Already in 1954 high requirements for audio reproduction were discussed for improving: existing High Fidelity standard in the USA for:

The radio Designer's Handbook (long Ford Smith) which referred to a frequency range of 30 cycles per second to 20 kHz a linearity required ± 0.1 railways! For this ambitious aim of better performance, the distortion factor which proposed less than 0.5 % (THD) required a Signal to Noise ratio of 62 railways.

Into principle, any three dimensionally media does more offer the degrees for a simple analogue stereo independent.

Already in the year 1954 in the USA high requirements were discussed for the rise of the HiFi quality yardsticks prevailing there: In the radio Designer's Handbook (Langford Smith) had been called for a frequency range which can be aimed at from 30 cycles per second to 20 kHz a linearity tolerance of ± 0.1 railways! For this ambitious goal to a better music performance the distortion factor should amount to at the most 0.5 %. In addition a value of 62 railways emerged for the noise distance.
In principle each three-dimensional medium offers the degrees of freedom for a simple similar stereo-Aufzeichnung, e.g. height and width for the amplitude of both channels as well as the length for the time. However also here the devil is in the detail...

A.D. Bluem flax had already 1933 a single-lane Stereoschallplatte for the British E.M.I. Enterprise develops (British patent No. 394,325). It continued its work later for the creation of an improved recording method with Columbia record in the USA. There, as also in some European countries, the first Stereo LPs was introduced to the summer 1958.

Still at the beginning that yearly had competed a German English prototype with an American version around that final standard: "Tiefe/Seite" procedures advanced of London record CO after Telefunken idea (contractions" +") with of the Westrex Inc., New York, favored diagonal procedure "45/45" and/or. "x".

RKS the beginning OF that year, A German English prototype had been even competing with at American version for the definite standard: The London record CO, inspired by on idea OF German Telefunken company, which pushing A rectangular cutting method for both channels, shortly called "+", while Westrex Inc., New York, which favouring A diagonally one, the "45/45" or "x".

A.D. Bluem flax had developed A single Groove stereo disk for British E.M.I. (Electrical & musical Industries) already in 1933, certified as British patent No. 394,325. Later on, he continued with his work for making on improved records system RK Columbia record into the the USA There, and thus into some European countries, the roofridge stereo disks were introduced in buzzers 1958.

In principle each three-dimensional medium offers the degrees of freedom for a simple similar stereo-Aufzeichnung, e.g. height and width for the amplitude of both channels, and length for time. However, it's the little things (or just ways OF different thinking) that always cause the of problem.
The recording system as developed by London record CO represents Fig. 1.1. Westrex Inc. had taken more over this system into principle, but turned it tons of a 45 degree position. Naturally, the position OF the stylus, respectively its axis, which turned bake perpendicularly. This system of does guarantee equal mechanical and electrical properties for both channels, while the vertically channel OF the "+" wants recognized problematical for distortion, and the horizontal for stylus force and clamping.

Thus, the x-Method became world standard into the end.

Fig. 1.2 shows A realization OF 1.1: Industrial pickup with moving armature (respectively moving magnet) that on is widely known as mm of type.

CROSS talc suppression for audio reproduction should emergency case below 20 railways into accordance with the roofridge standard. A measure OF 30 railways (typical RK that time) does mean on angular deviation below 1,5 degree for the stylus, respectively at error deflection OF less than 0,04 µm RKS 10 kHz! However, suppression more better than 40 railways which achieved later on.

Regarding A basic effect OF mono as wave as stereo disk on recording, there wants enormously.

Of London record CO the principle representation of the pick-up shown in Fig. 1,1 clarifies developed recording method. The Westrex Inc. had taken over, turned this arrangement in principle these however simply around 45° degree. Around the same amount to senkrecht naturally the stylus and/or their axle was again back turned. This system guaranteed same mechanical as electrical characteristics for both channels. On the other hand one recognized problems for the vertical channel with "+" because of distortion susceptibility as well as unfavorable needle printing and wedge-holds back for the horizontal. With it the x became generally accepted gumpion procedures as world standard.

Fig. an implementing shows 1.2 after Fig. 1.1. That execution represents an industrially manufactured pick-up, with mobile magnetic anchor (armature), to being certain pole pieces (pieces polarizes) and the coils (coils). All usual mm pick-ups ("Moving magnet") are the basis this remark example.

