

DIRECT PLAY BACK OF NEGATIVES OF HISTORIC SOUND CYLINDERS

Thomas Kessler
Arbeitsgruppe Bildverarbeitung
GFal e.V. Berlin
Albert-Einstein-Str. 16
12489 Berlin
Telefon +49 (0)30 6392 1643 Telefax +49 (0)30 6392 1661
eMail: kessler@gfai.de Internet: <http://www.gfai.de/projekte/spubito>

Dr. Susanne Ziegler
Museum für Völkerkunde
Arnimallee 27
14195 Berlin
Telefon +49 (0)30 8301 201 Telefax +49 (0)30 8301 292
Internet: <http://www.smb.spk-berlin.de/mv>

Abstract

The Edison Cylinder Phonograph has been widely used since the beginning of this century to gain large amounts of sound documents on wax cylinders. It was convenient for use in fieldwork and until the early 1930s, it was the only means of recording ethnographic data acoustically. A large collection of copper negatives of these wax cylinders is held by the Berlin Ethnographic Museum. The contents of these so called "galvanos" should be played back in the most gentle way. For this task the GFal has developed a play back system using a combination of image processing and a mechanical sensor. The precisely measured sound track geometry is converted to acoustic signals that can be directly transferred to digital sound media. The obtainable sound quality is comparable to the then used technique of making wax copies and playing them on a cylinder phonograph. Furthermore the new method can still be applied in many cases when the making of wax copies is not feasible.

The Berlin Phonogram Archive

The Department for Ethnomusicology at the Museum for Ethnology in Berlin holds one of the largest collections of traditional music from all over the world, recorded between 1893 and 1943.

The History of the Berlin Phonogram Archive dates back to September 1900 when Carl Stumpf used an Edison phonograph to record a group of Thai musicians performing in Berlin. This was the beginning of an institution which was organisationally part of the Psychological Institute of Berlin University directed by Carl Stumpf. In 1905 the Phonogram Archive was institutionalised under Erich M von Hornbostel.

Due to von Hornbostel's international reputation and fruitful co-operation with scholars from different fields, such as scientists from social and natural sciences, colonial and missionary officers, an international collection was established. By the end of WWII the number of cylinders

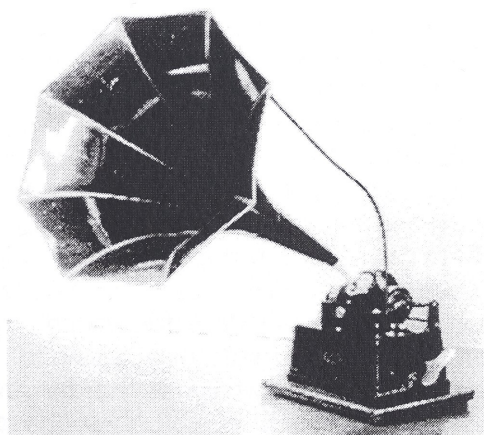


Fig. 1: Edison Phonograph

totalled more than 16,000 recordings. The geographic distribution of recordings is as follows: Africa 35.5 %, Asia 25.7 %, Australia and Oceania 11.4 %, Europe 15.5 %, America 11.7 %.

The history and the reputation of the Berlin PHA is due to Carl Stumpf and Erich M von Hornbostel, who were not only managers, but were also responsible for the scientific output of the Archive. Thus, the work of Stumpf and Hornbostel, based on the recordings of the PHA led to the foundation of a new scientific field, Comparative Musicology / Ethnomusicology.

After Stumpf's retirement in 1921 the Phonogram Archive was joined with the Staatliche Hochschule für Musik, but physically remained in its former building, the Berlin Palace. Von Hornbostel, now in an official position, continued in his mission of safeguarding traditional music in all parts of the world before it became extinct or westernised. In the 1920s and early 30s valuable collections of traditional music, mostly recorded by musicologists, entered the archive and formed the basis for regional research.

In 1933 Hornbostel left Germany, and the archive was attached to the Museum of Ethnology with Marius Schneider as director. In 1944 all the material was evacuated, but fell into the hands of the Russians who took it to Leningrad. In the Phonogram Archive of the Russian Academy of Sciences the material was copied and in 1960 handed over to East German authorities. As late as 1991 the Phonogram Archive returned to the Ethnological museum, and now more than 95 % of the pre-war holdings have been identified.

