

DISK RECORDING

VOLUME 2 DISK PLAYBACK AND TESTING



**An anthology
of articles on
disk recording
from the pages of the
Journal of the
Audio Engineering
Society
Vol. 1-Vol. 28
(1953-1980)**

disk recording

VOLUME 2

DISK PLAYBACK AND TESTING

I Disk Playback

J Disk Pickups

K Tone Arms and Turntables

L Testing and Quality Control

1 Records

2 Phonograph Cartridges

Volume 1 GROOVE GEOMETRY AND THE RECORDING PROCESS
covered the following topics:

**Groove Geometry; Disk Recording Systems; Cutterheads and Lathes;
Styli and Lacquer Blanks; Record Pressing; High-Density Disk Technology;
Standards and Invention; and Related Reading.**

preface

In 1893, when Emile Berliner first flattened the recording cylinder into the now familiar disk, Thomas Edison gave it little chance of succeeding. It was not until 1928 that Edison finally conceded, insuring that the cylinder would take its place among the museum oddities of the past. In a speech given at an Audio Engineering Society convention in 1960, held at the Alexandria Hotel in Los Angeles, George Brown, head of the then-existing Ampex United Stereo Tape operation, gave the phonograph record "... five years to get off the market." As a result, many manufacturers of disk-cutting equipment gave up their traditional crafts and embraced that modern miracle, tape, as "the great stringy hope." IBM changed its dictating machines to magnetic belts and the computer industry raced headlong into the consumption of reels and reels of digital tape, while consumers started a love affair with reel-to-reel, eight-track cartridges, and compact cassettes.

Those consumers of music whose habit it was to put a tall stack of records on the changer and to turn them over when all had been played, rightfully found the endless eight-track cartridge much handier. And those who enjoyed music in their automobiles, who had gone through several disappointments at the hands of 16 $\frac{2}{3}$ -r/min car record players, naturally fled to the magnetic medium.

Then came video and, again, the word was tape: easy to edit, easy to erase and reuse, easy to handle and non-wearing; but unfortunately, available in no fewer than six incompatible standards.

But the disk record would not die! Its well-engineered replication process; its large 12-inch by 12-inch point of purchase advertising area; its convenient storage; its high storage density; the rapid access it affords without long and tedious winding; its durability and its ever-improving quality all testify to the rightness of the disk medium. Where one deals with a permanently prerecorded medium, it would seem economically odd to use magnetic tape, since one of its biggest advantages over the disk is its erasability, reusability, and almost unlimited duration of play, even, at times, at the expense of quality.

Even IBM went back to disk for its latest dictating system, while it is apparent that disk storage has revolutionized computer-memory density and access speed. The circle was further closed when special phonograph records were made by direct-to-disk techniques with telling improvement in quality.

Of course, a great deal of progress has been made since Berliner's first disk record: progress in material selection, in plating and stamping, in turntable design, in pickup and tone-arm construction, in groove geometry, high-density cutting, and last, but not least, in the cutting lathe. The pages in this two-volume anthology tell of this progress and also of the research and development which made such progress possible. The readers will learn from these volumes how audio engineering drew on the mechanical, electrical, and material engineering sciences to achieve an

outstanding system for speech and music reproduction. It should be stressed that such progress could be obtained only by international cooperation on both the engineering and marketing level.

Now the disk faces a new challenge as a storage medium for video information. The recording of video has been a spooled-ribbon medium for about as long as phonograph recording has existed. Optical sprocketed film, still the king of the motion-picture industry, soon found its match in magnetic recording, replacing one linear-motion medium with another.

But in 1976, 58 years after the first such experiments, the world's first video disk was marketed by Telefunken-Decca. Technology is now available to produce laser-recorded and -played disks, and traditionally cut and replicated disks which are playable equally on laser, electrostatic, and pressure-pickup players.

