

PATENT SPECIFICATION

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(54) INFORMATION RECORDS AND METHOD OF MAKING SAME

(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 is divided from application No. 13075/72 (Serial No. 1,392,202) to which reference may be had for a discussion of the background to the invention.

The parent application is directed to a novel form of information record disc and playback system suitable for video information and involving the provision on the record disc of a dielectrically coated conductive surface having therein a spiral groove dimensioned to receive a playback stylus and containing an information track constituted by variations in the bottom geometry of the groove. The conductive surface may be constituted by a conductive coating on a grooved disc substrate. The playback stylus includes a conductive electrode. On playback, changes in capacitance between this electrode and the conductive surface of the disc, resulting from the groove bottom geometry variations, are sensed to provide a signal representative of the recorded information.

The present invention is directed to a method of recording such information on a disc substrate which can subsequently be conductively coated to provide the conductive surface.

According to the present invention, an information recording method comprises the steps of coating a spiral groove in the surface of a disc with a material of a character exhibiting a difference in its resistance to dissolution in a given developing fluid after subjection to electron beam bombardment; intruding successive regions of the coated groove bottom along said spiral on said disc

surface in the path of a beam of electrons, while simultaneously alternating the intensity of said beam of electrons between a first intensity level substantially equal to zero and a second intensity level appreciably greater than zero, under the control of signals to be recorded; and subjecting said disc surface, after said intrusion of said coated groove bottom regions in said path, to the influence of said given developing fluid whereby to provide a disc having groove bottom regions alternating between differing depths in accordance with said signals.

As is described hereinafter, the alternation of the beam intensity can be so controlled in time as to produce certain particular groove bottom geometries some of which form the subject of divisional applications Nos. 52206/74 and 52207/74 (Serial Nos. 1,392,205 and 1,392,206). As regards the disc record itself, attention is drawn to application No. 49430/74 (Serial No. 1,392,204).

The invention in its several aspects may be more fully understood from the following description of the accompanying drawings repeated from the parent application and in which:

Figure 1 is a perspective view of a portion of a grooved storage medium and a section of the tip of a pickup stylus tracking in a groove thereof;

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 4A 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 modified recording technique according to the present invention;

Figures 4B—4D are diagrams showing the capacitance variations detected by a pickup

stylus which scans over the portion of the groove shown in Figure 4A;

5 Figure 5A is a top view of a groove in which information is recorded in the form of a frequency modulated carrier signal, pursuant to another such modified recording technique;

10 Figure 5B is a diagram showing the capacitance variations which would be detected by a stylus tracking the portion of the groove shown in Figure 5A;

15 Figure 6 is a circuit diagram partially in block form showing circuitry which may be adapted for effecting recording by a technique in accordance with the present invention;

20 Figure 7 is a flow diagram illustrating in portions 7A through 7J a process by which a capacitive video disc may be manufactured utilizing the recording technique just mentioned;

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

30 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 is described in greater detail in the parent application. 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.

40 Viewing the groove portion of the disc in detail, it is seen that the base material of disc 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.

50 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. The modulation systems of more particular concern for the present invention will be discussed subsequently. Elements 18 appear as protrusions in a signal information track 16. The elements 18 provide capacitance variations between the pickup stylus 20 and the metallized layer 11.

65 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.

75 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.

80 The pickup stylus 20 illustrated in Figure 1 includes first and second dielectric support members 21 and 22, and a conductive electrode 23. 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. An alternative form of stylus is also described in the parent application.

85 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.

90 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

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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.

Figure 4A is a top view of a groove 14 illustrating a modified form of recording in the information track 16, the recording being in the form of an amplitude modulated carrier. 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 (when provided with a metallized surface having a dielectric coating thereon) is shown diagrammatically in Figure 4B by the pulses 41' which correspond in location to the signal elements 41 in Figure 4A. Figure 4C 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 4D 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 connected to the stylus to respond to the varying capacitance.

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 4B by the elements 45', 47' and 49' and in Figure 4C 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 to 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 4D 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 4D. Considering Figure 4D as also illustrative of the output signals from an electrical pickup circuit, such a signal will remain at a constant level (zero) during the interval 52.

