

NOTEBOOK "SOUND SIGNAL PROCESSING"

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NOTES ON SONICITY

On "sonicity"

- by definition, "sound" (from Latin *sonus*) vibrational medium (water, air) event limited to audible perception by humans; sonicity implicit causation of sound, such as electromagnetic waves, electronically transduced to loudspeaker vibrations

- "sound" becoming inhuman once human hearing itself machinically "resolved into a series of processes of registration, transmission and transformation, which were then emulated and reenacted experimentally"; "by technical devices able to perform these functions [...] as a model in these processes", sound decoupled from human perception, becoming epistemic object; once de-anthropomorphized, technologies of recording, broadcasting and reproduction of sound no longer modelled on the human ear; analytic recording (Marey's *méthode graphique*, Scott's "phonograph"), by allowing "repeated access to their recordings of fleeting sound events", turning the vibrational signal into a a-sonic trace. "Ensembles of sirens, resonators, the harmonium and tuning forks enabled the arbitrary production of well-defined sound. With the use of the phonograph and gramophone, sound became independent of its original context"; media technologies of recording transmission and transformation resulting in a non-audible phenomenality of sound: tones and clangs, signals and noise, information and distortion," and the vibration of a sounding body was only one form of energy among others" = draft workshop *Sounds of Science*, MPI-WG, Berlin; notion of sound extending to culturally "meaningless", aperiodic (white) noise

- electronically-generated high frequency oscillations' (electromagnetic waves) under the media-archaeological gaze understood in their operative micro-temporality; main principle in all oscillators "a tension between *opposing forces* combined with a regenerative or *positive feedback*" = György Buzsáki, *Rhythms of the Brain*, New York (Oxford UP) 2006, 142

- sonagrams a process by which imperceptible sonic articulations are rendered accessible to human senses as visual data by a process of transduction and pixelization; radar's visualization of sonic data a similar mode of processing. While technical media like the gramophone store sound for replay, electronic media store implicit sonicity as information. 'Any electronic instrument electromagnetically transubstantiates the essence of sound from mechanical vibration into an essentially different, but physically analog form of existence, from explicit sound to implicit sonicity; when digitized, temporal articulations of the real become implicit information of the symbolic, available for digital re-call via computational "algorhythmics" = Shintaro Miyazaki, *Algorithmics*. Understanding Micro-Temporality in Computational Cultures, *online* in: *Computational Culture*, Issue 2 / 2012 (<http://computationalculture.net>)

- a "sense of ending"; when pick-up of the record player put into the vinyl groove, the spiral writing of the groove itself is already the starting of its own end; music, once recorded on a sonic time object, has an in-built sense of

ending, different from geometrical existence as score; vs. ideal "timeless"
Fourier analysis of the sonic signal

- "technical media are media of non-solid, non-phenomenological worlds (electro-magnetic fields, high-level mathematics, speeds beyond human comprehension" = chapter "Non-human media", in: Jussi Parikka, *What is Media Archaeology?*, Cambridge / Cambridge, Mass. (Polity Press) 2012, 55-61 (62)

Matter sounds: Acoustic earthquake monitoring

- recording for subsequent analysis of otherwise ephemeral vibration; for implicit sonicity to be articulated acoustically, it has to be inscribed in solid matter; functional sonification a major practice to detect sudden changes in monitoring earthquakes; *matter sounds*: "By time-compressing the output of a seismometer, it is possible to present seismographic data in an auditory display" = Sheridan Dauster Speeth, *Seismometer Sounds*, in: *The Journal of the Acoustical Society of America*, vol. 33, no 7 (July, 1961), 909-916 (abstract); with time-critical capacity of human hearing, possible "that the seismic sounds due to natural earthquakes may be distinguishable from those due to underground explosions"; "the ear's ability to use the information contained in the temporal dynamics of the short-time audio spectrum" = Speeth 909. Remarkably, though, in order to perform such distinctive analysis, "[a] pair of seismograms, one of an explosion, the other of an earthquake, [...] had been digitalized <sic> at a sampling rate of ten samples/sec., and were available on punched cards. To equalize intensities, the two sets of cards were fed into an IBM 7090 where every sample of one set was multiplied by a constant to produce equal rms amplitudes. Both were then read onto a magnetic tape through a digital-analog converter at sampling rates of 1000, 2000, 4000, and 8000 samples/sec. This provided time compression factors of 100, 200, 400, and 800. The resulting analog tape was played through an AR-1 loudspeaker, and a clearly discriminable difference between the two seismograms could be heard" = 909 - thereby resulting in a "audio tape" of a second, implicitly sonic quality ("sonicity"). A similar high-speed playback of an earthquake has been used by the seismological laboratory of the California Institute of Technology "as an input for a speech sonograph to facilitate "the study of transient effects" = Speeth, 909, note 5

- high frequency trading, in e-commerce, asking for a phenomenological interface to reveal its micro-temporal moment, which deserves different forms of becoming visualized or better: sonified, just like earthquake analysis is better done by audification, since the human ear is most attentive to micro-temporal changes (known from music listening)

"Post-digital" nostalgia for sound matter? On *Untitled II*

- discovery of electro-acoustics, mechanically sounding body no longer conditional, de-coupling the sonic event from matter; pick-up of an electric guitar transducing material vibrations of the string into almost immaterial electro-magnetic induction (even if, in addition, there is still a sublime effect of the wooden block for material resonance: friction, dissipation). Within the technical medium, sound becomes a pure signal, subject to analysis,

transformation, and synthesis. "In the digital age, sound finally became fully autonomous: As a pure stream of information it is now amenable to any kind of algorithmic manipulation "without the involvement of a sounding body in the conventional sense" = CTM 2015 "Un Tune" (draft)

- for an algorithm to unfold, a strict sequential order mandatory (be it linear, or loops, or conditional jumps like "GOTO" order in BASIC); turingmachine as such not time-critical; its numerical (digital) pulse sequences take place stepwise, counting; a more metronomic time-base (duration of each step, cycling units, speed, technological "prosody") only takes shape when such a "score" is actually implemented into a computing machinery, becoming "algorhythmicized" (Miyazaki)

- "post-digital" art re-injecting bodily and other matter back into electronic sound; re-sonification: media-artistic slowing down high-frequency medium operations to make them accessible to human (sonic) perception again (like early digital computing still audible); media archaeology as decisive "archaization" / slowing down in the temporal domain; rather chronophotography than the cinematographical illusion of continuous movements

- primary component of an electro-acoustic synthesizer, the "oscillator", connecting electronic components in a feedback loop; LCR circuit containing capacitor, coil and resistor

Fourier('s) implicitly "sonic" analysis of heat conduction and its cold calculation

- techno-mathematical operation of Fourier Analysis transforming the time domain of the sonic wave form into the frequency domain; a given function represented by a series of sinusoidal functions; Fourier transform "decomposes a function of time (a signal) into the frequencies that make it up, in a way similar to how a musical chord can be expressed as the frequencies (or pitches) of its constituent notes" = https://en.wikipedia.org/wiki/Fourier_transform, accessed August 30, 2017

- implicit sonicity in all Fourier Transformation, even though in Fourier's original publication (1822) on heat conduction, such mathematical analysis applied to other vibrational and oscillatory events only marginally; decompose complex (but periodic) functions like what is perceived as sound into the sum of simple (sine and cosine) waves which - in reverse - can be expressed (and thus: computationally addressed) as frequency, i. e.: numbers; sound as addition of tones; drone = "Ge/Summe" (both as kymatically and mathematically)

- by Fast Fourier Transformation, any kind of (digitized) sound broken down into discrete time slices, shunks of sound / Gabor's "acoustic quanta"

- "Ces considérations offrent un exemple singulier des rapports qui existent entre la science abstraite des nombres et les causes naturelles" = Jean-Baptiste Joseph Fourier, *Théorie Analytique de la Chaleur*, Paris (Firmin Didot) 1822, 15; Fourier derives a general conclusion: "Plusiers questions de

mécanique présentent des résultats analogues, tels que l'isochronisme des oscillations, la résonance multiple des corps sonores" (ibid.)

- Nyquist / Shannon sampling theorem betraying the natural (physical) criterium of indexicality, proving that (at least for the range of human sensual perception) a continuous signal can be quantized and time-discretely be digitized and still be reconstructed without loss of *information* when this is done with a frequency at least doubling the highest frequency contained within the signal

- Fourier's mathematical insight into dynamical processes anticipated by Leibniz' concept of the unconsciously calculating ear; implicitly sonic

- Hermann von Helmholtz rhetorically questioning if Fourier's analysis might not be a "mathematical fiction" = Hermann von Helmholtz, *Die Lehre von den Tonempfindungen als physiologische Grundlage für die Theorie der Musik*, Braunschweig (Vieweg) [*1863]; 6th edition 1913, 58 - "bloß eine mathematische Fiktion, welche zur Erleichterung der Rechnung erlaubt sein mag, aber nicht notwendig irgend einen entsprechenden realen Sinn zu haben braucht?"; human ear actually performing a mathematical analysis of complex sound into its frequency components itself

- vibrating electrons, atoms and molecules the cause for energy conduction within and between adjacent bodies; appropriately, quanta of thermic wave energy within crystals called *phonons* = entry "Thermal conduction" in the online encyclopedia Wikipedia, accessed September 27, 2013

Paris (Schaeffer) vs. Cologne (Stockhausen): Body-performative electro-mechanical kinetics vs. circuitry-operative electronics

- sono-epistemological conflict between Paris studio of *musique concrète* (Pierre Schaeffer) and the Cologne WDR radio of Electronic Music (created by Herbert von Einem): recording and manipulation of originally physical sound *versus* electronic sound generated by tone oscillators from the beginning, in pure sonicity

- Pierre Schaeffer operating with recorded sound and noise from natural surrounding, *la musique concrète*, by means of the recording device of the magnetic tape, cut into new combinations; *Studio für elektronische Musik* established under direction of Herbert Eimert in 1953 at the Cologne broadcasting radio station, where sound has been originally generated by electronic devices (literally "synthecised"), based not on musical harmonics, but on pure sine wave, on serial aesthetics, statistic probabilities, mathematical stochastics ("sound" in media-archaeological listening) = Friedrich Knilli, *Das Hörspiel*, Stuttgart (Kohlhammer) 1961, 30 f.