As a fall-out of this high-density video-disk technology, there are now proposals for small, very-long-playing, multi-channel audio disks, one even encased in a cassette! It is hoped that this two-volume Anthology will encourage future study and research. Volume 1 concentrates on the recording process, while Volume 2, soon to be published, deals with the playback of records. The Appendix of Volume 2 will feature a thorough patent review going back more than 100 years.

One thing is certain: the mechanical disk has developed during a 100-year period when standards could grow in an orderly fashion. Today, the long-playing record is one of the world's best standardized storage media. Never again, I feel, will any system, regardless of how simple, capture the world with a single standard equally respected in Beijing, Berlin and Baltimore.

October 1980

In Volume 1 of this Disk Anthology we covered the groove geometry as well as the process of creating the groove structure. Volume 2 concentrates on the reproduction of the groove in all of its aspects. The number of significant papers in this area is so extensive that it will be necessary to create yet another book, Volume 3. It will be exclusively devoted to a painstakingly assembled Patent Review of the disk recording field going back to the 1870s, featuring reproductions of the significant illustrations of most of those patents. I feel that such a thorough insight into inventions in this field, whether or not they were ever used, will help to stimulate creativity and will prevent inventors of tomorrow from embarking on research which duplicates work done long ago.

October 1981

Stephen F. Temmer

VOLUME 2

contents

I. DISK PLAYBACK

Distortion in Phonograph Reproduction. H. E. Roys (1953 January)	3
Analyzing the Long-Playing Pickup Problem. Theodore Lindenberg (1953 January)	11
Effect of High-Frequency Pre-Emphasis on Groove Shape. Jerry B. Minter and Aldo R. Miccioli (1953 October)	14
The Fundamentals of Disk Reproduction. S. Kelly (1954 July)	20
On Stylus Wear and Surface Noise in Phonograph Playback Systems. F. V. Hunt (1955 January)	28
Comments on "On Stylus Wear and Surface Noise in Phonograph Playback Systems." D. A. Barlow (1956 July)	45
Record Stylus Pressure. A. M. Max (1955 April)	49
Limiting Factors in Gramophone Reproduction. D. A. Barlow (1957 April)	53
The Limiting Tracking Weight of Gramophone Pickups for Negligible Groove Damage. D. A. Barlow (1958 October)	62
The Deformation of Plastics with Hard, Spherical Indentors. D. G. Flom and C. M. Huggins (1959 July)	66
Stylus Mass and Reproduction Distortion. J. Walton (1963 April)	70
Transient Response and Intermodulation Studies in Phonograph Reproduction. Benjamin B. Bauer, Arnold Schwartz, and Arthur J. Gust (1963 April)	76
High-Frequency Stylus-Groove Relationships in Phonograph Cartridge Transducers. Philip Kantrowitz (1963 July)	81
Corrections to "On Stylus Groove Relationships in Phonograph Cartridge Transducers." Philip Kantrowitz (1963 October)	93
Compatibility of Stereo Recordings and Monaural Playback. I. J. Sobel and Ronald Knuebel (1969 April)	94
Stereo/Mono Disc Compatibility: A Survey of the Problems. J. M. Eargle (1969 June)	99
A Linear Theory of Phonograph Playback. James V. White (1971 February)	105
Horn Theory and the Phonograph. Percy Wilson and Geoffrey L. Wilson (1975 April)	112
Overcoming Record Warps and Low-Frequency Turntable Rumble in Phonographs. Kenneth Clunis and Michael J. Kelly (1975 July/August)	118
On The Transcription of Old Phonograph Wax Records. Hans Meulengracht-Madsen (1976 January/February)	127
Measurement of FM Distortion in Phonographs. James V. White and Arthur J. Gust (1979 March)	133