Figure 5A is a top view of a portion of a groove 14 illustrating 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 4, the capacitance pickup stylus will detect a maximum capacity when the conducting element in the pickup stylus is centered above a modulation element and comes into contact therewith. When the conducting element is aligned with a depressed area, the capacitance decreases. Figure 5B shows diagrammatically the accompanying capacitance variations and is drawn to align the capacitance variations 55', 56', 57' and 58' with the corresponding signal elements 55, 56, 57 and 58 of Figure 5A. As the pickup stylus scans over the modulation information, it is seen that the negative going capacitance portions of Figure 5B correspond to the constant width depressed areas interleaved with the elements 55, 56, 57 and 58 of Figure 5A. The spacing between successive depressed areas is varied by the signal to provide the signal

information recording. Although Figure 5B is a graph of the capacitance changes, it may also represent an electrical signal provided by pickup circuitry connected to the stylus electrode. The method by which information is recorded in the various recording formats discussed above is described in detail below in the discussion of the manufacture of a video disc.

5 The record disc 10 (shown in Figure 1) may be pressed from a recording medium such as a nickel stamping master in much the same manner as a phonograph record is manufactured. Due to the extremely small dimensions of the grooves and modulation elements, however, the fabrication of such a stamping master may be relatively complex. A flow chart, shown in Figures 7A-7J, aids in understanding of the various steps of an illustrative procedure which may be employed pursuant to principles of the present invention to obtain a completed video disc. The flow chart portion between Figure 7A and Figure 7G represents an illustrative seven-step process for stamping master production, which will now be described in detail.

10 (1) In Figure 7A, a base disc 85 of a one-half inch thick aluminum blank 14 inches in diameter is machined flat to .0002 inches. A protective coating of pyralin polyamide is applied to the machined aluminum surface to prevent chemical attack of the aluminum base through pinholes in a lacquer coat which is next applied to the base disc. A uniform layer 86 approximately .005 inches thick of Randolph recording lacquer is applied to the polyamide surface. After drying, the lacquer is machined flat to .0002 inches and the original grooves, comprising a single closed end 360° groove at the outer periphery of the disc and a spiral groove, are machined in the lacquer using a sapphire cutting tool having a radius of .0002 inches. The depth of the cut is .0005 inches and the spiral groove pitch is approximately 1,000 grooves per inch.

15 (2) After sensitizing the surface of the lacquer coating with a solution of stannous chloride, a conductive coating of silver 87 is chemically deposited on the lacquer. A nickel layer 88 is then electroplated to the silver coating to a depth of .010 inches to form a nickel replica of the lacquer layer. As shown in Figure 7B, the entire disc is in a sandwich form comprising the aluminum base disc 85, a lacquer coating 86 with the original grooves, a silver coating 87, and a layer of nickel 88 having negative grooves (negative grooves are defined as being the inverse of the original lacquer grooves).

20 (3) As shown in Figure 7C, the nickel replica is then cemented to a second aluminum base 90 which is prepared in a

manner similar to the first base. Epoxy 89 is spread over the machined surface of the second aluminum base and the second aluminum base is pressed onto the electroplated nickel replica to bind the nickel replica to the second aluminum disc. When the epoxy has partially cured, the sandwich structure is clamped into a fixture which is employed to separate the two alumina discs at the interface A between the lacquer coating 86 on the first aluminum disc and the chemically deposited silver 87.

25 (4) Once separated, the second base includes the nickel replica 88 epoxied to the base 90 and the silver coating 87 over the nickel. The grooves in the nickel are a negative replica of the original lacquer grooves. The silver layer is then passivated with a solution of potassium dichromate. A second nickel layer 91, .010 inches deep, is then electroplated onto the passivated silver coating to form the nickel recording master shown in Figure 7D.

30 (5) A third aluminum disc 93 is prepared in the same manner as the first and second discs and epoxy 92 is applied to its machined surface. As illustrated in Figure 7E, the third disc 93 is then pressed to the nickel recording master. Once the epoxy has partially cured, the entire structure is placed in the separating fixture and the nickel recording master is separated from the nickel replica at the interface (illustrating as point B in Figure 7E) between the electroplated nickel master 91 and the passivated silver coating 87.