The Berlin Phonogram Archive was famous not only for its collections, but also for technical reasons. Berlin was the only Phonogram Archive which could produce copper negatives of original wax cylinders. These negatives were supposed to save the musical information for the future in the best way in original form and, at the same time, to serve as matrices for copies in unlimited number. Today, the galvano-negatives form a very valuable material, because they survived in their original form without being destroyed.

Today, an ambitious re-recording project is underway, supported by the Stiftung Preußischer Kulturbesitz and Stiftung Deutsche Klassenlotterie Berlin. A collection of CDs and a catalogue will be published hopefully by September 2000, when the hundredth anniversary of the first recordings is celebrated.

Edison Cylinders and Galvanos

Edison cylinders are about 5 cm in diameter, 10 cm in length and hollow. With grooves separated by about ¼ mm, each cylinder holds about two minutes of sound. Other sizes of diameter up to 10 cm and length up to 15 cm have also been used. The rotation speed was not standardised in the early days and was selectable between 90 and 180 rpm. The groove profile is a replica of the sound pressure during recording and has a maximum depth of about 20 µm.

Edison cylinders for sound recording are made of a special kind of wax, which is harder than the material of which candles are made [EXNER97]. Nevertheless it is soft enough so that recording by a pure mechanical device is possible. Unfortunately the process of playing back these records wears them out. The sound quality gets worse with each play back process and after about 10 play backs the record is destroyed.



Fig. 2: Wax cylinders and copper negatives (galvanos)

In order to use records scientifically the former Berlin Phonogram Archive chose the very ingenious method of producing a copper mold of each recorded wax cylinder by means of galvanisation, resulting in so called galvanos. New wax cylinders for play back could then be cast from these molds. The wax used for casting had to have some special features in order to be able to be removed from the galvanos after cooling down.

The Direct Galvano Player

In 1996 information on how new wax cylinders were made from galvanos was not obtainable. So our idea was to regain the recorded sound directly from the galvanos. By using an endoscope, the sound tracks with their hill and dale modulation were clearly visible on the inside of galvanos and there was expectation to be able to gain the sound content of the galvanos purely by optical methods [STANKE97]. This is preferable because the sound tracks wouldn't be touched by the play back device so that any damage would be excluded.

This approach worked so far, but only with galvanos with very deep modulation where the height profile was clearly visible. Furthermore the required high frequency response hasn't been obtained with optical sound detection.

Since the optical track detection and track holding was working quite well, we tried to replace just the optical sound detection by a sensitive mechanical sensor driven by a specially shaped diamond stylus. By reducing the revolutions per minute we could use a very low force on the stylus. Combined with it's elliptic shape it has been shown that no damage is taking place to the galvanos while being played.

A specific feature of the galvanos is that the tracks are negative, i.e. consisting of ridges and not of grooves. Because of this, the stylus is not guided by the track. Consequently there must be some active tracking mechanism, which is detecting the momentary track position and holding the stylus centred in the middle of the track. In our case this is performed by a real time image processing system, using an endoscope and equipped with a CCD Camera.

The camera image is digitised by a frame grabber. The image of the laterally illuminated grooves is compared with a nominal groove image by a computer. From this calculated lateral displacement is used for following the middle of the sound track.

A galvano handling system has been built, consisting of two translation stages and one rotation stage. The rotation stage can hold galvanos from 50 to 100 mm diameter and rotate them at a selectable constant speed. A rubber belt drive is used for isolation against motor and gear vibrations. The drive uses a geared dc servo motor with incremental encoder for speed control. The first translation stage is used for following the sound track. It moves the mechanical sensor and endoscope along the galvano's rotation axis. The second translation stage is used for pressing the sensor stylus onto the inner galvano surface. Both translation stages are equipped with geared dc servo motors which can be controlled by a computer. The second translation motor can also be switched to an analogue control circuit.

The mechanical sensor consists of a plate-spring carrying a diamond stylus. While the stylus is pressed onto the sound track on the inner galvano surface the galvano is rotated at a constant slow speed. By doing this the plate-spring follows the height profile of the sound track. The sound signal is then obtained by measuring the spring displacement by means of a miniature inductive transducer (differential transformer). The sensor output is amplified and digitised with 12 bit resolution at an appropriate sampling rate. This is chosen in such a way that at the standard play back rate of CDs (44.100 kHz) the original sound pitch is obtained.