- Schaeffer's *Phonogene* (like his *Morphogene*) continuous like phonograph; "sons animés" as Duchampean concept of "found objects", Pierre Schaeffer, *Traité des objets musicaux*, different form "objet sonore"; in electronics (instead of simply "electrics"), term derives from the triode, undoing all mechanical hindrance; no kinetic but cybernetic coupling as electric circuitry, electro-

magnetic inducting happening without bodily intervention which is still cultural technology. machine music vs. electronic music (Meyer-Eppler). Schaeffer: performative electro-mechanism; Cologne studio: operative by machines. still "hands on instrument" in Cologne, but in the cybernetic sense of directing (Steuerung), not: direct sound production by physical energy. Electrons in thermionic tube have no mechanical energy, rather: intelligent control of voltage like in synthesizer. kinetic = body techniques in sound production, vs. full technology. if kinetics, then in the sense of Reuleaux / Babbage: coupling. as long as human hands tinker with technology, this is "soft" media-archaeological experimentation (exploring the machine); Brian Kane, "Twilight of the Sound Object", conference *Sound Art Matters*, University of Aarhus, June 1-4

Sonic memory's two technological embodiments: physical signal and archival symbol

- in micro-physical *close listening*, the materiality of the recording medium itself becomes poetical
- digitalization a radical transformation in the ontology of the sound record - from physical signal listening to a listing of its numerical values; media culture turns from phonocentrism to mathematics again
- difference between audification and sonification and musification; first one is the "archaeological" layer (acoustics of "the real"), sonification is already a symbolical representation and musification represents the imaginary (the semantic); ears as reverberative micro-wave emitters sonificators themselves
- "sound" from a CD player nothing but a sonification of a serial array of binary data, that is: square-shaped signals; symbolisation in form of bits, while being an abstraction from the real world, does not mean that the relation between the information and the physical world has become purely arbitrary. When analog signals from the physical world are being sampled (i. e. time- and value-discretely quantized), the resulting strings of bits ("words") as still quasi-indexically shaped by the original physical event which, in the case of digital visual recording of dance, is the moving bodies
- music not the sonic event in itself but a phenomenon of integer mathematics, thus: symbolic regime; sound as mathematics *in operativity*, that is: implemented into vibrating matter
- Technical Committee of the International Association of Sound Archives in its standard recommendations for archival sound recording in December 2005: relative to technological changes of conditions = http://www.iasa-web.org/IASA_TC03/IASA_TC03.pdf, accessed June 2011; digital data need constant up-dating and „migration“ (in terms of emulating hardware to run them); conceptual shift from the frozen archive to permanent re-implementation

Sonic memory: Electronics makes a difference

- digital recording representing fundamentally different materialities and logics (techo/logies) in terms of their ways of registering time-variant signals, time-based forms of reproduction and their "archival" being in time; electronic tube, especially the triode, once liberating technical media from mechanical constraints, thus: from erasure over time; still the tube or transistor are subject to decay over time themselves

Material entropy versus symbolic endurance of sound recording

- with refinement of the Phoenician alphabet to the Greek phonetic alphabet, acoustic articulation (speech, singing, oral poetry) becoming symbolically „recordable“ (coded) for space- and time-independent re-performance (decoding)

- „archival“ permanence of recorded sound signals almost invariant towards change with time („absconding from history“, as expressed by Rainer Bayreuther), leading to ahistorical immediacy in the moment of re-play; physical reality of storage devices over time: increasingly subject to macro-temporal entropy such as the material deterioration of Edison cylinders or magnetic tapes. Digitized signals at first sight represent the re-turn of traditional music notation (the score), but this time the symbols („bits“) are endowed with operational activity; they are algorithmically executable

Media "music"

- source code / poetry working as well when just reading it (even silently) – the success of the phonetic alphabetic recording / of mnemonic or high level programming; musical score depending on its actual sonic realisation in its physical sound bodies = Hammerstein 1866: 2, respectively its „hardware“; algorithms become operative only when implemented in matter, being in the world, thus: in time

- music-as-theory belonging primarily to the symbolical order (notation / concept. As such music is invariant against entropic time, different from the incorporated sound whose physicality is time-bound indeed (the "real"). "Being in music [...] is conceivable only as an 'enclave'" = Erlmann 326, paraphrasing Stern

- media and music both coming into being only in performance; „musical situation“ (Stern) and the definition of technical media, coming into existence only in the process of performance („Vollzug“); temporal experience of listening to music is „faktischer Mittvollzug der Bewegungen“, a „Mitgehen“ = TS 1930: 66

- since emergence of signal recording devices like Léon-Scott's Phonautograph or Edison's Phonograph, an acoustic event can be re-played invariant towards historical change; „phonographic situation“ (term coined in accordance with Stern) a temporal ecstasy, "off" historical time. What the transposer does to pitches and voices, the phonograph does to acoustic time = Stern 1930: 59, note. 1, on "Transponierung"

- gramophone disc, according to Stern, does not reveal an acoustic image of the *Mondscheinsonate*, but the *Mondscheinsonate* itself = quoted in Ellensohn 2008: 64 / *Antiquiertheit des Menschen*, § "Matrize" - just like radio does not reproduce speech and music, but actually displays them

- "[T]he *sine qua non* of writing the history of past music is to have this past music *re-enacted in the present*" = Collingwood's 1928 lecture "Outlines of a Philosophy of History", in: Collingwood 1946/1993: 441; equivalent to time-signal based technologies

Symbolic notation: invariant against historic, i. e. entropic time

- Isidor from Sevilla: „Nisi enim ab homine memoria teneantur soni, pereant, quia scribi non possunt“ = quoted in Hammerstein 1966: 4 - until the arrival of Guido of Arezzos notation of musical duration (symbolically) and the phonograph (signal-really) allowed for fixing sonic articulation / phonography

- in replay of an ancient phonographic record, *the audible past* (Jonathan Sterne) rather articulates itself in the noise of the recording device (the ancient wax cylinder) than the recorded voice or music; the medium talking both on the level of enunciation and of reference. What is heard most: the cultural content (the formerly recorded songs) or the medium massage such as limitations in vocal bandwidth, even noise (the wax cylinder scratch and groove)?

- tempor(e)ality of technical media grounding in the entropic deterioration of the electric charge and chemical carrier of the magnetic tape *versus* symbolical, i. e. almost time-invariant „tradition“

- an archival record suspended from historical respectively entropical time? traditional archival endurance of records, based on the very materiality of its carriers (storage media), changes its nature from endurance to the „enduring ephemeral“ (Wendy Chun) when the record is not fixed any more on a permanent storage medium but takes places electronically; flow (the dynamic essence of electric current) replaces the inscription

Re-entry of "music" as symbolic form: computing

- *musical* memory symbolically notated in scores, while *sonic* memory preserved in signal-based phonograph recordings, endowed with "temporal indexicality"

- different from the age of handwritten and printed textuality, electronically stored signals (French *écriture magnétique*) themselves become ephemeral like sonic or vocal articulation in previous times. "Although digital information is theoretically invulnerable to the ravages of time, the physical media on which it is stored are far from eternal" = Jeff Rothenberg, Ensuring the Longevity of Digital Documents, in: Scientific American, Vol. 272, No. 1 (January 1995), 42-47 (42)

- in computational media, alliance between computing (algorithm) and *mousiké* (rhythms) implicitly returns; sonicity "matters" not as actually acoustic, but processual event; "implicit sonicity" refers to sound not as an audible phenomenon but its "message" as time-signal

Abuses of "sound" for computer graphics

- vector graphics (for early computer games) as "abuse" of audio-*Ausgang* of PCs (since the only analog interface, where from bit values *Spannungen* can be generated), to direct cathode ray beam in vector monitors = communication
Stefan Höltgen, 23 January 2015

- hybrid inbetween: "Digital Vector Generator" (DVG) as internal chip between digital computer and vector screen (addressed by Opcodes)

- term "Rasterbildschirm" *Ansteuerungsmodus* of Cathode Ray Tube electro-physical essence irreducibly remains "analog", different from the genuine pixel screen; hybrid: vector games output on raster screen (with smoothing Besenham algorithm for Anti-Aliasing of scalar effects)

Listening (to) radio transitively and nuclear "radio"

- only graphical representations of the sound wave allowing to be analysed and represented as the Fourier series of periodic functions (sine waves); in reverse: synthetic acoustics?" = Boris Yankovsky, *The Theory and Practice of Graphical Sound*, as quoted and translated by Smirnov 2012: 210

- transition of discrete pulse trains into an impression of continuous waves implicitly sonic (and becomes audible by attaching a loudspeaker: Philips LOCMOS (Local Oxidation Complementary Metal-Oxide Semiconductor) Bliker; an essential emanation of electronics itself, the perceptible effect being a direct function of operative media-diagrammatics. The technical impulse diagram reveals the coming-into-existence of this electro-rhythmic sequentiality with the kinematographic effect of a circulating waveform; discrete pulses generated by a symmetric astable multivibrator with a fixed frequency are combined with a calculated system of delays, time-defined by capacitors and resistors, differentiating the current at the exit of inverters

- with the "resonant circuit", radio suddenly becomes the "sonification" of an *implicit* "syntony" (David Lodge); Aitken 1976; archaeological investigation close to engineers' signal analysis of physical media