35 (6) The nickel recording master has positive grooves (i.e. the same as the original lacquer grooves) on its surface, which is then cleaned. A positive working photoresist 94 is then applied to the surface of the nickel recording master as illustrated in Figure 7F. Once the photoresist has dried, a small area of the locked groove has its photoresist removed and a 1/16" dot of Aquadag (Registered Trade Mark) is placed on the exposed metal surface. Adjacent to the dot several scratches are cut. The dot and scratches serve as a target for the electron beam of a scanning electron microscope (S.E.M.) which is used in the recording of the signal information and are used to adjust the beam current of the S.E.M. and to focus the S.E.M. beam respectively. The disc is now ready for exposure by the beam of the scanning electron microscope to modulate the spiral groove with information to be recorded. The recording is accomplished by selectively exposing the photoresist coating which covers the recording master surface and is completed between the steps 7F and 7G of the flow chart of Figure 7.

40 Since the dimensions of the spiral groove and signal information therein are relatively small, care must be exercised to properly align and mount the recording master before

the recording process is begun. A description of the procedure used is given here:

After the photoresist coating is deposited on the nickel recording master, the structure including its aluminum base is mounted on a turntable fixture located in a vacuum chamber adapted to operate in conjunction with a scanning electron microscope (S.E.M.) utilized to expose the photoresist. The S.E.M. employed in one application was a Stereoscan Model No. 2A manufactured by Cambridge Scientific Instruments Ltd. Adjustments are provided on the turntable for aligning the master using a dial indicator gauge to insure the surface of the disc is in a horizontal plane within .0004 inches (peak-to-peak deviation). Before the chamber is evacuated, the record is also inspected and its position on the turntable adjusted so that it is concentrically mounted. This is accomplished by using an optical microscope having a cross hair reticle under which the locked groove is positioned. The locked groove is a separate single 360° groove at the outer periphery of the nickel recording master. As the turntable is rotated, the position of the recording master is varied relative to the center of rotation of the turntable to insure the locked groove remains under the intersection of the cross hair reticle (within $\pm .0005$ inches) during a complete revolution.

Once the record master is mounted on the turntable and properly aligned, it is positioned, so that the S.E.M. beam will impinge on the Aquadag dot placed near the locked groove during the processing of the record master. It is noted that the optical microscope is mounted above the turntable so that its field of view will have its center coincide with the center of the S.E.M. electron beam landing area. When the record master is prepositioned so that the Aquadag dot on the disc is located at the center of the field of view of the optical microscope the beam from the S.E.M. will impinge on the Aquadag dot once the optical microscope is removed and the column of the S.E.M. is placed above the turntable. After optically prepositioning the record master, the optical microscope is removed and the S.E.M. column is coupled over the vacuum chamber which is now evacuated.

The electron beam of the S.E.M. falls on the Aquadag dot to which an electrical contact is made through the conductive nickel so that the S.E.M. electron beam current can be measured. The beam current is adjusted to its desired level by measuring this current. The turntable is then translated slightly so that the beam falls on the scratches adjacent the Aquadag dot and the S.E.M. is focused on the scratches using the normal S.E.M. focusing procedures.

Once the beam is focused the current is set, the turntable is translated radially until

the electron beam falls on the flat land area between the locked groove and the spiral groove. This area is relatively flat and serves as the calibration surface for a balanced type position detector which responds to reflected electrons from the surface of the photoresist on the recording master. The detector is calibrated for a null reading when the beam is located over the relatively flat land area but produces an output signal when the beam falls on a slanted surface and therefore will provide signal information as to the position of the electron beam of the S.E.M. relative to a groove. Once the detector is calibrated, the turntable assembly is translated radially until the spiral groove is detected by the position detector.

The turntable is rotated by a drive mechanism and brought to its recording speed, illustratively .9 r.p.m. held constant to approximately 1%. As the position detector indicates alignment with the center of the spiral groove, a control system utilizing the output signal from the position detector is activated to lock the electron beam to the center of the groove. Simultaneously, the radial drive translation mechanism is activated so that the turntable is moved under the landing point of the S.E.M. electron beam at a rate of one groove spacing per revolution of the turntable. The rotation of the turntable is controlled by a closed loop system to maintain the rotational speed constant. As the recording master is rotated and translated under the beam, the photoresist is selectively exposed by the electron beam of the S.E.M. by deflecting the electron beam across the groove at a predetermined rate and by blanking the electron beam in an appropriate manner to record the signal information. Illustrative electrical circuits which may be employed to provide the signals for modulation of the electron beam of the S.E.M. are shown in Figure 6, and will now be described (before returning to the flow chart consideration).