The uebersprechdaempfung for rendition enterprise should not fall below 20 railways in accordance with the first standard. The then usual measure of 30 railways means a
increasing stylus deflection for low frequencies, as shown by this equation:

\[
\alpha = \frac{s}{\omega}
\]

A stylus Deflection
\(s\) stylus Rapidity (const.)
\(\omega\) Angular signal frequency

Therefore, appropriate signal compression wants necessary for to acceptable disk capacity!

Appendix A gives detailed information about almost all different standards for decompressing equalization. This DATA which published in 1958. Both 'RCA Victor' and 'TELDEC' were applied on stereo disks. The RCA Victor standard, "new Orthophonic", advanced tons of RIAA Equalization definition.

Fig. 1.4 [5]

Top diagram is based on thoroughly larva test with micro groove disks RK the end to OF the Fifties. It shows the case of down OF of upper cut off frequencies versus grinding OF sapphire stylus 'sanding off length', given in µm. The more smaller diagram informs about durability (in hours) OF sapphire stylus for stereo or 'duplo' and mono of system.

After thorough investigations toward end of the 50's for micro groove plates the influence the sapphire wear was determined on the upper critical frequency (above) and the spieldauer (down) for stereo "Duplo, which can be expected -" and mono systems.
The genesis OF Vinyl stereo record - Synopsis - developing history of the Stereoschallplatte

Fig. 1.5
A stereo Groove - a Stereo groove.
Left channel: 1000 cycles per second of sine signal - left channel
Right channel: 12,000 cycles per second of sine signal - right channel
Top OF this image ton the disk's centre. Photo released by Dutch RONETTE company [ 1 ].
The upper contour of the admission [ 1 ], coming from RONETTE (NL), points to the disk center.

Geometrical and Physical relation and of problem

Grooves

Fig. 1.6 of gives A geometrical impression OF the disk standard different. The ' mono ' size, known as ' normal ' (e.g. ' N78 ' for A disk OF 78 r.p.m.) which predecessor OF the monophonic ' Micro ' that should finally replaced by stereo standard.

The minimum groove width which reduced from 55 µm (Micro) tons of 40 µm for stereo standard. The radially distance from groove ton groove wants about 120 µm RKS at AVERAGE signal level for both channels.

A stereo pickup CAN thus used for playing mono disks (Micro standard), but A mono one would damage A stereo groove within A short time.

Plattenrillen

Fig. 1.6 vermittelt einen geometrischen Eindruck der verschiedenen Standards. Das Mono- Format, als Normal-Format bekannt mit z.B. N78 für eine Schallplatte mit 78 Umdrehungen pro Minute, war Vorläufer des monophonen "Micro", das schließlich durch das Stereiformat ersetzt wurde.

Die minimale Rillenbreite wurde von 55 µm (Micro) auf 40 µm für den Stereo-Standard reduziert. Der Radialabstand von Rille zu Rille beträgt etwa 120 µm bei einem durchschnittlichen Stereosignal- Pegel.

Ein Stereo- Tonabnehmer kann auch zum Abspielen von Mono-Platten (Micro- Format) verwendet werden, aber ein Mono-Abnehmer würde eine Stereorille innerhalb kurzer Zeit zerstören.
Pinch Effect

Since the CROSS sectional shape of the recording stylus is a 90 degree trifishes, pinch effect wants come into appearance for large groove amplitudes RK high frequencies. Fig. 1.7 demonstrates the outcome OF this effect: A and B represent shape and position of recording stylus that wants cause differential groove width. Thus, A spherical or conical stylus CAN only acts this precondition by A vertically compensatory movement (lake C & D) which, more however, wants PUT A disadvantageous effect on totally distortion. Therefore, about 1963 or 1964, the biradial or elliptical stylus has been introduced tons successfully elude this problem, cf. E & F, and reduce distortion caused by Clamping Effect (s. appendix B).

Skating

Since the groove for stereo standard has been geometrically sized down, there acres tons more consider even OTHER physical effects which had been neglected for mono disk players or ' turntables ': The vertically stylus force must wave adjustable for more lower scales. Moreover, on additional mechanical system must compensate horizontal skating. This effect which going tons play A very important role for gradually reduced stylus force. Fig. 1.8 explains in detail.
The genesis of Vinyl stereo record - Synopsis - developing history of the Stereoschallplatte

Trackability

Best reproduction of high frequencies requires lowest effective stylus measured (m) RK lowest force. Therefore, highest compliance (C) of stylus rod wants needed. Both of quantities define resonantly frequency of the pickup:

$$\omega = (mc)^{-0.5}$$

where $\omega$ is angular resonantly frequency [3].