- uncover (*aletheia*) the hidden agenda of technomathematical artefacts, or artefactuality, media not only on their structural but on their *operative* level. Heidegger never opened his radio; radio has been synecdochically disguised. Radio means the circular propagation of electromagnetic waves (thus "broadcast"). One special form of signal transmission, short wave radio, operates on the basis of reflection of radio signals in the ionosphere (literally "between heaven and earth"); the well-known effects like "fading" in listening

to Short Wave is transitive listening to the instant ionospheric "weather" report (communication of seasonal Ionospheric "weather forecast" in Amateur Radio journals)

- "It's more typical to speak of visible light as wavelengths measured in nanometers or angstroms. I'm using frequency to be consistent with sound. They're equivalent, as frequency is just the inverse of wavelength" = „24/192 Music Downloads ...and why they make no sense“, Autor: „Monty“, 1st March 2012 = <http://people.xiph.org/~xiphmont/demo/neil-young.html>; accessed March 2012

- case of radio-active deposits, we are not dealing with immobile materiality or passive symbolic codes, but with matter which emits signals actively. Nuclear waste, by definition, is "radio" active; so why not take the radiation itself as basis for continuous signalling? "Every form of physical energy propagation can be used as a channel for conveying messages" = Sebeok 1985: 459; sonification an option of indicating the degree of radio-active decay itself - and not just "acoustically" coded images as in the case of the Voyager disc or acoustic records from noises, sound and ethno-music recorded on earth

"Immaterial" sonic heritage? Archaeo-acustics

- UNESCO caring for the preservation of *immaterial* heritage of ephemeral cultural articulation like speech, dance, music, and computer software. The ephemeral is what the traditional museum can not preserve; preservation of processual techno-logical knowledge like computer software (Doron Swade)

- mediatempor(e)al specificity of "acoustic space" (McLuhan) as opposed to the geometricized space of the Gutenberg print era. On the other hand the "deep" time of archaeoacoustics (a term coined by Scarre and Lawson 2006) which - still - is radically present whenever it is measured and re-enacted. Any sonic articulation can not be past and is by definition ahistoric (different from "music" which belong to the symbolic regime, i. e.: historiography; no wave-based model of acoustics in antiquity = Devereux *ibid.*, inhibited by symbolical regime of "musical" order

- archaeoacoustics by modern performance of music at ancient sites; investigative research "using monitoring with *electronic* instrumentation" = Paul Devereux, *Sound & Ancient Sacred Places*, in: UN TUNE. CTM - Festival for Adventurous Music & Art, 16th Edition, Berlin 2015, such as sound generation (wide frequency "pink noise"), and studying acoustic resonance inside acoustic spaces; siren research

- resonance frequency detected *by measurement* in several prehistoric monuments in England and Ireland focused on 110 Hz, equals the lower baritone register of the human voice = Devereux & Jahn 1996; effects on the human brain activity = I. Cook, *Ancient Acoustic Resonance Patterns Influence Regional Brain Activity*, Princeton International Consciousness Research Laboratories Internal Report (2003), referred to in: P. Devereux, *Ears and Years. Aspects of Acoustics and Intentionality in Antiquity*, in: C. Scarre / G. Lawson (eds.), xxx; past can be made to "speak" = M. S. Bruchez, *Artifacts that speak*

for themselves. Sound underfoot in Mesoamerica, in: *Journal of Anthropological Archaeology* 26 (1), 2007, 47-67

Tuning into the past

- "In technical terms, 'tuning' is the process of getting into a certain state of resonance, and in electronics is related to so-called 'tuned circuits'" = Shintaro Miyazaki, *Listening to Wetware Circuitry. Sonic Experimentations and Algorhythmicity*, in: *UN TUNE. CTM - Festival for Adventurous Music & Art, 16th Edition, Berlin 2015*, 64-67 (64); tuning involving circuitry; to get reception the circuitry of a radio receiver needs to oscillate with the same frequencies as the radio sender's carrier frequency

- epistemological equiprimordiality: "Electric oscillations as well bioelectric signals and acoustic vibrations are equal in mathematical terms, and can all be describe by using equivalent circuit diagrams. Moving from acoustics to electronics was thus merely an act of algebraic translation" = Miyazaki 2015: 65; term "sonicity" meant to catch this co-originary analogy - and to name sound which not only became silenced (like the "Funkstille" in German military radio at the end of World War II), but to name "inaudible operativity" = Miyazaki 2015: 67, as such like radio carrier waves which are active even when there is no low-frequency modulation by voice or musical waves at all; preface to Barkhausen, *Schwingungslehre*

- sound from / in the past not overall ephemeral but coupled to matter from which it originates physically or electronically. Rather than just extending variety of "historical sources" by sonic dimension, sonic media have a proper temporality themselves. "ideo-sound" refers to the aging of media materialities, such as the "pre-echo of magnetic tape that has long gone unheard", up to "the crackles and pops of scratched vinyl" or "the skipping of a CD" = Jens Gerrit Papenburg, *(Re-)Mastering Sonic Media History* (typescript January 2015), published version in: same author / Holger Schulze (eds.), *Sound as Popular Culture. A Research Companion*

- present re-entry of the scratchy sound from a vinyl record more than just a "post-digital" sonic fetish; listening to it with a media archaeological ear, "understood" epistemologically, as an index of *LoFi* sound as media criticism and as a technically self-reflective potential of disturbance and noise

- for philology, a text never exits "outside of the physical support that offers it for reading (or hearing)" = Roger Chartier / Guglielmo Cavallo 1999: 5, as quoted in Papenburg, op. cit.

Message or noise? Acoustic archaeology

- implicit sonicity; address "noise" as an essence of technical media

- the scratching, the noise of the recording apparatus and storage matter; true media archaeology starts here; allows for phonographic forensics: noise of the machine allows for provenance identification of the archival record;

phonograph as media artefact does not only preserve the memory of cultural semantics but past *technical* knowledge as well, a kind of frozen media knowledge embodied in engineering and waiting to be un-revealed by media-archaeological consciousness

- Technical Committee of IASA in its recommendations from December 2005 insists that the originally intended signal is just one part of an archival audio record; accidental artefacts like noise and distortion are part of it as well - be it because of faults in the recording process itself (sender noise) or as a result of later damage caused in transmission (channel noise); two kinds of signals, the semantic and the «*mémoire involontaire*», message *and* noise

- differentiate between the „social“ respectively „collective“ (Halbwachs) memory of sonic events (auditory memory) and the actual (media) recording of sonic articulation from the past. For an archaeology of the acoustic in cultural memory the human auditory sense does not suffice; track the sonic trace with genuine tools of media studies (which is technical media). One way of „acoustic archaeology“ is to play a musical partition on historic instruments. But the real archaeologists in media archaeology are the media themselves - not mass media (the media of representation), but measuring media which are able to de-cipher physically real signals techno-analogically, and representing them in graphic forms alternative to alphabetic writing, requiring „moving“ diagrams (since sound is articulation in time): the oscilloscope

Active media archaeology: Sonic revelations from the past

- "sound rescued from the archive" understood in a double sense: a) sound technically retrieved from the archive; b) the non-archival quality of sound

- media archaeology concerned with latent, implicit rather than manifest, directly audible sound knowledge *within* the material dispositive - which is not explicitly turned into written knowledge yet

- ancient Greek *mousiké epistéme*; in the absence of signal processing media, musical analysis served as a substitute for insight into time-based processes. As such the science of music both enhanced and hindered the insight into acoustic media, as in the case of Galileo Galilei. With his experiments of generating sound by rubbing patterned surfaces, Galileo involuntarily came close to inventing the phonograph = H. Floris Cohen, Galileo Galilei, in: Paolo Gozza (ed.), *Number to Sound. The Musical Way to the Scientific Revolution*, Dordrecht et al. (Kluwer) 2000, 219-231 (222); in sonic articulations he detected primarily music, not "audio": the proof of the connection between numerical proportionality in tonal pitch and the impulse theory of sound

- emphasis on "sound", has been the most "immaterial" cultural articulation (before the electronic age) already

- historical research primarily text-based archival philology, as opposed to a science of signals. Battles have been described and interpreted, but the real noise and smell of a combat could not be transmitted until the arrival of the Edison phonograph = Bernhard Siegert, *Das Leben zählt nicht. Natur- und*

Geisteswissenschaften bei Dilthey aus medienschichtlicher Sicht, in: Claus Pias (ed.), Medien. Dreizehn Vorträge zur Medienkultur, Weimar 1999, 161-182 (175), referring to: Wilhelm Dilthey, Die Abgrenzung der Geisteswissenschaften. Zweite Fassung, in: same author, Gesammelte Schriften VII, 311

- getting tuned to non-canonical epistemology, not by texts and the spoken word, but by a French childrens' song: *Au Claire de Lune*. In an act of active media archaeology by the computer itself it has been achieved that the graphic recording of Léon Scott's analyses of the human voice could be re-transformed into acoustic articulation. By means of optical reading of signals and application of digital filters, it is possible to digitally trace past acoustic signals from records. From such an operation we expect sound, but really what we primarily hear is noise - just like the first (archived) recording of sound in Norway, a tinfoil flattened to a „document“ and annotated by a remark by a former collector who claims this has been the first Norwegian recording of music on Edison cylinder; digital reading, algorithmic filtering and final re-sonification of this record by a laboratory in Southampton led to a kind of re-sonification where the ear wants to detect something like music or speech - but it actually hears nothing but noisy patterns.