The height profile of the sound tracks consists of the sound information with relative small amplitude and a very low frequency part with often much larger amplitude, originating from deviation from ideal cylindricity and mechanical imperfections of the support. The amplitude of the interfering low frequency component exceeds the maximum sensor range. To overcome this problem, an active control mechanism has been implemented, which holds the mean vertical sensor position constant within 100 μm . A residual low frequency interference remains superimposed on the sound signal and is removed by a digital low pass filter.

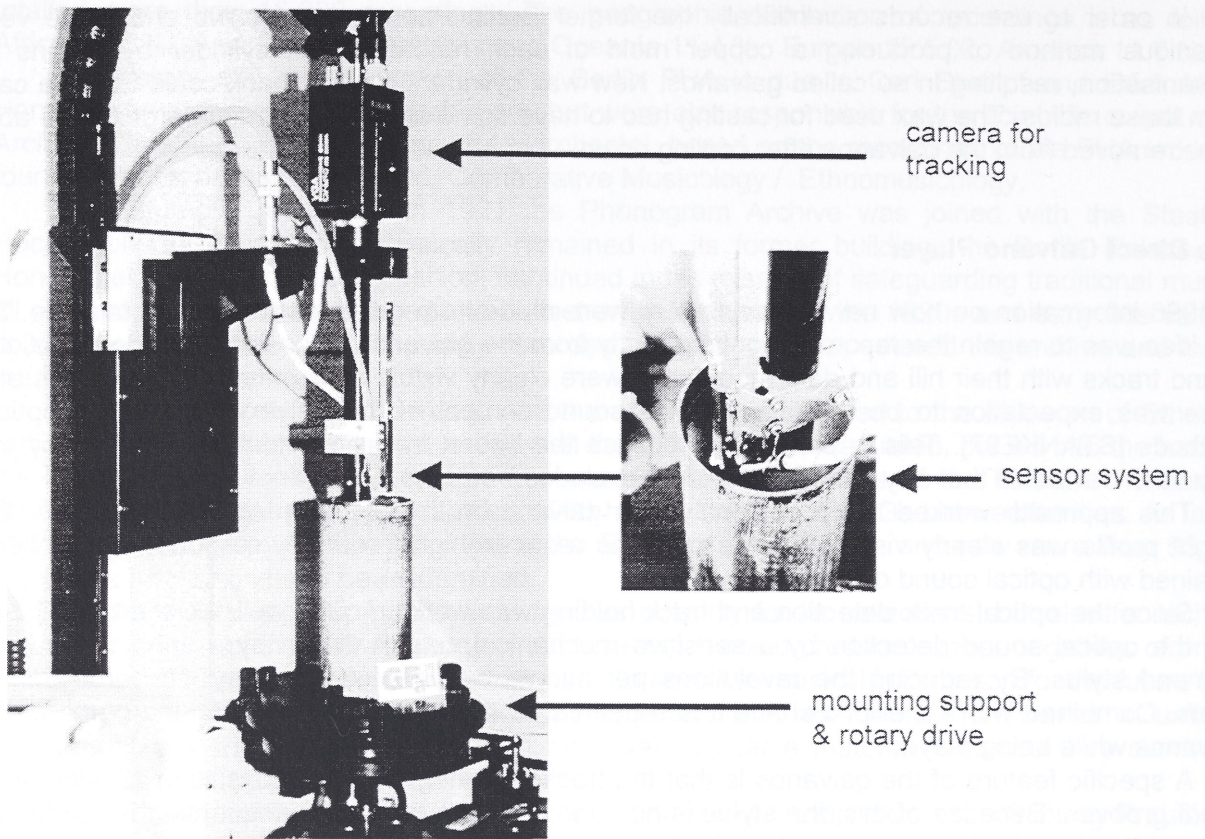


Fig. 3: System components of the direct galvano player

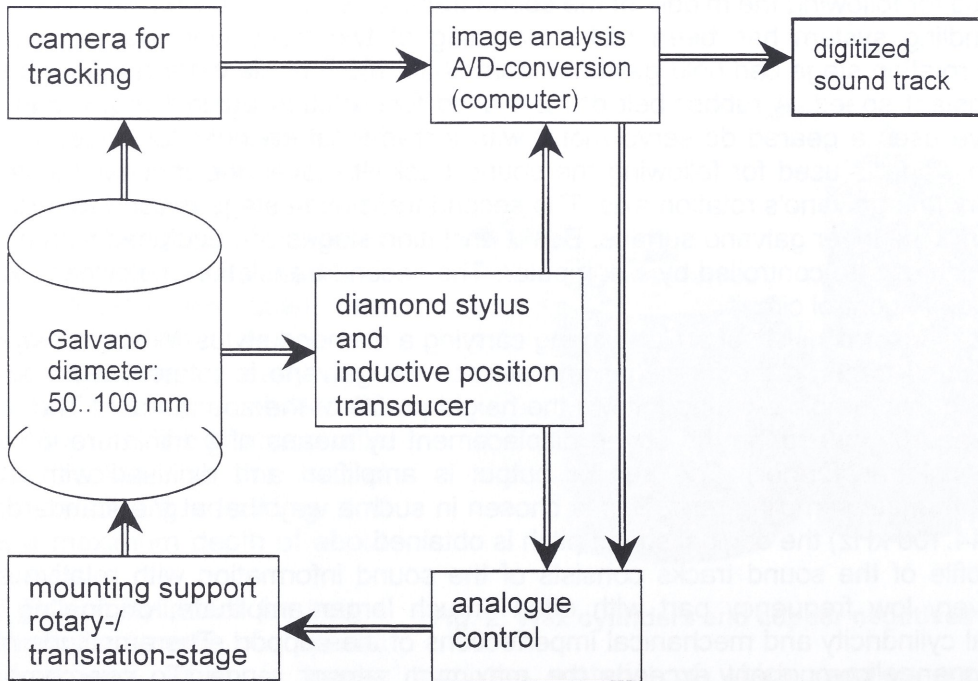


Fig. 4: Principle of the direct galvano player

Results

Play backs made with our direct galvano player have been compared with wax copies played on a modern cylinder player. The sound quality is similar though the sound timbre is somewhat different. This has been expected due to the fact that our sensor measures absolute displacement and gives a flat frequency response like a condenser microphone, while the cylinder player used for comparison uses a dynamic cartridge which needs an equalizing amplifier to get the desired frequency response. Also the noise of the direct galvano player is somewhat higher probably induced by the friction between the diamond stylus and the copper surface.

No evidence of damage of the sound tracks by the playing process has been detected. Microscopic inspection after several play backs didn't show any differences at the used low stylus force. Also the sound quality didn't change. The obtained sound curves didn't show any erosion of the peaks.

