131 of rotating shaft 130 and as the shield enclosure 104 is lowered, the engaging mechanism will engage the lead screw 131 and shield enclosure 104 thereupon will be driven transversely across the disc such that the stylus arm 106 will track the proper grooves. As the end of the disc is reached (i.e., the innermost groove) the engaging mechanism 138 will have come to the end of the lead screw 131 and will automatically disengage therefrom. The shield enclosure 104 can then be returned to its initial position or any position on the video disc. Although the player mechanism shown is manually operated, it could readily be adapted for automatic operation.

FIGURE 11 shows an enlarged view of the stylus arm 106 and stylus arm centering ramp 107 as well as some of the other components shown in FIGURE 8. As the shield enclosure 104 is lowered so that the stylus 20 engages a groove (not shown) in the disc 100 supported by the turntable 101, the stylus arm 106 will be lifted from the centering ramp 107 because of the horizontal and vertical compliance of the flexible connector 110 and the pivot assembly 120 (shown in FIGURE 8). The stylus arm centering ramp is designed so that during playback the stylus arm 106 will not contact the ramp. If the drive mechanism produces a minor tracking error, the stylus arm 106 will be able to move laterally to follow the groove. At the end of the playing of the disc when the shield enclosure 104 is lifted, the stylus arm 106 will return to its center position due to the beveled edges of the stylus arm centering ramp 107. The flexible pivot assembly (120 in FIGURE 8) which operates in conjunction with the flexible connector 110 to enable the stylus arm 106 to track the record groove is shown in FIGURE 12.

In FIGURE 12 it is seen that the flexible pivot comprises an arm mount member 180, a spring mounting member 190 and a mounting bracket assembly 200. The arm mount 180 is attached to the stylus arm 106 and the mounting bracket assembly 200 has a mounting lug 204 which is attached to the groove velocity error corrector 125 (shown in FIGURE 8) by means of a locking screw shown in FIGURE 8. The

arm mount assembly 180 includes slots 182 and 184 and the mounting bracket assembly 200 includes slots 206 and 208. A spring member 195 mounted in the spring mounting plate 190 has tab members 192 and 194 which fit into slots 182 and 184 respectively of the arm mount assembly 180; and tabs 196 and 198 which fit into slots 206 and 208 respectively of mounting bracket assembly 200. It is noted that these tabs do not slide completely into the respective slots but allow a small clearance which forms leaf springs to allow horizontal and vertical motion. In FIGURE 12 it is seen that spring tabs 192 and 194 allow vertical motion of the stylus arm 106 relative to the mounting bracket 200 and spring tabs 196 and 198 allow horizontal motion with respect to mounting bracket 200. This arrangement thereby allows relatively easy vertical and horizontal motion of the stylus arm while preventing rotational motion of the arm and, in addition, provides the necessary longitudinal strength (i.e., in the direction of the length of stylus arm 106) to allow the groove velocity error correction mechanism 125 to move the stylus arm assembly in the longitudinal direction.

FIGURE 13 is a circuit diagram, partially in block and partially in schematic form, of electrical circuitry which may be employed to process the capacitance variations detected between the electrode 23 and the metallized surface 11 of the recording medium 10 (of FIGURE 1) to produce useful output signals. When the baseband recording system is employed to record information on the video disc, the circuit can be, for example, used to provide an amplitude modulated carrier signal which is applied to the antenna terminals of a television receiver for producing a television display. In FIGURE 13, variable capacitor 300 represents the capacitance between the electrode 23 and the metallized surface 11 of the disc, which capacitance is varied by the signal elements recorded in the disc. The series capacitor 305 shown in dashed lines represents the capacitance between the metallized layer 11 and ground. The electrode 23 is coupled to an inductor 245 by means of the electrical conductor 110 (also shown in FIGURE 8). Inductor 245 has a tap terminal 249 to which is coupled a peak detector circuit 255 comprising a diode 256 and the parallel combination of a resistor 257 and a capacitor 258 coupled from a terminal on the diode remote from its connection to inductor 245, to ground. Capacitor 258, shown as a lumped parameter in FIGURE 13, may, in an actual circuit, simply comprise the sum of the stray capacitance of the leads and the input capacitance of the pre-amplifier 260. A second tap terminal 247 on inductor 245 is coupled to