- past sound not just "restored" by applying digital filters but has to be remembered with all the traces of decay which has been part of its tradition, its media-temporal (entropic) characteristics must be archived as well: the scratches, the noise of an ancient phonographic cylinder when being digitized; remain(s) close to the physical record; not just symbolically emulated but a/effectively simulated; "archive" its temporal (entropic) behavior as well. One method of keeping recorded sound from the past alive known from computing as physical modelling (f. e. in sound reproduction); *granular synthesis* in audio engineering and *physics-based sound synthesis* = digital audio processing logarithms built upon the essential physical behaviour of various sound production mechanisms

- chemical decay of recordings from the past such as Edison cylinders belonging to the essential feature of the sonic record and can now be algorithmically simulated. Not just the recorded sound is emulated, but the chemical process within the sound carrier itself. A "close reading" of a physical record like a magnetic tape is a laser scan of its magnetic field (which can be made visible by chemical colouring) which then can be digitally processed into sound again

- sound, let to its own surroundings, articulates *it-self*, is rather noise such as can be expected in any transmission channel according to the theory of communication developed by Claude Shannons - a theorem which can be extended to transmission in time as well, that is: tradition. In such noise articulates itself what baroque allegories showed as the nagging „tooth of time“ - the articulation of physical entropy, the manifestation of the temporal arrow; according to the Second Law of Thermodynamics each system tends, over time, to increasing dis-order

- "We may assume the received signal E to be a function of the transmitted signal S and a second variable, the noise N . [...] The noise is considered to be a

chance variable just as the message [...]. In general it may be represented by a suitable stochastic process" = Claude E. Shannon, *The Mathematical Theory of Communication* [1948], in: ders. / Warren Weaver 1963: 29-125 (65)

- media-archaeological dispositive for digital type of (almost) lossless reproduction of information by identical symbols has been the Gutenberg printing technology (as opposed to handwritten copies of manuscripts) with its negative types to re-produce letters positively in identical numbers - a form of reproduction later re-invented by the photographic negative, the Talbot Kalotype (as different from the unique Daguerre positive), which led Walter Benjamin to remark that reproduction technology both disconnected and freed ("er/löst") the reproduced object from the realm of tradition, by replacing the unique event (the condition for its „auratic“ character) by its mass multiplicity. Temporal tradition is thus replaced by a rather topological dissemination = Walter Benjamin, *Das Kunstwerk im Zeitalter seiner technischen Reproduzierbarkeit* [originally published in its French translation 1936], Frankfurt / M. (Suhrkamp) 1963, 13

- entropic deterioration of the electric charge and chemical carrier of the magnetic tape *versus* symbolical, i. e. almost time-invariant "tradition" by copy

- analog sound carrier, which is in-formed physical materiality, can still be identified according to the criteria of the material source-critical method, digital signal transfer primarily is information in its communication engineering sense (given by Shannon), that is: unbound from energy and matter by coding (as Norbert Wiener in his *Cybernetics* insists).

- in media-active archaeology, the technological apparatus itself the archaeologist proper. Patrick Feaster and David Giovannoni thus succeeded in re-sonifying the preserved phonautographic engravings ("Schallbilder"), beginning with Scott's recording of a sound folk tone of 435 Hz in the year 1859. 150 years later science realized that with optical „reading“ of such acoustic signal lines sound can be re-synthesized, and all of the sudden a children's song sounds again. What metaphorically looks like the pick-up of sound images by a „virtual, digital gramophone needle" = Harald Haack, *Die erste Klangaufzeichnung. Eine Audiografie*, <http://newsbattery.blogspot.de/2008/05/07/die-erste-klangaufzeichnung-eine-audiografie>; in fact something media-epistemologically different, a picking-up of a completely new kind: digital sampling

- "sonophenomenological" (Johann Kroier) listening vs. "acoustemological" (xxx) *understanding* of sound as object / subject of investigation

A media-archaeological approach to sound

- vibratory affect, according to Steve Goodman, temporally prior to its cognitive perception, even autonomous (Deleuze); "the affective action of a body on a body *precedes and thus conditions* a subject's cognitive response" = Kane 2015: 5; micro-temporality of implicit sonicity; fore-running temporal "attack" of a tone from piano or synthesizer key

- as epistemological approach, media-archaeology of "implicit sonicity" understands "sound" (signals) and "music" (symbols) as an articulation "to (re)organise and reflect events in time"; Constantin Engelmann, Auditory Projections, in: Flusser STUDIES 17 (May 2014), *online*
- temporality of technical media and their affect on human temporal perception; "sonopoetics" *resonating* with Jonathan Sterne's / Tara xxx essay on "The Poetics of Signal Processing"; structural affinity between sound and technical media; both unfold only when being processed
- not submerging sound technologies within an overall historical / social / economical / gender (discourse of) "context", the media archaeological gaze tries to identify social et al. elements *within* technologies themselves and describe their implication not contextually but *implicitly* (as in-foldings) - an elementary, "micro-political" approach
- medium-specificity / format specificity or infrastructure specificity. Formats (in terms of streaming data) replace the traditional hardware-bound medium (Stefan Heidenreich's book *FlipFlop*, 2004); transformation of radio (vanishing of Short Wave World Radio which puts us in contact with the Ionosphere so physically); growing oblivion of hardware in algorithmics; even programming has become virtual; physical implementation a marginal aspect of "technical informatics"; programming in Assembler in a media-epistemological context, enlightens the time-sensitive and hardware-relative aspects of computing; an anamnestic project: not media nostalgia but insisting on questioning the aesthetics and discourse of "high level" script languages
- software tools to re-construct past acoustic settings / "auditory displays" (Gregory Kramer); how did Beethoven music sound in now vanished concert halls of Vienna where his compositions were originally performed (Weinzierl); acoustic "amplifiers" ("echeia") in Greek and Roman theatres; tempor(e)alities of sound & media, both in the sense of ahistorical perception of the past in music (tempauralities), and the micro-temporal chronopoetics within sound / electro-acoustic media
- Sterne's MP3 book; series title "Sign, Storage, Transmission". add in brackets: "Symbols"; signal- vs. symbol-based recording, and "processing" (when all the mathematical intelligence steps in)
- deMarinis, on the acoustic tempor(e)ality of a re-sounding ancient Roman bell

Water waves, flimmering air: Order by fluctuation

- challenge to maintain a certain temperature (the notion of *homeostasis*) adapted by cybernetic thought, resulting in a both epistemic (Rheinberger) and technological (Wiener) things: positive, respectively negative), feedback mechanisms. Communication, control, and regulation in "thermal" technologies refers to both sensory and signal transfer in the animal and the machine (Wiener); has been transformed from a physical measure ("temperature") into the mathematical practice ("information"), just like "thermic" heat waves, once

mathematically analyzed by Fourier, became literally *transformed* into synthesis from data, thus: computational objects

- signal-to-noise ratio in breaking waves at the seashore appears arbitrary; subconscious *pétites perceptions* (such as in listening), according to Leibniz, still calculates such phenomena, as nucleus of a statistical theory of noise and random

- sonic difference between stochastic noise and musical order evident in time reversal: Even if played from tape in reverse, noise sounds equal; Boltzmann's entropy defining the arrow of time

Informational aesthetics: Entropy in (cloud) painting

- instead of symbolic order by classification, informational aesthetics (Abraham Moles, Iannis Xenakis) allowing for degrees of disorder, which, in communication theory, implies the highest degree of (possible) information, where the actual message is *one selected* from a set of possible messages = introduction in Shannon, "A Mathematical Theory" (1948)

- different from anthropocentric concept of culture, Max Bense in his claim for an "exact aesthetics" switching to what a neologism might call *entropology*. Bense identifying the *aesthetic state* as the "energy" of an artistic object, resulting from the mathematically contrary components order and complexity as previously defined by Birkhoff = Max Bense, *Ästhetik und Programmierung*, in: *Bilder Digital. Computerkünstler in Deutschland 1986*, ed. Alex u. Barbara Kempkens, München (Barke) 1986, 22-30 (22); Fig. *Das physikalische Unordnungsschema im Verhältnis zum ästhetischen Ordnungsschema*, in: Bense 1986: 29; according to Birkhoff, the "aesthetic measure" (M) equaling the ratio of order (O) / complexity (C), oscillating around the borderline between O and C = G. D. Birkhoff, *A Mathematical Approach to Aesthetics*, in: *Scientia*, September 1931, 133-146; in *The Aesthetic Problem* Birkhoff makes the "aesthetic appeal" of the geometric rotatable (while at the same time shape-invariant) polygon an element for such analysis (Chap. II "Polygonal Forms", 16), providing the "aesthetic measure" (numerical decimal values) to each form - the very basis for synthesis in computer graphics (Licklider). Birkhoff claims "to answer aesthetic questions by purely mathematical (logical) reasoning" = 46, parallel to Peirce's notion of *diagrammatic reasoning*. Chap. VIII (170- xxx) deals with "The Musical Quality in Poetry", consisting of a) musical quality (poetic significance) and b) time-critical metre (which Birkhoff actually does not investigate); "musical" therefore equals "harmonical"; rhyme, phonetic vowel analysis, tabular analysis (Markov!) of Coleridge's poem *Kubla Khan*; "These computations indicate ..." (185) The less a work of art is redundant (responding to the already known), the more it is *informative* in the engineering sense as developed by Claude Shannon's in "A mathematical theory of communication" (1948); "entropy" as a measure in works of art is a category born from information engineering

- Rudolf Arnheim, *Entropy and Art. An Essay on Disorder and Order*; Arnheim's preference for an realignment of information with order instead of uncertainty; reminds of a fundamental misunderstanding within the conceptualisation of

entropy itself. Shannon focuses on the initial selection of a special sequence of symbols from a limited alphabet, an act which reduces to uncertainty in the prediction of character sequences; intellectual reduction of entropy is accompanied by "thermal" noise affecting the signal within the *medium* channel of transmission, making it more difficult for the receiver to separate signal from noise (esp. in cryptography) - a situation well known from philological hermeutics

- In Shannon's identification of information with entropy, a particular message reduces the entropy in the ensemble of possible messages (which in terms of dynamical systems is a phase space). Wiener, on the other hand, calls it *negative* entropy; to him - like Arnheim -, information means order, while an orderly thing not necessarily embodies much information. Shannon remarked on that difference: "I consider how much information is *produced* when a choice is made from a set - the larger the set the *more* information. You <sc. Wiener> consider the larger uncertainty in the case of a larger set to mean less knowledge of the situation and hence *less* information" = quoted after James Gleick, *The Information: A History, a Theory, a Flood*, chap. 9 "Entropy and its Demons"; given that entropy is the extent to which a system is disorganized, Shannon's concept of information (entropy) inversely related to Wiener's concept of information (negentropy)

- a photographic reproduction of a painting subject to xerographical miniaturization which then in return is being magnified again, subject to gradual entropization: "Umzeichnung des Gemäldes 'Der Bildersaal' von Frans Francken II. Ausschnitte aus dem Prozeß einer fünffachen Verkleinerung und anschließender fünffacher Vergrößerung. Konzept: Ulriche Giersch" = from: Giersch 1983: 59 f.