In Figure 6, a film 60, having recorded thereon optical images in the form of successive frames of pictures in a format similar to motion picture film, is passed between a flying spot scanner tube 62 and a photo multiplier tube pick-up means 66. The flying spot serves as a source of illumination which sweeps over each frame of optical information contained on the film 60 in a raster similar to a television sweep raster pattern. A sweep and blanking time base control circuit 65 generates a deflection signal which is applied to the deflection yoke of the flying spot scanner tube and a control signal which is applied to an electro-mechanical film transport 64. This signal application serves to synchronize the deflection rate of the electron beam of the flying spot scanner tube 62 with the action of the film transport mechanism 64 so that, as each frame of the film 60 is

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completely scanned by the light spot associated with the beam of the flying spot scanner, the film transport mechanism 64 will move a successive frame into position between the flying spot scanner tube 62 and the photo multiplier 66. Suitable optical means are employed to project the light from the flying spot scanner to the film, and from the film to the photo multiplier.

Circuit 65 further includes a blanking signal generator and a synchronization signal generator for developing blanking and horizontal and vertical sync signals which are applied to a signal processing stage 70 by means of conductors 68 and 69 respectively. The blanking and sync signals are in predetermined time relationship with the deflection signal from circuit 65 and provide a recording signal which when detected during playback of the video disc is a standard composite television signal. In one embodiment, the sync and blanking signals from circuit 65 were time expanded by a factor of approximately 400 (as compared with standard N.T.S.C. signals), and were generated using an oscillator and suitable counting stages and logic circuits to provide the desired signals. It is noted that the system shown includes a single photo multiplier for use in detecting luminance signals only; if color signals are to be processed and recorded, three photo multiplier tubes with appropriate color filters may be employed to obtain the necessary color information from the film 60. An amplifier 67 amplifies the electrical signal output from the photo multiplier 66 and applies this analog signal to the signal processing stage 70.

The signal processing stage 70 includes a gamma correction amplifier 71 to predistort the linear luminance signals from the photo multiplier 66 into standard television video signals. Blanking signals from circuit 65 are applied to a gate circuit 72 by means of conductor 68. Also applied to the gate circuit 72 are the video signals from amplifier 71. During the vertical and horizontal blanking intervals, gate 72 responds to the applied blanking signals to block the video signals, thereby preventing their application to the mixing amplifier 74 by means of conductor 73. In the absence of blanking signals, the video signals from amplifier 71 will be passed through the gate circuit 72 and will be present on conductor 73.

Mixing amplifier 74 may be an operational amplifier, with horizontal and vertical synchronizing signals applied to one input by means of conductor 69, and the blanked video signals applied to the other input by conductor 73. The amplifier 74 combines these signals to insert the synchronizing signals during the blanking intervals to form at its output terminal 75 composite television sig-

nals which are then applied to modulator circuit 80.

Modulator 80 includes an oscillator stage 76 which, illustratively, develops 30 KHz signals which are applied to a ramp generator 77 to develop sawtooth shaped 30 KHz signals. The output of oscillator 76 is coupled to the deflection drive circuit 82 which is coupled to the beam deflection circuits of a scanning electron microscope (S.E.M.) 84 by means of conductor 83 to provide a sweep control signal. The output of generator 77 is further coupled to a comparator and logic circuit 81, and to an inverter stage 79. The output of the inverter is also coupled to stage 81. Video signals from the signal processing stage 70 are also applied to stage 81. The output of the comparator and logic stage 81 is coupled to the blanking control circuit of the S.E.M. 84 by means of conductor 78. Modulation of the recording master is accomplished by sweeping the electron beam of the S.E.M. transversely across the groove and selectively un-blanking the electron beam to expose the photoresist in the groove.

The modulator circuit 80 provides the sweeping and blanking signals to the S.E.M., and its operation to provide, for a first example, the AM carrier modulation shown in Figure 4A will now be described.