ground. An RF oscillator 250 applies radio frequency signals to inductor 245. A pre-amplifier 260 is coupled to the peak detector circuit 255 and provides amplified signals at its output. Circuit elements 245, 255 and 260 can be mounted in the shield enclosure 104 to reduce the stray reactances by placing the components in proximity with the pickup electrode. This is illustrated in the FIGURE by the dashed lines surrounding these circuit components. The output of pre-amplifier 260 is coupled to an amplifier 270 which further amplifies the detected signals. The output of amplifier 270 is coupled to AM modulator 280 and to a sync separator circuit 290. The output of the sync separator circuit 290 is coupled to a discriminator circuit 310. The output of the discriminator circuit 310 is coupled to an amplifier 315 which is coupled to the groove velocity correction circuit 125 shown in FIGURE 13. An oscillator circuit 320 produces a carrier signal which is applied to the AM modulator 280, and is modulated by the signal information from amplifier 270. The amplitude modulated carrier from modulator circuit 280 which appears at an output terminal A can then be applied to the antenna terminals of a television receiver, for example, or to a cable television network.

In operation, the RF oscillator 250 provides an excitation voltage to a resonant circuit which comprises the capacitor 300, capacitor 305, the inductor 245, the junction capacitance of diode 256 and the stray capacitance 258. The inductor segment between the RF oscillator 250 and terminal 247 operates as an auto-transformer primary, coupling the RF excitation signal to the resonant circuit. As the resonant frequency of the circuit is varied due to variations of capacitance 300, the amplitude of the excitation voltage at input of the diode varies. The resonant circuit Q and the excitation voltage level are chosen to provide a steep voltage vs. frequency characteristic at tap 249 so as to yield a signal detected by peak detector 255 of sufficient magnitude. The Q must be chosen, however, such that the resonant circuit simultaneously provides adequate bandwidth. The frequency of oscillator 250 is chosen such that it falls on one side of the frequency response curve of the resonant circuit and as the frequency of the resonant circuit changes due to signal information, will remain on that slope of the shifting frequency response of the resonant circuit during all signal conditions. Thus, as the electrode 23 tracks groove 14, capacitance 300 varies in accordance with the recorded information. The varying capacitance shifts the resonant frequency of the tuned circuit which includes capacitance 300. Since a constant

frequency bias signal (from oscillator 250) is being applied to the circuit, as the resonant frequency varies, the response of the circuit to the bias frequency changes as a function of the recorded information, thereby providing an amplitude varying output signal at terminal 249. Peak detector 255 detects these amplitude variations by means of diode 256 and the filter network comprising resistor 257 and capacitor 258 removes the frequency components above the signal information. In one embodiment, inductor 245 was fabricated from 15 turns of No. 30 (A.S.W.G.) copper wire, tightly wound on a 1/8 inch diameter mandrel. Tap 249 was five turns from the connection of inductor 245 to conductor 110. Tap 247 was eight turns down from tap 249 and the oscillator 250 was coupled to inductor 245 two turns down from tap 247. Diode 256 was a Hewlett Packard Associates type 2900 and resistor 257 was 10 kilohms. The capacitance 258 had a reactive impedance of 5 kilohms at a frequency of 4MHz.

The signals from detector 255 are coupled to pre-amplifier 260 which can also be mounted in the shield enclosure 104 to reduce noise interference with the signal. The output signal from amplifier 260 is then applied to a second amplifier 270 for further amplification. In an illustrative embodiment, amplifier 260 has a voltage gain of ten, while amplifier 270 has a voltage gain of 100. Output signals from amplifier 270 can be employed to drive whatever system the signals are recorded for. For example, if used for audio frequencies, signals from amplifier 270 can be applied to a power amplifier for driving sound transducers. When utilized for audio frequency recording, the turntable rotational speed can, of course, be greatly reduced to increase the playing time.

In the embodiment shown in FIGURE 13, the system is employed for the recording and playback of baseband recorded NTSC television signals including synchronization signals. Thus, the output signal of amplifier 270 will include video frequency signals as well as vertical and horizontal synchronization signals. A sync separator circuit 290 separates the horizontal synchronization pulses from the composite signal and couples them to a discriminator circuit 310. The discriminator is designed to provide a control voltage when the synchronization signals from separator 290 vary from the nominal 15.7 KHz rate due to groove velocity changes. Thus, it is seen that the synchronization signal frequency provides a pilot tone recorded on the disc which can be detected by discriminator 310 to provide a control voltage when the recorded sync signal frequency deviates from its proper value due to disc velocity errors.