- whereas machine has no criterium at what point a picture is not a picture any more but a sheer random distribution of grey or color values (the media-archaeological perspective), only to humans there is a threshold of figurative sens. Emmett William has experimented with the cognitive borderline between what can still be perceived as a meaningful image and an informal electrostatic xerographical distortion "mit den Nahtstellen zwischen noch erkennbarem Bild und den informellen Gebilden elektrostatischer Verzerrung" = Giersch 1983: 67; even an empty page, re-xeroxed a couple of time, generates entropic distribution of graphical traces = Ian Burn 1968

- media art collective Active Archive's *Ephemerol Scan*, where an archival object is placed on a flatbed scanner and minutely read on various levels of resolution, which are then arbitrarily distributed across the image. "The Ephemerol Scanner turns any object into a field of fluctuating pixels and allows you to move within and between such images through wormholes of corresponding pixels" = annotation to the book cover illustration of Ina Blom / Trond Lundemo / Eivind Rossaak (eds.), *Memory in Motion. Archives, Technology and the Social*, Amsterdam (Amsterdam University Press) 2017

- conference website www.suchbilder.de still active; its flash animation making pixels progressively affiliate themselves according to color similarity - a digital code dissimulating physical entropy. Analytically, this corresponds with algorithms which identify, mathematically analyse and sort non-continuous,

arbitrary strokes in oil paintings as a new method of identifying individual "styles" in art history

Remark on Surveillance Media (PRISM and sonicity)

- US-American communication surveillance and data storage program PRISM; once started under the name ECHELON after Second World War; no "Pantopticon" but interception - German "Abhören", a term from the auditive field; radio signal transmission of the former Soviet Union to be intercepted by a net of radar stations

- Thomas Y. Levin / Ursula Frohne / Peter Weibel (eds), CTRL[SPACE]. Rhetorics of Surveillance from Bentham to Big Brother, Cambridge, Mass. (MIT) / Karlsruhe (ZKM) 2002. On the NSA: Matthew M. Aid, A Culture of Secrecy 1998

- frequent media-artistic misinterpretation of the soundscape *within* radio antenna spheres: the audio field recordings produced on the former radar detection station on Teufelsberg in West Berlin, under the title *Radarstation 2* by the media art group Fantomton = <http://fantomton.de/experimente/radarstation-2-call-for-tracks/>

- military radar spheres meant to shelter the actual revolving antenna; nothing can be heard but peripheral sounds (like the cooling aggregate), while the actual short wave radio signals had to be demodulated and amplified by special radio receivers to be transduced into audible articulations which then could be decoded by human ears *via* earphones or loudspeakers; presence of sound in such spheres is sublime in the sense of Edmund Burke; one is aware of them but can not perceive them with human senses; classify such phenomena of "implicit sound" under umbrella term *sonicity*; "das Sonische" (sonicity) as implicit sound, sound as an epistemic artefact

- in contemporary radio wave transmission, signals coded in binary impulses. Pulse Code Modulation (whose "philosophy" was aptly described by Claude Shannon) in fact, has first been developed first for the most secret system of high command telephony SIGSALY in the Cold War era, but the acoustic event here has not been the actual telephone conversation (which was rather encoded in teletyping), but the so-called one-time pad which consisted of twin records with completely noisy signals - the most secure random key for en- and decryption

- PRISM system not "listening" to analog radio waves but "reads" discrete alphabets, embodied in electromagnetic pulse transmission over fiber glass cables for data exchange and transfer in the Internet. Just as Walter Ong has described the phenomenon of a return of orality in the electronic age (termed "secondary orality"), there is a re-turn of reading in telecommunication - but not for visual perception any more (the eyes), but for computer algorithms which filter data streams; traditional interception of radio communication replaced

- sonification of electro-magnetic emissionen from computer monitors; "Van-Eck-Phreaking"; Markus G. Kuhn, Electromagnetic Eavesdropping risks of Flat-

Panel Displays, University of Cambridge (Computer Laboratory) 2004; *online* <http://www.cl.cam.ac.uk/~mgk25/iss2006-tempest.pdf>

- "mathematical sonicity" of *quasi*-musical structure (in the Platonic sense) without being audible at all any more; digitisation of radio transmission (as practiced almost universally today) actually "silenced" the traditional radio channels. The answer is: no, just that the audio- (or rather radio-)sphere of telecommunication has turned from the explicit to the implicit sonification, from direct audification of wave forms (corresponding with the electro-mechanical transducer in phonography) to indirect parameter mapping of discrete data points, from acoustic sound to mathematical sonicity. For his PhD thesis *algorithmisiert*, Shintaro Miyazaki's series of experiments in the sonification of algorithmic data which govern our tele-communication, with specific media configurations like detectors of electro-magnetic waves ("EM Sniffer") themselves acting as non-human archaeologists of such knowledge. For the accompanying audio CD as integral part of the textually expressed argumentation, which by the very nature of its topic (the rhythmic dimension of computing) requires steps beyond what can be expressed within the Gutenberg galaxy, Miyazaki e. g. transposed the sonically so-called "Daktylen" in frequency- and time multiplexing of GSM mobile telephony = Diss. Miyazaki: 185 f., into audible sound; thesis Miyazaki fig. 4.17, p. 186, shows scheme of GSM-Daktyla; *online from web site Kulturverlag Kadmos, book presentation* *Algorithmisiert*

Sonic delay and media time

- delay time (caused by the inertia of matter) and run time (*alias* "dead time") unfolds as temporal interval between a system input and its response at the output. As transport time, this refers to micro-mobility on the media-archaeologically accessible ground level of electronic circuitry. "The time it takes for material to travel from one point to another can add dead time to a loop. [...] The distance may only be an arm's length, but a low enough flow velocity can translate into a meaningful delay" = Doug Cooper, Dead Time Is The "How Much Delay" Variable; <http://www.controlguru.com/wp/p51.html>; this form of a temporal *inbetween* central to the notion of media itself. Time in communication itself is "medium" in Claude Shannon's functional definition of the channel of transmission.

Explicit sound and implicit sonicity as temporal knowledge

- genealogy of term *sonus* ranging from the concrete physical materiality of sound up to its epistemological definition = Frank Hentschel, entry "Sonus", *online* www.sim.spk-berlin.de/static/hmt/HMT_SIM_Sonus.pdf (accessed July 2013); retro-neologism *sonitas*

- privileged alliance between technological media and music and / or sound, based on the assumption that their common denominator is its temporal processualities; neo-logism sonicity does not refer to the apparent phenomenological quality of sound but rather to its essential temporal nature which is its subliminal message behind the apparent musical content; sonic

media; time signal and its technical processing converge

- discovery of sound not as acoustic but as epistemic object: implicit sound ("sonicity"); temporality of sound which couples it tightly to the essence of media operativity

- term "sonicity" not referring to the apparent phenomenological quality of sound but to its essential temporal nature which is its subliminal message behind the apparent musical content; Marshall McLuhan's central argument ("the medium is the message") in *Understanding Media* (1964)

- Martin Heidegger's ontology of technology: "The Question Concerning Technology", in: *Basic Writings*, edited by David Farrell Krell, San Francisco (Harper Collins) 1993, 307-342; *The Question Concerning Technology and other Essays*, New York (Harper and Row) 1977

- archaeonautics of sound: sonic analytics within big audio data and options of algorithmically navigating them

- term borrowed from computer programming, "recursions" not simply historically situated variations but challenging the historical order of events itself as technologically implemented chrono-automatism; thinking media time in technological terms

"sonic" illustrations?