Referring to Figure 4A again, the depressed areas 43 correspond to un-blanked sweep excursions of the beam of the S.E.M. over the positive photo resist of the recording master (layer 94 of the recording master shown in Figure 7F). Areas 41 between the depressed strips 43 correspond to sweeps of the S.E.M. electron beam where the electron beam is cut off (i.e., blanked). When no video signal is present at the input to the comparator and logic circuit 81 of modulator 80, the logic circuit blanks the electron beam of the S.E.M. during alternate sweep intervals to record the un-modulated carrier signal as shown at the left portion 42 of Figure 4A. The exposed areas 43 represent negative swings of a carrier signal, for example, and the unexposed areas 41 represent positive swings of the carrier signal. The information track is modulated by the video information as the video signal increases from zero by increasing the unblanked portion of alternate sweep intervals while increasing the blanked portions of the intervening sweep intervals. As a video signal of varying amplitude is applied to stage 81, the comparator compares the amplitude of the video signal with a reference signal (which is developed from the signal from the ramp generator 77 and the inverter circuit 79) to provide a blanking signal at conductor 78 which varies in accordance with the video signal. In Figure 4A, for example, the un-blanked portions of the odd sweep intervals 45, 47 etc. (shown at the left side of portion

44 of the signal track 16) increases with increasing video and the unblanked portions of the even sweep intervals 46, 48, etc. decrease with increasing video. The video is the same for intervals 45 and 46, decreases at point 47, is the same for 48 and then increases from 49 to 51. During the time interval 52, the video signal is constant. The heavy outlined edges of the blanked and unblanked modulation elements graphically illustrate the waveform shape of the video signal. Thus, in the presence of a video signal, the percentage of each blanked and unblanked portion of successive sweep intervals of the electron beam of the S.E.M. becomes a function of the existent video level during the sweep intervals. It is necessary to select a sweep rate sufficiently high to ensure the video sampling rate provides the desired resolution. A 30 KHz rate employed in one embodiment provided approximately 600 sweep intervals for each horizontal television line during playback of the video disc at 360 RPM when the recording master was rotated during recording at .9 RPM. In the AM carrier modulation system corresponding to Figure 4A, the comparator and logic circuit 81 insure this AM modulation configuration which presents essentially a constant support area for the pickup stylus while providing a capacitance variable in accordance with the video signal.

In the FM modulation system shown in Figure 5, the modulator 80 can be modified to provide a blanking signal to the S.E.M. which has unblanked intervals of equal duration but with the spacing between successive unblanked intervals varying in accordance with the video signal applied to the modulator.

When the recording is completed, the recording master is removed from the vacuum chamber and photoresist is developed to etch away the exposed areas in the grooves.

While illustrative parameters have been given above, it will be appreciated that they can be varied to alter the recording time or produce modulation signals on the photoresist at various intervals. If, for example, the intensity of the electron beam is increased, the turntable speed can be increased for a constant exposure of the photoresist. For an equivalent spacing of each modulation element, the sweep frequency of the electron beam would also be increased.

Turning again to the flow chart in Figure 7, after the recording process is completed, step seven of the seven-step process is performed.

(7) A stamping master is fabricated from the nickel recording master (having the exposed and developed photoresist coating) by depositing a coating of nickel (95 in Figure 7G) by an electroless process which is described in U.K. Patent No. 1,326,676. The

stamping master is then completed by electroplating a layer 96 of nickel, e.g. .008 inches thick, onto the electroless plated nickel coating. The nickel stamping master is then separated from the nickel recording master at the interface (indicated at point C in Figure 7G) between the electroless nickel coating 95 and the developed photoresist 94. The stamping master has negative grooves on its surface including modulation elements therein and can be used for stamping vinyl records which will have positive grooves corresponding to the desired original lacquer grooves modulated according to the recorded information.

Once the nickel stamping master 95, 96 has been fabricated, it can be employed to mass produce vinyl disc replicas 97 in Figure 7H in conventional record stamping machinery such as that used in the audio record industry. It will be appreciated that at this stage the grooved surfaces of the disc replicas are not conductive or dielectrically coated. To achieve this the vinyl disc is metallized as represented in Figure 7I by the metal layer 98, and a dielectric coating 99 (Figure 7J) is next applied to the metallized surface. These final processing steps may be carried out as follows. First, the vinyl disc is thoroughly cleaned. The metallization step shown in Figure 7I is accomplished using a vacuum chamber, and a material such as aluminum is vapor deposited to a thickness of 500 Å over the surface of the vinyl disc. A coating of suitable dielectric material such as polystyrene is then glow discharge deposited in a vacuum chamber on the metallized surface to a depth of approximately 500 Å, thus completing the processing of the disc.