The control signal from discriminator 310 is applied to the mechanism 125 of FIGURE 8 by means of amplifier 315 to provide a corrective longitudinal motion to the stylus arm 106 in a direction to tend to cancel the groove velocity error. The operation of this groove velocity corrector and detector circuit is explained in greater detail in application No. 13074/72 (Serial No. 1383336) previously mentioned. The composite signal from amplifier 270 can also be applied to an amplitude modulator circuit 280 if it is desired to couple the video signals to the antenna terminals of a television receiver. Oscillator 320 has a frequency chosen to coincide with one of the UHF or VHF channels of a television receiver and supplies a carrier wave to the modulator which is amplitude modulated by the video and synchronization signals from amplifier 270. Modulator 280 includes video clamp circuitry for clamping the video level at a predetermined value. The amplitude modulated signal from stage 280 can then be coupled directly to the antenna terminals of a standard television receiver which serves as the display device for video signals recorded on the video disc 100 of FIGURE 8.

The circuitry described is used when baseband signals are recorded on the video disc. When AM carrier signals (such as shown in FIGURE 6) are recorded, the AM modulator 280 of FIGURE 13 would be replaced by a mixer circuit to shift the frequency of the detected AM carrier signal to one of the television channels. Also a peak detector circuit is inserted prior to the sync separator to provide detected composite video signals from the modulated carrier signals.

Likewise, a circuit modification is necessary when the FM recording system illustrated in FIGURE 7 is employed to record signals on the disc. In such case, an FM detector circuit must be inserted into the circuit of FIGURE 13 immediately after the amplifier 270 (i.e., between amplifier 270 and the AM modulator 280 and sync separator 290). It is noted that with all of the various recording schemes, the front end of the pickup circuit (i.e., those components in block 104, the RF oscillator 250, and the signal and stray capacitances 300 and 305 respectively) is identical and only small circuit modifications are necessary when switching from one recording format to another.

WHAT WE CLAIM IS:

1. A record playback system comprising: a disc record having a spiral groove in a conductive surface thereof, said groove containing an information track constituted by variations in the geometry of the bottom

of the groove with a dielectric coating of substantially uniform thickness overlying said conductive surface; a stylus including a support element of insulating material tapering to a tip at one end thereof and supporting a conductive electrode terminating at said tip; means for effecting during playback relative rotational movement between said disc and stylus with the stylus tip received in the disc groove; and means electrically coupled to said stylus electrode for responding to variations in the capacitance exhibited between the stylus electrode and said conductive surface of said disc during such relative movement thereby to develop an electrical signal representative of information recorded in said information track.

2. A record playback system according to claim 1 wherein the stylus electrode terminates in a curved edge surface matching a predetermined cross-sectional curve defined in the bottom of the groove.

3. A record playback system according to claim 1 wherein the information track in the record groove is constituted by variations in the depth of the groove in a region thereof between groove sidewalls of substantially invariant geometry.

4. A record playback system according to claim 1 wherein said geometry variations of the bottom of the groove are provided by a combination of areas of the groove bottom which are depressed, and other areas which are un-depressed, relatively to a continuous smooth curve at least in part defined in the cross-section of the groove by the un-depressed areas and the groove sidewalls.

5. A record playback system according to claim 1 wherein the bottom of the groove includes first recurring regions regularly spaced along the length of the groove and in each of which at least a portion of the groove bottom is depressed to a maximum depth with any remaining portion of the groove bottom area in each such region raised relative to said maximum depth, and second regions separating the first regions and in each of which at least a portion of the groove bottom area is raised relative to said maximum depth with any remaining portion of the groove bottom area in each second region depressed to said maximum depth, the percentage of depressed groove bottom area in each first region varying in accordance with the recorded information, and the percentage of depressed groove bottom area in an adjoining second region varying complementarily with respect to that in the first region so that the percentage of groove bottom area raised relative to said maximum depth in successive pairs of first and second regions remain substantially constant and independent of the recorded information.