- printed texts necessarily excluding sound matter; in a deeper sense, there is implicit sonicity in diagrams and graphs that are derived from sound sources, and by optical scanning graphic information (even an image of an early gramophone record) can be re-sonified "again"; sonagram (spectrum analysis) or sonogram (ultrasound-based visualization) maintaining an indexical relation to the measured event in diagrammatic sonicity

- genealogy of technologies to visualise sound and the human voice (in terms of signal recording and its spectrographical analysis) = Mara Mills, *Deaf Jam. From Inscription to Reproduction to Information*, in: *Social Text* 102, vol. 28, No. 1 (Spring 2010), 35-58

- out-spoken book title *Sonic Time Machines*; digital file (after sampling) expressed as wave visualisation (oscillogram), and as frequency domain (spectrogram), to demonstrate the "analog" and "digital" aspect of argumentation "by itself"; sonicity not just metaphorical, but rather self-expressive; spectrograms on the y-axis either linear, or *logarithmic*

Calculating waves: Notes on "sonicity"

- media-archaeological level: sub-phenomenological "acoustic quanta" as time-objects (Gabor) vs. higher levels of "musical" dramaturgy as symbolic ordering of time

- McLuhan not sufficiently differentiating between „electric“ and „electronic“. With electronics, electricity does not count in its physical energy any more (as for lighting and the electric engine) but is used as a micro-energy for the intelligent manipulation (as in the vacuum tube triode for amplification and feed-back), leading to an electrified culture without writing; in digital electric information systems, all of the sudden, wiring becoming writing again - a symbolic order (as identified in Claude Shannon's Master Thesis *A symbolic analysis of switching relays*, 1938); different kind of textuality returns

- Jenny borrowing neo-logism "Kymatik" from Ernst Florens Friedrich Chladni's "Klangfiguren" = Marco Bischof, Biophotonen. Das Licht in unseren Zellen, Frankfurt/M. (Zweitausendeins) 1995, 219

- "degaussing" (Bill Viola's "sonic" definition of video image): when switched on to clear remnant electric charges that might disturb the image, the degaussing coil wrapped around the neck of a cathode ray video, television or computer monitor causes a rapidly oscillating magnetic field; this high current surge actually "is the cause of an audible 'thunk' or loud hum which can be heard" = entry "Degaussing" in <http://en.wikipedia.org> (accessed April 7, 2014)

- resonance, signaling, processing; distinctions between recording, transmission, and architectural technologies; between hearing, listening, and sound objects themselves; between different kinds of recording (alphabet vs spectrogram); differences electroacoustics makes; subthemes of digitization, time, or processing

- terminology in analog electronics such as "resonant circuit" by necessity borrowed from musical science as age-old substitute science of time / temporalities / time-based arts; aspects of coding, compression, etc. derive from telegraphy or communication engineering ("entropy"), not from the sonic sphere

Ontological "being" vs. sonic "beeing" (electronic imaging)

- in image compression algorithms, for a temporal interval *within* image processing for efficient transfer, even a two-dimensional static image like photography kind of "sonic" existence in the channel when being compressed by Discrete Cosine Transformation, before finally being transformed "back" into a two-dimensional image (for human eyes)

- "sonicity" conceptualizing sound not for its acoustics, but for its temporal form; Baird's Phonovisor not only by its very name but by its gramophone shape reminds of an unusual way of "looking" at signal-based images via sonic signals

- Video artist Bill Viola defining the electronic image as "Sound of one-line scanning"; sonification of the recorded television image (signal) has been an analytic tool for John Logie Baird already: "In testing out the amplifiers I used to use headphones and listened to the noise of the visio signal made. I became very expert in this and could even tell roughly what was being televised by the sound it made. I knew, for example, whether it was the dummy's head or a

human face. I could tell when the person moved, I could distinguish a hand from a pair of scissors of a matchbox, and even when two or three people had different appearances I could even tell one from the other by the sound of their faces. I got a gramophone record made of these sounds and found that by laying this with an electrical pick-up, and feeding the signal back to a television receiver I could reproduce the original scene. [...] If the cinema had never been invented the 'Phonovisor', as I christened the device, might have been / worth developing; it was certainly an intriguing process. Vision into sound and sound back into vision" = Television and Me. The Memoirs of John Logie Baird, ed. Malcolm Baird, Edinburgh (mercatpress) 2004, 64 f.; "mental leap here is thinking of the flat two-dimensional picture, in space, converted to a one-dimensional electrical signal, varying in time" = McLean 2000: 96

- confusion about term "beeing" of electronic media - typographic error or explicit pun? electronic dictionary: "Beeing = archaic spelling of being"; spelling of "beeing" used in reference to Heidegger's "Seyn": *Beeing and Time*; Heidegger's writing of German "Sein": being as "Seyn"; pun of the bee humming making sense in electronic imaging: "Spoken in terms of music the physical appearance of a transmission is a kind of humming noise. The video image repeats itself incessantly in the same frequency range. This new general state of humming represents a significant shift in our culturally derived thought patterns" = Bill Viola, *Der Klang der Ein-Zeilen-Abtastung / The Sound of One Line Scanning*, in: *Theaterschrift* no. 4 (issue *The Inner Side of Silence*), Brussels (September 1993), German / English, 16-54 (26)

- television images transmitted as electro-magnetic waves, with "the fluctuations being determined by the shape and / appearance of the object or scene being transmitted. If the fluctuating electric current is received on a telephone in place of a televisor, a noise is heard, this noise having a different character for every object, so that every scene may be said to have its corresponding 'image sound'" = Edgar Lerner, *Practical Television*. With a foreword by L. Baird, London (Benn) 1928, 167. "By recording these sounds on a phonograph, a permanent record can be taken, and if these records are played again into a microphone connected to a televisor working in synchronism with the phonograph, the original image is reproduced [...] so that we have a means of storing living images upon phonographic records. Mr Baird has given the name of 'Phonovisor' to this device [...] = *ibid.*, 168; "replica" of the Phonovisor would materially (very media-archaeologically) remind of the implicitly sonic nature of the television signal, and thereby undo the all too familiar distinction communication studies make between "auditive" and "visual" mass media. My concept of implicit "sonicity" may look rather idiosyncratic at first glance, but may be techno-epistemologically justified in the context of signal analysis

- media archaeology identifying the media-epistemological impulse): "From 1926 onwards, Baird and his team significantly improved the opto-mechanical 30-line television system [...], increasing the image rate to 12.5 per second, yet still allowing the 30-line television signal to be broadcast as if it were an audio signal. This was a deliberate choice by Baird to get a television service on air soonest using the BBC's existing audio broadcasting infrastructure. This, more than any technical limitation with camera systems or the like, was the reason the Baird Company appeared to persist with 30-line broadcasting from 1929 to

1935" = Donald F. McLean, The Achievement of Television: The Quality and Features of John Logie Baird's System in 1926, in: The International Journal for the History of Engineering & Technology, Vol. 84 (2014), Issue 2, 227-247 (244)

- in analogue electro-magnetic wave transmissions (either sound or vision), the modulated information reduced to a single electrical signal that varies in voltage (or current) with time. "At any instant, there is only one value" (communication Donald McLean, 22 September, 2017); the essential time signal unfolds in the tempoReal, within real numbers which no discrete symbolic machine can grasp, in principle (Turing 1936) / *en arché*. "Analogue television is communicated in the same way as sound - that single electrical that changes in amplitude with time" = McLean *ibid*.

"Improved Terpsitone" (Theremin / HU)

- media dramaturgy; Sean Michaels' 2014 novel lets a fictionalized Lev Sergeevich Termen describe: "My theremin is a musical instrument, an instrument of the air. Its two antennas rise up from a closed wooden box. The pitch antenna is tall and black, noble. The closer your right hand gets, the higher the theremin's tone. The second antenna controls volume. [...] always you are standing with your hands in the air, like a conductor. That is the secret of the theremin, after all: your body is a conductor" = quoted from "Foreword" Liam Cole Young to W. E. *Sonic Time Machines.*, referring to Sean Michaels, *Us Conductors*, Toronto (Random House Canada) 2014, 16. In fact, the body becomes a non-metaphorical condenser. Devices like the theremin generate a low-frequency signal audible to human ears by integrating two electric oscillator frequencies (*Schwebung* by interference). "The new, strange sounds of the electric avant garde would fundamentally transform the Western acoustic canon." The sound of the theremin is pure electric alternating current; it does not pass away like the natural tone, but persists, stays, keeps, lasts

- Terpsitone extended version of the etherophone where one dances inside two antenna circuits to modulate tone and pitch - named after the ancient Greek muse of dance; not only re-built this amazing form of intuitive "sonic" interface, but present an improved version: Implementing (by analog-to-digital conversion) the ancient Greek musical tuning (Aristoxenos) one actually experiences the somewhat different kind of "musicality" ancient Greeks had in their ears. Turning media-technological, electro-acoustic experience into knowledge

Discovering the ears on Flusser's face

- Flusser in his Sao Paulo lectures on (electronic) music, 1965; directs attention to the machine-induced noises of the modern world like "the syncopated rhythms of machine levers" and of "typewriters" replacing former symbolical social and festive rhythms, close to Marshall McLuhan's definition of the electronic age as "acoustic space" = Marshall McLuhan (with Edmund Carpenter), *Acoustic Space*, in: same authors (eds.), *Explorations in Communication. An Anthology*, Boston (Bacon Press) 1960, 65-70; Flusser

distinguishes the present situation by its "acoustic character rather than a visual one" = Lecture 16

- Xenakis regarding programmed and electronic sounds: "We are all Pythagoreans"; after World Fair of 1958 foundation in Paris Studio *CEMAMu* (Centre d'Etudes de Mathématique et Automatique Musicales); with UPIC program generating (Unité Polyagogique Informatique du CEMAMu) graphical curves, drawings; parallel Meyer-Epplers physico-mathematically founded sound and informational aesthetics theory; cybernetic epistemology

- media-induced electronic music which is not just an extension of the classical instrumental tradition but a new quality, corresponding with music in its purest (Fourier-)analytic form. "The tape composed by the composers is the immediate articulation of the intellect. It means nothing, but it expresses directly the structure of thought" = Lecture 16; Flusser celebrating electronics as a cultural form induced by technologies based on the electro-magnetic field; magnetic recorder described by Flusser as the true archaeologist of the sonosphere, listening with technological ears without evaluating music from noise: "A random sound is recorded on tape: may be the sound of a bell, or of a locomotive, or of the human voice reciting a verse from the Bible. "The tape is recorded and then cut-up, and its segments are then submitted to deliberate manipulation. They are amplified, twisted or condensed. The segments thus manipulated are then re-composed onto a new tape, in a deliberate order and structure, that is, vertically, horizontally, diagonally and in a sequence that is independent from the primitive tape. This is a composition in the strict meaning of the term" = Lecture 16; Flusser a true contemporary of William Burrough's acoustic cut-ups and their posthuman assumptions; on William Burrough's audiotape cut-ups from the 1960s: N. Katherine Hayles, *How We Became Posthuman. Virtual Bodies in Cybernetics, Literature, And Informatics*, Chicago / London (University of Chicago Press) 1999, 208 f.; music as intellectual concept turning into sound only when implemented into the physical world which is the moment when parameter t (the time axis) is involved: "The tape is then played through an apparatus for sound reproduction, and we can then experience this music acoustically, this is, in its temporality" = Lecture 16; embodiment of musical compositions into physical materiality provides it with a temporal dimension which defines sonicity against pure concepts - just like an algorithm is not yet computing but needs an operative computer to be executed in time. Mathematics is not able to perform itself; a diagram for sound synthesis as well needs a real electronic synthesizer to happen as sound.