Its influence on low frequencies rank can be taken from Fig. 2.6 of document VSR1Pickups.htm that has been linked more farther below.

Tone Arms

The recording stylus will follow a straight line from rim to the disk's centre. However, the reproducing stylus of a conventional pickup arm does leave an arc on its way to the groove's end. Turntable designers were facing this problem by making arms of special geometry, for example S-formed versions or expensive tangential constructions.

Dynagroove

In 1963, RCA Victor Studios of New York, in association with David Sarnoff Research Center of Princeton, USA, introduce 'Dynagroove'. This is sophisticated recording system for reduction of groove distortion that comes up when the stylus cannot correctly follow critical groove sections. The complete set includes a computer which does filter all those sections, re-calculates them, and counter-controls accordingly the recording stylus.

German distributor of those disks was TELDEC [8].
Dynaflex

In 1971, RCA Corporation announces "big invention" that will enormously reduce surface noise (especially so-called 'ticking'), slippage, and other non-homogeneous properties of conventional LP disks. For field testing, more than 12 million Dynaflex Disks had been already put into circulation in the previous year.

This more flexible disk has a compound that does guarantee also much better durability as well as much smoother grooves for (almost) imperceptible noise. The disk's thickness was reduced from 50 to 30 mil in its groove area, and its weight from 135 to 90 grams. Experts confirm this as big step in development [9], [10].

Final Results

Considering all mechanical and electrical points of view for most efficient technical solutions, there have been statements that "a high quality turntable with a first class cartridge will leave no provable signs of wear on good vinyl disks made in the Seventies or later."

Nowadays, high performance calculation techniques and electronic components allow the design of high accuracy phono pre-amplifiers that are guaranteeing a frequency response of 10 to 25,000 Hz at a linearity of ±0.1 db, and a THD factor of less than 0.001%. The S/N ratio, of special importance for digital audio, can be easily hold at nearly 100 db by High-Tec semiconductors.

LP Remastering

Nonetheless, an appliance with afore-said electrical specifications might be absolutely necessary for saving

Heutzutage gestatten sehr hochwertige Berechnungsverfahren und elektronische Bauelemente die Dimensionierung hochpräziser Phono- Vorverstärker, die einen Frequenzbereich von 10 Hz bis 25.000 Hz bei einer Linearität von ±0,1 dB und einem Klirrfaktor von weniger als 0,001% garantieren. Der insbesondere für Digital-Audio wichtige Rauschabstand kann mit 'HighTec' Halbleitern leicht bei ca. 100 dB gehalten werden.

"LP Remastering"

Eine technische Ausstattung mit den vorgenannten elektrischen
valuable vinyl records to a digital audio file in order to tolerate the lowest level for some disturbing physical effects carried on even through the best pickups (see Appendix B).

Generally, the special requirements for phono pre-amplifier design are much stronger than for any other audio purpose, since there is to correct a frequency dependent level range running up to 40 db at a certain constant amplification that has to be fixed usually between 35 and 45 db!

A filter design that has been introduced as Lin-p-Master represents an example for this technology. Its appliance can also drive Line Input of computer soundcards.

State of the Art:
Pickups & Pre-Amps
Examples from the Sixties to the Seventies:

| Pickups | Pre-Amplifier |

Appendix A

Characteristics Of Different Standards

Note: A table is given farther below.
1 Old European Characteristic: "250"
   HMV N78 (His Masters Voice) and
   Columbia N78 produced by E.M.I.
   England. CETRA N78, Italy.
   This standard may be also applied to records by English
   Parlophone, Brunswick, ...
   Time Constant: 636 µs (250 Hz).

2 Old European Characteristic: "500"
   Applicable to many European records produced before 1950, and
   also to many U.S. companies except RCA Victor, Columbia.
   Time Constant: 318 µs (500 Hz).

3 Columbia N78
   Time Constants: 530 µs (300 Hz) and 100 µs (1,590 Hz).

4 Columbia LP M33
   HMV M33, produced in England.
   Vanguard, Bach Guild, Cetra M33, Vox.
   Time Constants: 1,590 µs (100 Hz), 318 µs (500 Hz), and 100 µs
   (1,590 Hz).