The control signal from discriminator 310 is applied to the mechanism 125 of FIGURE 8 by means of amplifier 315 to provide a corrective longitudinal motion to the stylus arm 106 in a direction to tend to cancel the groove velocity error. The operation of this groove velocity corrector and detector circuit is explained in greater detail in application No. 13074/72 (Serial No. 1383336) previously mentioned. The composite signal from amplifier 270 can also be applied to an amplitude modulator circuit 280 if it is desired to couple the video signals to the antenna terminals of a television receiver. Oscillator 320 has a frequency chosen to coincide with one of the UHF or VHF channels of a television receiver and supplies a carrier wave to the modulator which is amplitude modulated by the video and synchronization signals from amplifier 270. Modulator 280 includes video clamp circuitry for clamping the video level at a predetermined value. The amplitude modulated signal from stage 280 can then be coupled directly to the antenna terminals of a standard television receiver which serves as the display device for video signals recorded on the video disc 100 of FIGURE 8.

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of the groove with a dielectric coating of substantially uniform thickness overlying said conductive surface; a stylus including a support element of insulating material tapering to a tip at one end thereof and supporting a conductive electrode terminating at said tip; means for effecting during playback relative rotational movement between said disc and stylus with the stylus tip received in the disc groove; and means electrically coupled to said stylus electrode for responding to variations in the capacitance exhibited between the stylus electrode and said conductive surface of said disc during such relative movement thereby to develop an electrical signal representative of information recorded in said information track.

2. A record playback system according to claim 1 wherein the stylus electrode terminates in a curved edge surface matching a predetermined cross-sectional curve defined in the bottom of the groove.

3. A record playback system according to claim 1 wherein the information track in the record groove is constituted by variations in the depth of the groove in a region thereof between groove sidewalls of substantially invariant geometry.

4. A record playback system according to claim 1 wherein said geometry variations of the bottom of the groove are provided by a combination of areas of the groove bottom which are depressed, and other areas which are un-depressed, relatively to a continuous smooth curve at least in part defined in the cross-section of the groove by the un-depressed areas and the groove sidewalls.

5. A record playback system according to claim 1 wherein the bottom of the groove includes first recurring regions regularly spaced along the length of the groove and in each of which at least a portion of the groove bottom is depressed to a maximum depth with any remaining portion of the groove bottom area in each such region raised relative to said maximum depth, and second regions separating the first regions and in each of which at least a portion of the groove bottom area is raised relative to said maximum depth with any remaining portion of the groove bottom area in each second region depressed to said maximum depth, the percentage of depressed groove bottom area in each first region varying in accordance with the recorded information, and the percentage of depressed groove bottom area in an adjoining second region varying complementarily with respect to that in the first region so that the percentage of groove bottom area raised relative to said maximum depth in successive pairs of first and second regions remain substantially constant and independent of the recorded information.



6. A record playback system according to claim 5 wherein the groove cross-section in each of said regions has a shape such that the surfaces of the groove sidewalls and any raised portion of the groove bottom area define respective sections of a continuous smooth curve.

7. A record playback system according to claim 1 wherein the groove cross-section alternates along said groove between a first shape in which the surfaces of the groove sidewalls and the intervening groove bottom define a continuous smooth curve and a second shape in which the surface of said intervening groove bottom is depressed relative to a groove bottom level corresponding to said continuous smooth curve.

8. A record playback system according to claim 7 wherein the capacitance exhibited between said stylus electrode and said conductive surface of said disc varies between a maximum exhibited when the tip of said stylus is within a groove region of said first cross-sectional shape and said curved edge surface of said stylus electrode is separated from said conductive surface of said disc by a first distance substantially equal to the thickness of said dielectric coating, and a minimum exhibited when the tip of said stylus is within a groove region of said second cross-sectional shape and said curved edge surface of said stylus electrode is separated from said conductive surface of said disc by a second distance exceeding said first distance by a distance corresponding to the extent of groove bottom depression relatively to said level.

9. A record playback system according to claim 4, 6, 7 or 8 wherein the groove bottom, where depressed, is depressed relatively to the level corresponding to said continuous smooth curve by a distance greater than the thickness of said dielectric coating.

10. A record playback system according to claim 2 and claim 4, 6, 7, 8 or 9 wherein said curved edge surface of the stylus electrode matches said continuous smooth curve at least in a central area of the groove.

11. A record playback system according to claim 10 wherein with said stylus tip received in said groove for playback said curved edge surface of the stylus electrode abuts the coated groove bottom where not depressed relatively to said continuous smooth curve.