J. DISK PICKUPS

An Analytical Approach to Phonograph Pickup Design. Walter O. Stanton (1954 April)	149
Present-Day Developments in Magnetic Pickups. Walter O. Stanton (1955 April)	153
Magnetic Pickups and Proper Playback Equalization. Walter O. Stanton (1955 October)	157
A Program to Design a High-Quality Pickup. Walter O. Stanton (1956 January) .	161
The High-Fidelity User Looks at Pickup Design. Julian D. Hirsch (1957 October)	168
A Single-Element Stereophonic Cartridge. John F. Wood (1959 April)	172
Reproduction Distortion—Its Measurement and Influence on Stereo Phonograph Cartridge Design. Philip Kantrowitz (1961 April)	177
Design of a Stereophonic Pickup Cartridge. G. A. Morrell, Jr. (1961 July)	183
The Rational Design of Phonograph Pickups. F. V. Hunt (1962 October)	186
A Two-Gram Phonograph Pickup System for Home Record Changers. B. B. Bauer, A. L. DiMattia, E. Kaulins, and G. W. Sioles (1963 October)	202
Electrical Loading Networks for Stereo Phonograph Cartridge Transducers. Philip Kantrowitz (1965 April)	207
Optimizing the Dynamic Characteristics of a Phonograph Pickup. C. R. Anderson, J. H. Kogen, and R. S. Samson (1966 April)	213
Tracking Ability Specifications for Phonograph Cartridges. J. H. Kogen (1968 April)	221
Notes on Pickup Design and Response. D. A. Barlow (1971 March)	226
Mechanical Playback Losses and the Design of Wideband Phonograph Pickups. James V. White (1972 May)	233
On the Noise Performance of a Magnetic Phonograph Pickup. B. I. Hallgren (1975 September)	239
Low-Frequency Tracking Behavior of Pickup Arm-Cartridge Systems. James M. Kates (1976 May)	246
The Dynamic Vibration Absorber Principle Applied to a High-Quality Phonograph Pickup. Allen R. Groh (1977 June)	251

K. TONE ARMS & TURNTABLES

Resonance, Tracking, and Distortion—An Analysis of Phonograph Pickup Arms. R. E. Carlson (1954 July)	259
The Radial Tone Arm—An Unconventional Phonograph Pickup Suspension. H. E. Roys and E. E. Masterson (1956 July)	271
A New Viscous-Damped Tone Arm Development. Chester A. Snow, Jr. (1958 July)	275
A New Approach to the High Performance Turntable Problem. Rein Narma and E. P. Skov (1958 October)	280
A Stereo Groove Problem. George Alexandrovich (1961 April)	286

The Design and Performance of an Integrated Stereo Pickup and Arm. P. J. Pyke (1962 July)	288
On the Damping of Phonograph Arms. B. B. Bauer (1963 July)	293
Sensitivity of Phonograph Turntables to Normal Loads. T. S. Cole, Sr. (1967 October)	298
Comments on "Sensitivity of Phonograph Turntables to Normal Loads." Jerome B. Halter (1968 July)	301
Reply to "Comments on 'Sensitivity of Phonograph Turntables to Normal Loads.'" T. S. Cole, Sr. (1968 July)	302
A New Direct-Drive Phonomotor. K. Kobayashi (1970 June)	303
An Evaluation of the Forces Required to Move a Tone Arm. John J. Bubbers (1970 October)	304
Dynamic Damping of Stylus Compliance/Tone-Arm Resonance. Gary T. Nakai (1973 September)	308
The Aspects of Low-Inertia Tone-Arm Design. Peter Rother (1977 September) . 316	
Impulse Response of the Pickup Arm-Cartridge System. Stanley P. Lipshitz (1978 January/February)	326
Comments on "Impulse Response of the Pickup Arm-Cartridge System." Jacob Rabinow (1978 October)	342
Reply to "Comments on 'Impulse Response of the Pickup Arm-Cartridge System.'" Stanley P. Lipshitz (1978 October)	343
A Vibration-Stabilizer System for Phonograph Reproduction. C. Roger Anderson (1979 April)	346
Optimum Pivot Position on a Tone Arm. Susumu Takahashi, Sadao Taguchi, Nobuyuki Kaneko, and Yasuhiro Fujimoto (1979 September)	352