5 NAB National Association of Broadcasters.
   Time Constants: 530 µs (300 Hz) and 100 µs (1,590 Hz).

6 NARTB National Association of Radio and TV Broadcasters, has
   replaced NAB standard. Applicable to Artist, Capitol, MGM,
   Westminster (see disk cover), Tempo M33 (approximate char.)
   Time Constants: 2,720 µs (60 Hz), 318 µs (500 Hz), and 100 µs
   (1,590 Hz).

7 AES Audio Engineering Society, made in 1951 this reproduction
   definition for compatibility to standards mostly used in the USA.
   Time Constants: 398 µs (400 Hz) and 64 µs (2,500 Hz).

8 London London Gramophone Corporation:
   London M33 & M45,
   Decca (most possibly).
   Time Constants: 1,590 µs (100 Hz), 318 µs (500 Hz), and 57 µs
   (2,800 Hz).

9 CCIR Recommendation No. 134
   by VIIth Plenary Assembly, 1953:
   Germany 1952-1955: DGG 33 1/3 LP.
   Time Constants: 450 µs (350 Hz), and 50 µs (3,180 Hz).

10 IEC
   A recommendation of 1955 for playing N78 disks, according to B.
   S. No. 128 (British Standard).
   Time Constants: 3180 µs (50 Hz), 450 µs (350 Hz), and 50 µs
   (3,180 Hz).
11 RCA Victor & IEC No.98
refers to this "New Orthophonic" standard since 1952. Recommendation of 1953 by NARTB, of 1955 by IEC No.98, and B. S. No. 128. World standard since 1967. Time Constants: 3180 µs (50 Hz), 318 µs (500 Hz), and 75 µs (2,120 Hz).

12 TELDEC
Telefunken and Decca founded a record company that used a characteristic proposed for German DIN-Standard on July 1957: DIN45533, DIN45536, DIN45537. Time Constants: 3180 µs (50 Hz), 318 µs (500 Hz), and 50 µs (3,180 Hz).

Table 1.1
Characteristics of Different Standards
Equalization Data for Play Mode [6] [7]

<table>
<thead>
<tr>
<th>f Hz</th>
<th>1 250 db</th>
<th>2 500 db</th>
<th>3 Col.M78 db</th>
<th>4 Col.M33 db</th>
<th>5 NAB db</th>
<th>6 NARTB db</th>
<th>7 AES dB</th>
<th>8 London db</th>
<th>9 CCIR db</th>
<th>10 IEC N78 db</th>
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| Back to Text |
A theoretical view to the harmonic distortion factor $k$ (respectively $d$) of the vinyl record shows that it cannot be reduced to zero for geometrical and physical relations [12]:

$$k = \frac{s^2 r^2 \omega^2}{v^4}$$

$s$  Rapidity of Stylus  
$r$  Radius of Stylus  
$\omega$  Angular Frequency  
v  Groove Velocity

Note that 's' represents the rapidity at maximum level. The so-called "Clamping Effect", which is standing in connection with quadratic distortions, also depends on rapidity, stylus radius, and groove velocity. This effect is caused by stylus force against the apex at the zero transition. The clamping is

$$a_{\text{N}} = \frac{r}{2} \left( \sqrt{2 + \frac{s^2}{v^2}} - \sqrt{2} \right)$$

Clamping has length measure. This equation was found in [2].

---

Die theoretische Betrachtung des Klirrfaktors einer Schallplatte zeigt, dass dieser wegen geometrisch-physikalischer Verhältnisse nicht auf Null reduziert werden kann [12]:

$$k = \frac{s^2 r^2 \omega^2}{v^4}$$

$s$  Schnelle  
$r$  Radius der Abtastnadel  
$\omega$  Kreisfrequenz  
v  Rillengeschwindigkeit

Für die Schnelle ist ihr Vollaussteuerungswert (8...10 cm/s) anzusetzen. Der mit quadratischen Verzerrungen im Zusammenhang stehende sogenannte "Klemmeffekt" ist ebenfalls von Schnelle, Nadelradius und Rillengeschwindigkeit abhängig. Dieser Effekt entsteht durch Druck der Abtastnadel gegen den Scheitelpunkt an den Nulldurchgängen. Die in Längeneinheit definierte Klemmung ist nach [2]:

$$a_{\text{N}} = \frac{r}{2} \left( \sqrt{2 + \frac{s^2}{v^2}} - \sqrt{2} \right)$$
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     61-63.)
     and No.9, P.24,25,65.