- Flusser correlating the options of electronic music with non-Euclidean geometry as much as McLuhan does in his later work; kind of sonification might transpose mathematical equations onto tapes, just as a techno-mathematical theory of music has been developed by the avantgarde engineer of digitally controlled analog synthesizers Erkki Kurenniemi; Mikko Ojanen et al., *Design Principles and User Interfaces of Erkki Kurenniemi's Electronic Musical Instruments of the 1960's and 1970's*, in: *Proceedings of the 2007 Conference on New Interfaces for Musical Expression (NIME07)*, New York, NY; http://www.nime.org/2007/proc/nime2007_088.pdf

- electronic music "appeals directly to our intellect" <Lecture 16> in sonic understanding but is hindered by cultural accommodation to traditional music which "still mobilizes our sensitivity" = ibid.

- Flusser longing for the ahistoricity of techno-structural sonicity. Training in listening to electronic music will help humans "to grasp the beauty of pure thought" = Flusser in his Sao Paulo lectures on (electronic) music, 1965, lecture 16; "pure sine-tone" (Eimert / Stockhausen) oscillator in electro-acoustics and the binary computer for digital music composition, re-called as *a posteriori* precursor of such "pure music" both as sound and as mathematical sonicity in its perfect articulation Baroque music; in the emerging epoch of electronic music (Flusser's lectures in 1965) "currently in all of our programs [...] composers such as Vivaldi and Tartini are going through a rebirth" = Lecture 16; this iteration (to remain within the algorithmic language) demanding a nonlinear description of the chrono-logics of implicit sonicity. Thereby when "concerts are enacted with authentic instruments from the fifteen hundreds" <ibid.>, what is named "historically informed performance" in fact is experimental archaeology, archaeo-acoustics not in its chronological but structural sense - both in terms of the materiality (instrumental behaviour) and the intellectual concept of music

- Flusser's clear differentiation between the symbolic regime of musical mathematics and its temporal implementations as sound leading directly to a media archaeology of sonic articulation

Non-semantic media expressions: channel noise

- digital Psophometer, model 1072: featuring measurement of metallic noise, level and transmission loss over a transmission line, recorder output

- conference *Beyond Noise - Acoustic, Technical and Metaphorical Aspects of Noise in Music and Visual Arts*, UCSB, 1-3 August, 2002; Schweighauser, "literary acoustics"

- radical aesthetics, beyond "social" interaction (human-human), encompasses human-machine and machine-machine communication

- "anti-noise"; "signal to noise" ratio, noise vs. order, low-frequency and low-amplitude noise, noise and silence

- Hillel Schwartz, *Making Noise. From Babel to the Big Bang and Beyond*, New York (Zone Books) 2011

- after noise has been discovered as a techno-cultural dimension worth of attention, it looks as if it vanishes again into the dark (or rather into silence): the digital realm, with its mathematical codes, is conceptually noiseless in itself; noise there just turns into a surface effect, an artificial re-entry of past media. After an epoque of avantgarde-liberation of sound from music, of emancipating noise in explicitly sense-less (nevertheless sensible) ways, in digital "noiseless communication" the limits of hardware still insist on the irreducible noise of matter

- musical composition (different from physical sound) not in need of recording on magnetic tape, gramophone or Compact Disc (the age of reproduction / repetition); sufficient if generative algorithm can be located, to re-generate
- radio-telescopes, registering rather noise than harmonies from deep space; there is no (more) soul" as a medium of processing sound into harmonics
- technical media immediacy by noise? noise a way of sensually experiencing communication theory (Shannon)
- noise as a specific expression of thermionic tube / Schrot-effect
- media archaeological aesthetics, which Attali deciphers for composers like Xenakis: *dépersonnalisation*, "vide de sens" = 1977: 185, that is: re-archeologizing the sound; "empty formalism" (Brian Eno) essence of computing
- noise (*eigenrauschen*) as evidence of the medium is hidden, suppressed, by so called content and interfaces; comes forth in moments of technical breakdown
- noise generated as impulse for Techno music from *analog* synthesizers
- materiality of hardware noisily re-emerging against the purist aesthetics of virtual worlds (where there is no noise, no physical decay)
- aesthetics of "live" recording phenomenologically identified by the presence of noise
- Lauri Siisiäinen, Foucault and the Politics of Hearing, New York (Routledge) 2013, chap. "Message or Noise", 31 ff.
- photographic image surface aesthetics which is diffractive distribution of photo-chemical noise / silver halogenite grains / crystals, literally; optotechnical gaze, sonotechnical listening
- acoustic (different from visual) noise and technical time-signal a *time-based* event, that is: can only be perceived in a dynamic process, never ever at a single given moment or *punctum temporis*
- sampling as enduring repetition of minute particles by the pattern-oriented interface of sequencer programs like Cubase and Logic = Rambow xxx: 183
- noise as a mode of measuring, like acoustic runtime tomography for local weather-forecast

Beyond noise? Discrete numbers

- mathematical stochastics calculating with noise, literally; being a deterministic system, turingmachine not knowing noise; can only simulate / pseudo-noise

- noise knowing the real world / about the world of the real, that is, the symbolically incalculable; noise absorbs so much more storage space when it is to be remembered or to be processed in realtime" = Hillis: 114

- end of 1920s Baird's *televisor*: "In these early prototypes, a transmission could be considered successful as long as an image took shape against the choppy grey static. [...] But if these images rush to make a claim on reality, it rests on the fact of transmission - reproduction at a distance - not on the veracity of its representations" = Richard Dienst, *Still Life in Real Time. Theory after Television*, Durham / London (Duke UP) 1994, 20

- audio / visual noise a media-archaeological reminder of media immediacy: message or noise?

- analog / digital conversion not only filtering the noise of materiality, but as well introduces new kinds of noise: "The digitization process introduces errors into the signal, which can be approximated by a Gaussian noise source with a magnitude equal to the least significant bit. [...] Similar devices operate in the opposite direction in *Digital-to-Analog Converter (DAC or D/A)*. A resistor ladder can be used to convert a set of bits to a voltage" = Neil Gershenfeld, *The Physics of Informatic Technology*, Cambridge (UP) 2000, 222

- often, in digitally sampled music, an artificial re-entry of noise into Dolby-clean digital space, to remember the past epoch of analogue electronic media (thus the analogue synthesizer is still in vogue, like DJs use vinyl, still)

- extend *theorein* to *akouein*; from symbolic regime to *noise*, signals

- *The Matrix*, data- and number-clouds: „trace program running". Such a texture of digital codes, of course, is not noise, but pure mathematics, against material physics. Does noise corresponds with „the real“ (in Jacques Lacan's sense), does it have a privileged relation to the real / do technical media, since photography (ghostly touches) and the gramophone (being able to record non-semantic information) have a direct access to the real as opposed to the iconological / alphabetical symbolic *order*?

- John Cage, no „beyond noise“ in the real world: In his piece for piano 4'33 where no key is struck, the silence of music makes the background noise of the piano player's body and the surrounding noise audible; computer as well: with no operation by the human user, the machine runs to build an empty window on the terminal at all

- language of literature able to express this transformation of cultural aesthetics into audiovisual, noisy surroundings? Can the audiovisual media be interrogated by semantics? Don DeLillo tries it in his novel *White Noise*, taking as his title the acoustic and visual background of a running TV set without reception; "white noise" not nonsense, but a ceaseless particle stream of information in constant motion; this metaphor (Schweighauser's oxymoron of "literary acoustics") of white noise permanently carries the media-archaeological memory of that moment when the images are not yet messages, but simply signal media (end of 1920s, Baird etc.). "In these early

prototypes, a transmission could be considered successful as long as an image took shape against the choppy grey static. [...] But if these images rush to make a claim on reality, it rests on the fact of transmission - reproduction at a distance - not on the veracity of its representations" = Richard Dienst, *Still Life in Real Time. Theory after Television*, Durham / London (Duke UP) 1994, 20

- Photoshop post-production options: remove / add noise

- in technological and channel noise, the medium revealing itself (with Shannon)

- no total (white) noise; „noise“ itself already a rhetorical figure, an idealization of something which does not ever exist in pure form; always already structure, figuration, pattern: so-called "white noise" (background noise) a hermeneutic or aesthetic abstraction, since it does not exist physically

- digital regime, with its mathematical codes, noiseless in itself; noise there just turns into a surface effect, an artificial re-entry of past media. After noise has been discovered as a techno-cultural dimension worth of attention, it looks as if it vanishes again into the dark (or rather into silence); noise just turning into a surface effect, an artificial re-entry of past media. Emblematic of this re-entry is Mike Figgis' film *Timecode* (2000). While its squared, quadrupled screen with four parallel continuous actions shot with digital video itself allegorizes the nature of the pixel-based digital image (4 mega-pixels, so to say), the dramaturgical invention of letting moments of earthquakes cut through the segmented images every once in a while is like an allegory of the disruption of representation itself, the flash-like invasion of the analogue world into clean digital space.