WHAT WE CLAIM IS:—

1. An information recording method comprising the steps of coating a spiral groove in the surface of a disc with a material of a character exhibiting a difference in its resistance to dissolution in a given developing fluid after subjection to electron beam bombardment; intruding successive regions of the coated groove bottom along said spiral on said disc surface in the path of a beam of electrons, while simultaneously alternating the intensity of said beam of electrons between a first intensity level substantially equal to zero and a second intensity level appreciably greater than zero, under the control of signals to be recorded; and subjecting said disc surface, after said intrusion of said coated groove bottom regions in said path, to the influence of said given developing fluid whereby to provide a disc having groove bottom regions alternating between differing depths in accordance with said signals.

2. A method according to claim 1 wherein said successive regions of the coated groove excluding groove sidewall portions are in-



44 of the signal track 16) increases with increasing video and the unblanked portions of the even sweep intervals 46, 48, etc. decrease with increasing video. The video is the same for intervals 45 and 46, decreases at point 47, is the same for 48 and then increases from 49 to 51. During the title interval 52, the video signal is constant. The heavy outlined edges of the blanked and unblanked modulation elements graphically illustrate the waveform shape of the video signal. Thus, in the presence of a video signal, the percentage of each blanked and unblanked portion of successive sweep intervals of the electron beam of the S.E.M. becomes a function of the existent video level during the sweep intervals. It is necessary to select a sweep rate sufficiently high to ensure the video sampling rate provides the desired resolution. A 30 KHz rate employed in one embodiment provided approximately 600 sweep intervals for each horizontal television line during playback of the video disc at 360 RPM when the recording master was rotated during recording at .9 RPM. In the AM carrier modulation system corresponding to Figure 4A, the comparator and logic circuit 81 insure this AM modulation configuration which presents essentially a constant support area for the pickup stylus while providing a capacitance variable in accordance with the video signal.

In the FM modulation system shown in Figure 5, the modulator 80 can be modified to provide a blanking signal to the S.E.M. which has unblanked intervals of equal duration but with the spacing between successive unblanked intervals varying in accordance with the video signal applied to the modulator.

When the recording is completed, the recording master is removed from the vacuum chamber and photoresist is developed to etch away the exposed areas in the grooves.

While illustrative parameters have been given above, it will be appreciated that they can be varied to alter the recording time or produce modulation signals on the photoresist at various intervals. If, for example, the intensity of the electron beam is increased, the turntable speed can be increased for a constant exposure of the photoresist. For an equivalent spacing of each modulation element, the sweep frequency of the electron beam would also be increased.

Turning again to the flow chart in Figure 7, after the recording process is completed, step seven of the seven-step process is performed.

(7) A stamping master is fabricated from the nickel recording master (having the exposed and developed photoresist coating) by depositing a coating of nickel (95 in Figure 7G) by an electroless process which is described in U.K. Patent No. 1,326,676. The

stamping master is then completed by electroplating a layer 96 of nickel, e.g. .008 inches thick, onto the electroless plated nickel coating. The nickel stamping master is then separated from the nickel recording master at the interface (indicated at point C in Figure 7G) between the electroless nickel coating 95 and the developed photoresist 94. The stamping master has negative grooves on its surface including modulation elements therein and can be used for stamping vinyl records which will have positive grooves corresponding to the desired original lacquer grooves modulated according to the recorded information.

Once the nickel stamping master 95, 96 has been fabricated, it can be employed to mass produce vinyl disc replicas 97 in Figure 7H in conventional record stamping machinery such as that used in the audio record industry. It will be appreciated that at this stage the grooved surfaces of the disc replicas are not conductive or dielectrically coated. To achieve this the vinyl disc is metallized as represented in Figure 7I by the metal layer 98, and a dielectric coating 99 (Figure 7J) is next applied to the metallized surface. These final processing steps may be carried out as follows. First, the vinyl disc is thoroughly cleaned. The metallization step shown in Figure 7I is accomplished using a vacuum chamber, and a material such as aluminum is vapor deposited to a thickness of 500 Å over the surface of the vinyl disc. A coating of suitable dielectric material such as polystyrene is then glow discharge deposited in a vacuum chamber on the metallized surface to a depth of approximately 500 Å, thus completing the processing of the disc.