L. TESTING & QUALITY CONTROL

1. RECORDS

The Control of Quality in Phonograph Records. Edward H. Uecke (1956 October)	363
The Calibration of Disc Recordings by Light-Pattern Measurements. P. E. Axon and W.K.E. Geddes (1957 July)	367
Stereo Disk Problems. Erling P. Skov (1960 January)	378
Stereo Disk Problems (Addendum). Erling P. Skov (1960 July)	385
Maximum Peak Velocity Capabilities of the Disk Record. J. W. Stafford (1960 July)	387
Some Aspects of Wear and Calibration of Test Records. Roger Anderson (1961 April)	391
Psychoacoustics, the Determining Factor in Stereo Disc Distortion. John E. Jacobs and Paul Wittman (1964 April)	395
On the Measurement of Rumble in Phonograph Reproduction. Benjamin B. Bauer (1967 April)	404
The Scanning Electron Microscope: A New Tool in Disc-Recording Research. J. G. Woodward, M. D. Coutts, and E. R. Levin (1968 July)	408

The Dynamic Range of Disc and Tape Records. Daniel W. Gravereaux, Arthur J. Gust, and Benjamin B. Bauer (1970 October)	416
Analysis of Crosstalk on Stereo Test Records. Bernhard W. Jakobs (1971 April)	422
A Theory of Scanning Loss in Phonographs. James V. White (1973 March)	430
Hertzian Theory and Scanning Loss. Duane H. Cooper (1973 June)	439
Automatic Detection of Impulse Noise. George R. Kinzie, Jr. and Daniel W. Gravereaux (1973 April)	440
New Methods of Automated Flutter Analysis. K. O. Bader and Barry Blesser (1974 March)	444
Measurement of Recorded Level and Channel Separation on Phonograph Discs Using Optical Interferometry Techniques. T. Inoue, I. Owaki, K. Ohba, S. Nakamura, and John Eargle (1974 November)	448
Performance Tradeoffs in Disk Recording. James V. White (1974 December)	450
Measurement of Cutter Heads by Pulse-Train Methods. Teruo Muraoka, Hideo Onoye, and Kaoru Totsuka (1978 September)	456
Distribution of the Phonograph Signal Rate of Change. Jorma Lammasniemi and Kari Nieminen (1980 May)	462

L. TESTING & QUALITY CONTROL

2. PHONOGRAPH CARTRIDGES

Locked Concentric-Grooved Disc for Use in Measurements of Disc-Reproducer Performance. Jack Feinstein (1956 April)	469
Automatic Plotting of Cartridge Response. C. P. Germano (1959 July)	475
Mechanical Impedance Measurements at the Stylus of Stereo Phonograph Cartridge Transducers. Philip Kantrowitz (1963 October)	481
Techniques for Measuring the Vertical Tracking Angle of Stereophonic Phonograph Pickups. J. G. Woodward (1965 July)	487
Absolute Calibration of Pickups and Records. A. Schwartz, A. J. Gust, and B. B. Bauer (1966 July)	494
High-Frequency Intermodulation Testing of Stereo Phonograph Pickups. J. G. Woodward and R. E. Werner (1967 April)	497
Frequency Response Analysis of Phonograph Pickups on Calibrated Test Records. Bernhard W. Jakobs (1970 June)	510
A Practical High-Frequency Trackability Test for Phono Pickups. C. Roger Anderson and Paul W. Jenrick (1972 April)	518
Measurement of Phonograph Cartridges by the Pulse-Train Method. Teruo Muraoka, Hideo Onoye, and Akio Takayanagi (1974 September)	523
Continuing Evaluation of Phonograph Cartridges by Pulse-Train Methods. Teruo Muraoka, Hideo Onoye, and John M. Eargle (1976 November)	532
Automatic Assembly-Line Testing of Cartridges. Ernst Frandsen (1978 November)	536
Three FM Methods for Measuring Tracking Angles of Phono Pickups. James V. White and Arthur J. Gust (1979 April)	543