12. A record playback system according to any preceding claim, wherein said stylus support element has an external face extending substantially symmetrically about a plane of symmetry for said support element and has tapering edges in the vicinity of said conductive electrode, the latter being provided on said face of said support element.

13. A record playback system according to claim 12, wherein the material of said support element underlying said face to a depth appreciably exceeding the thickness of said electrode, and the conductive electrode on said face, both terminate at the stylus tip with curved edge surfaces substantially matching at least a central section of the groove bottom.

14. A record playback system according to any preceding claim, wherein said conductive surface of the disc is provided by a conductive coating overlying a grooved disc substrate, said conductive coating having a substantially uniform thickness of a dimension sufficiently small, relative to the dimensions of said groove and the geometry variations in the groove bottom, that said conductive coating follows the contours of said groove and the groove bottom variations.

15. Playback apparatus for use with a disc record having a dielectrically coated conductive surface and a spiral groove in said surface containing a record information track constituted by variations in the geometry of the bottom of the groove, said playback apparatus comprising: a stylus including an elongate support element of insulating material tapering to a tip at one end thereof, and provided on a face having tapering edges in the vicinity of said tip with a conductive electrode of substantially uniform thickness; a turntable for supporting said disc record in a playing position permitting disc groove entry by said stylus tip; turntable rotating means for establishing in said playing position of the disc record relative motion between it and said stylus longitudinally of the groove to cause capacitance variations between said stylus electrode and said conductive surface of said disc according to said geometry variations; and means electrically coupled to the stylus electrode and responsive to said capacitance variations for developing an electrical signal representative of information recorded in said information track.

16. Playback apparatus according to claim 15 wherein said relative motion provides capacitance variations between a maximum when the stylus electrode is opposite a groove region of minimum groove bottom depth, and a minimum when the stylus electrode is opposite a groove region of maximum groove bottom depth.

17. Playback apparatus according to claim 15 or 16 wherein the material of said support element underlying said face to a depth appreciably exceeding the thickness of said electrode, and the conductive electrode on said face, both terminate at said tip with curved edge surfaces of a predetermined curvature to match a cross-sectional curvature defined in at least a central section of the groove bottom.



tion of the disc record groove bottom.

18. Playback apparatus according to claim 17 wherein the degree of tapering of said edges of said support element face is sufficient to allow entry of said stylus tip within the coated groove to a depth permitting abutment of said curved edge surfaces of the stylus with the coated groove bottom.
19. Playback apparatus according to any one of claims 15-18 wherein said face of the stylus support element extends substantially symmetrically about a plane of symmetry of said element.
20. Playback apparatus according to any one of claims 15-19 wherein in a plane transverse to the stylus elongation the thickness of the stylus electrode transverse to said face of the stylus is small relative to its lateral dimension near said tip.
21. A stylus for playback of information recorded on a disc record as depth variations in the bottom of a spiral groove provided in a surface of the disc record and having a predetermined cross-sectional curve defined in the bottom of the groove, said stylus comprising an elongate support element of insulating material tapering to a tip at one end thereof, said support element having a face with tapering edges in the vicinity of said tip; a conductive layer on said face of said support element; said conductive layer terminating at said tip with a curved edge surface substantially matching the curvature of at least a central section of the curve defined in the bottom of the disc record groove whereby abutment of a significant area of said curved edge surface with portions of said groove bottom defining said groove in a central region thereof may be achieved.

22. A stylus according to claim 21 wherein said conductive layer comprises a conductive coating affixed to said face of the support element, the material of said support element underlying said face to a depth appreciably exceeding the thickness of said coating, and the conductive coating itself, both terminating at the stylus tip with curved edge surfaces substantially matching the curvature of at least said central section of the groove bottom curve of the disc record.

23. A stylus according to claim 21 or 22 wherein said conductive layer is of uniform thickness.

24. A stylus according to claim 21, 22 or 23 wherein said conductive layer is a coating of conductive material on a rear face of said support element tip, the latter also having an uncoated front face and converging side faces extending from said rear face towards said front face.

25. Record playback apparatus substantially as hereinbefore described with reference to the accompanying drawings.

26. A record playback system (including the record substantially as hereinbefore described with reference to the accompanying drawings.

27. A record playback stylus substantially as hereinbefore described with reference to Figure 5 of the accompanying drawings.

T. I. M. SMITH

Chartered Patent Agent,

50, Curzon Street,
London. W1Y 8EU

Agent for the Applicant