The maximum play back speed depends on the galvano properties like visibility of tracks and deviation of the ideal cylinder. Normally 5 RPM can be used resulting in a play back time of about 80 minutes per galvano.

Due to the precise active positioning of the stylus, fragments of galvanos can be sampled and patched afterwards. This can be beneficial for re-recording of bad galvanos or galvanos made from broken wax cylinders.

Technical Data of the Galvano Player

diameter range of galvanos:	50 - 100 mm
max. length of galvanos	160 mm
playing Speed:	0.1 - 10 RPM
stylus force:	10 mN
sensor range:	150 μ m
sensor resolution:	0.04 μ m
sensor bandwidth:	1 kHz
frequencyresponse:	100 - 5000 Hz (depending on play back stylus)
digitising:	12 bits linear
sampling:	typ. 24 000 samples / revolution (selectable)
sampling rate of sound data:	44.100 kS/s
max. signal/noise:	40 dB (depending on galvano properties)

Acknowledgement

The development of the described direct galvano player has been funded by the Bundesministerium für Bildung und Forschung (03-ST9BER-8).

Literature

- [EXNER97] Nicolai Exner: "Phonographenwalzen: Probleme bei der Restaurierung, Informationssicherung und -übertragung von Tonträgern aus Wachs", Diplomarbeit, Fachhochschule für Technik und Wirtschaft Berlin, 1997
- [STANKE97] Gerd Stanke, Tim Wöhrle: "Bildanalytische Gewinnung von Tonsignalen aus alten Tonträgern - Kupfernegative von Edisonwalzen", Band "Einsatz neuer Technologien in den Geisteswissenschaften", S.48-50, Forschungszentrum Jülich 1997
- [ZIEGLER95] Susanne Ziegler, "Die Walzensammlungen des ehemaligen Berliner Phonogramm-Archivs" in: Baessler-Archiv, Beiträge zur Völkerkunde, Band XLIII, Sonderdruck aus Heft 1, Berlin 1995