WHAT WE CLAIM IS:—

1. An information recording method comprising the steps of coating a spiral groove in the surface of a disc with a material of a character exhibiting a difference in its resistance to dissolution in a given developing fluid after subjection to electron beam bombardment; intruding successive regions of the coated groove bottom along said spiral on said disc surface in the path of a beam of electrons, while simultaneously alternating the intensity of said beam of electrons between a first intensity level substantially equal to zero and a second intensity level appreciably greater than zero, under the control of signals to be recorded; and subjecting said disc surface, after said intrusion of said coated groove bottom regions in said path, to the influence of said given developing fluid whereby to provide a disc having groove bottom regions alternating between differing depths in accordance with said signals.

2. A method according to claim 1 wherein said successive regions of the coated groove excluding groove sidewall portions are in-

truded in a repetitively swept path of said beam of electrons with the beam intensity alternations so controlled in time in accordance with the signals to be recorded that the subsequent subsection of the disc surface to the developing fluid provides a disc in which, between groove sidewalls of substantially invariant geometry; at least a central section of the groove bottom alternates between first and second depths along the groove.

3. A method according to claim 2 in which the beam intensity alternations are so controlled in time in accordance with the signals to be recorded that the subsequent subsection of the disc surface to the developing fluid provides a disc in which the bottom of the groove has 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 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 is raised relative to said maximum depth with any remaining portion of the groove bottom 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 remains substantially constant and independent of the recorded information.

4. A method according to claim 2 wherein said successive regions in the coated groove excluding groove sidewall portions are intruded in a repetitively swept path of said beam of electrons with the intensity alternations of said beam so controlled in time in accordance with signals to be recorded that the subsequent subsection of said disc surface to the developing fluid provides a disc having successive groove bottom regions along said spiral alternating between first and second depths below groove sidewall portions of substantially invariant geometry, with the frequency of said groove bottom depth alternations being representative of said signals.

5. A method according to any preceding claim, including the steps of deriving from said disc, after subsection to said developing fluid flow, a replica disc having a grooved conductive surface with a spiral groove there-

in containing successive groove bottom regions of differing depths substantially corresponding to said successive groove bottom regions of differing depths of the first-mentioned disc; and coating the conductive surface of said replica disc with dielectric material.

6. A method according to claim 5 wherein said replica disc deriving step includes the following sub-steps, namely: deriving from the first-mentioned disc, after subsection to said developing fluid flow, a replica former presenting a negative replica of the groove and its depth-varying bottom regions in said first-mentioned disc; using said replica former to form a replica disc of formable material having a spiral groove in a surface thereof containing successive groove bottom regions of differing depths substantially corresponding to said successive groove bottom regions of differing depths of said first-mentioned disc; and depositing a layer of conductive material on the grooved surface of said replica disc to form said grooved conductive surface.

7. A recording method wherein the steps set forth in any of claims 1-4 are performed on two disc surfaces to form in each surface a spiral groove containing successive groove bottom regions of differing depths, with the groove bottom depth variations in the respective grooves being mutually independent and representative of respective ones of a pair of mutually independent information signals and whereafter there is derived from said disc surfaces, after their subsection to the developing fluid flow, a pair of replica formers presenting respective negative replicas of said grooves and their depth varying bottom regions in said disc surfaces, said pair of replica formers is used to form a replica disc having said grooves and their depth varying bottom regions reproduced on opposite surfaces of the replica disc, both of said surfaces of the replica disc are covered with a continuous conductive coating of substantially uniform thickness of a dimension sufficiently small, relative to the dimensions of said grooves and the groove bottom depth variations, that said conductive coating follows the contours of each groove and its depth variations, and a layer of dielectric material is formed on the conductive coating on said surfaces of said replica disc.

8. A method according to claim 5, 6 or 7 wherein said dielectric coating step comprises vapor depositing on the conductive surface a layer of dielectric material of substantially uniform thickness of a dimension sufficiently small, relative to the groove dimensions and the groove bottom depth



variations in said conductive surface, that said dielectric layer follows the groove contours including said variations.

9. A method of forming a record disc substantially as hereinbefore described.

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