- limitation of the "digital" by its very hardware which insists on the irreducible noise of matter

- quantum computer difficult to construct because the slightest background noise (like cosmic rays or even the background noise of so-called "vacuum" itself) destroying the fragile equilibrium of relational qbit states = Hillis 2001: 95

Beyond noise? Breaking waves

- human cognition phenomenologically tending to read figures out of ground noise; making sense of meaningless stochastic patterns (Electronic Voice Phenomenon); otherwise compressing algorithms for streaming data in computing not acceptable; non-human senses sensitive to noise, when communication happens not only between humans any more

- Leibniz, in the breaking waves at sea shore, hearing nature calculating (integrating / differentiating) itself, *nesciens* "sampling" sound waves; calculating takes place only in the "Zählorgan Ohr" = Georgiades 1985: 42; take away a pebble, the empty hole shapes literally "zero", "zifra" = "Nothing": a form (of absence), impressed on the medium, which is sand; Harris 2001: 120; the noisy limit of the digital computing: although materially built on

sand (silicium), not able to calculate the random distribution of sand (otherwise aliasing effects). And a human image drawn into the sand will (with Foucault) vanish in specific waves in ways no digital computer will ever be able to emulate. This image, after a while, will rather look like the jammed images in early analogue TV = Hillis: 121; a digital images of a pebble beach can easily be compressed, that is: calculated (of course the Latin word calculatin is derived from calculi themselves, that is: counting with pebbles in the sand

NOTES ON SONIC SPACE

Electro-acoustic space (McLuhan)

- McLuhan's analysis of the electronic "acoustic space" which he sharply discontinues from the machinic age; in research group around the journal *Explorations* and especially in his *Culture and Communication Seminar* on the campus of the University of Toronto where McLuhan got the term "auditory space" by the psychologist Carl Williams (who himself had it borrowed from E. A. Bott). "The phrase was electrifying. Marshall changed it to 'acoustic space'", the group member Edmund Carpenter remembers = quoted after: Michael Darroch, *Bridging Urban and Media Studies: Jaqueline Tyrwhitt and the Eplorations Group, 1951-1957*, in: *Canadian Journal of Communication*, Bd. 33 (2008), 147-169 (158)

- from the time-critical nature of the electronic image that McLuhan derives his insight into the radically temporal message of hight-technological media: "You are drawn into that tube, as an inner trip. You´re totally involved. You have no objectivity, no distance. And it is acoustic. It resonates. But this is a hidden ground, because superficially people think the´re looking at a visual program. And they´re not. They´re not looking at all - they´re absorbed, involved in a resonating experience" = McLuhan in interview with Jerry Brown, in: *The CoEvolution Quarterly*, Winter 1977/78, zquoted in: *Letters of Marshall McLuhan*, selected and edited by Matie Molinaro / Corinne McLuhan / William Toye, Toronto / Oxford / New York (Oxford UP) 1987, 177

- "I have never ceased to meditate on the relevance of this acoustic space to an understanding of the simultaneous electric world" = Marshall McLuhan, *The end of the work ethic*, in: M. A. Moos (ed.), *Media research. Technology, art, communication*, Amsterdam (G&B Arts International) 1997 [*1973], 92-109 (101). Siehe Michael Darroch, *Bridging Urban and Media Studies: Jaqueline Tyrwhitt and the Eplorations Group, 1951-1957*, in: *Canadian Journal of Communication*, Bd. 33 (2008), 147-169 (158)

- wave field synthesis; argument was taken up by a practicing radio journalist, Tony Schwartz in New York, became a professor of auditory perception at Fordham University. In his book *The responsive chord* (Garden City, New York: Anchor books) 1974 (paperback edition; hardcover edition 1973), he writes: "Space, time, the concept of self, etc., take on very different meanings when auditory patterns replace a linear, visual orientation" <8>

- McLuhan, with his "acoustic space" model of the electrical age, remains a nostalgic of the analog signal processing and electro-engineering (circuits,

closed circuits, like the early "closed circuit" installations in the video art of his days, such as Nam June Paik and Dan Graham). Ironically enough, the (in all ways) discontinuous digital processing remains hidden even today, where the analog is dominant on the computer interfaces. McLuhan remains with electronic media, not with the symbolic machine (the techno-mathematical paradigm). McLuhan, when referring to the computer, reduces it to an electronic medium - while neglecting its algorithms.

- McLuhan's model rather the analog computer. "Resonance" is his central figure: "Acoustic space is organic and integral, perceived through the simultaneous interplay of all the senses [...] the rich resonance of the tribal echoland" = Marshall McLuhan, *The Playboy Interview: Marshall McLuhan*, in: *Playboy Magazine*, March 1969; reprint in: Eric McLuhan / Frank Zingrone (Hg.), *The Essential McLuhan*, London (Routledge) 1997, 233-269 (www.columbia.edu/~log2/mediablogs/McLuhanPBinterview.htm), as quoted here from: Martina Leeker, *Camouflagen des Computers. McLuhan und die Neo-Avantgarden der 1960er Jahre*, in: DeKerckhove et al. (eds.) 2008, 345-374 (352). "Resonanz ist der Modus des akustischen Raums" = McLuhan 2002: 213

- broadcasting media differing from global communication as Internet, since this is not resonance-based (the electromagnetic waves technology) but topologically, alphanumerically connected (Internet protocols) - the return of number, but in disguised form (audiovisual and textual interfaces)

- In its technological and in its neurological sense the processual mode of "electronically mediated human communication" (Schwartz) - a term to be preferred against the simplifying notion of *audio-visual media* = Michel Chion, *Audio-Vision. Sound on Screen*, New York / Chicester (Columbia UP) 1994 [Frz. Orig. *L'Audio-Vision*, Paris (Nathan) 1990 - is resonance, reverberations. Not by coincidence Schwartz uses terms which stem from the sonic sphere, since every sonic articulation is radically time-based (otherwise it does not unfold at all): "In discussing electronically based communication processes, it is very helpful to use auditory terms [...] like *feedback ... reverberation ... tuning [...]*" = Schwartz 1974: 23; the electronic image (as opposed to the rather mechanical cinematographic frame) is closer to sound (thus to time) than to spatial imagery: "*The image we 'see' on television is never there*" = Schwartz 1974: 14

- Tony Schwartz in *The Responsive Chord* declares on the electronic TV image: when humans watch TV, their eyes function like ears: "In watching television, our eyes function like our ears" = Schwartz 1974: 14 - an theorem which has been taken over by McLuhan / Powers in *The Global Village* since. "Wenn wir fernsehen, funktionieren unsere Augen wie Ohren": Schwartz, quoted after McLuhan / Powers 1995: 94

- With "telephone, radio, film, records, and television, we developed a stronger orientation toward the auditory mode of receiving and processing information. [...] This was true not only for sound, but also for electronically mediated visual information, which is patterned like auditory information" = Schwartz 1974: 13

Articulation in "sonic" time: resonances

- Ars Electronica Festival in Linz, Bill Fontana, "Golden Nica" (category of Digital Musics) for his acoustic deconstruction of the bells of Big Ben in London under the title *Speeds of Time* = <http://resoundings.org>: Electronic sensors on the clock mechanism and microphones close to the bell generate spatio-acoustic composition which is played close to Big Ben itself; the manipulated, artificially calculated sound of the Bells interacts with the "natural" ringing of the bells. A *Schwebung*, an interference of these two acoustic spheres, results in a third tonality, which has been recorded by multitrack technology within the interval of 12 hours, to be re-installed in the art festival context; can be replayed in real-time, thus invariant to the delay in physical, "historic" time which has elapsed between the recording time and the time of reenactment

- McLuhan insisting that electricity is of the same nature than the acoustic world in its being everywhere simultaneous; cp. ray-tracing: "When trying to predict the reverberation time of specific designs, most architects throughout the nineteenth century relied on the notion of 'sound beams' (Schallstrahlen) and on laws of reflection borrowed from optics. The behavior of sound in different auditoriums could thus be graphically simulated [...]. [...] some theater architects began to respond to the new definitions of sound by physicists - who had come to understand it as a time- and medium-dependent periodic fluctuation in pressure [...]" = Viktoria Tkaczyk, *The Shot Is Fired Unheard: Sigmund Exner and the Physiology of Reverberation*, in: *Grey Room* 60, Sommer 2015, 66-81

- although not found in nature, sine wave useful for demonstrating the basic features of sound waves. "Like other wave phenomena, sound wave can be described in terms of four characteristics: *waveform* [...], *frequency* [...], *amplitude* [...] and *phase*. Because the frequency of sound waves is within the range of nerve cell signaling (at least of low frequencies), the auditory system can use this information directly in responding to sound stimuli; in vision, the frequencies of light waves are many orders of magnitude greater, and the response to frequency is only indirect via the energy content of different frequencies" = Purves (ed.) 2008: 153

- by nature (*physis*), sound waves belonging to the mechanical world, while light is within the range of the electro-magnetic spectrum, thus being a completely different quality; visual perception is the only "radio" organ humans are provided with, while ears cannot listen to radio (in its technical, Hertzian sense) at all, just in translation (by loudspeakers); still, sound waves and light converging in their common analysis as periodic events, counted in frequencies (undoing the material difference in the symbolic mathematical regime), like the earliest devices to create optical illusions of movement like William George Horner's Zoetrope have their predecessors in the study of acoustic oscillations and Ernst Florens Chladni's famous visualizations of such sound figures in 1787 = Daniel Gethmann, *Zauberscheiben und Schwingungsverhältnisse*. Simon Stampfer, Félix Savart und die Erfindung der stroboskopischen Methode, in: same author / Christoph B. Schulz (eds), *Apparaturen bewegter Bilder*, Münster (LIT Verlag) 2006, 51-79 (60 f.)

- McLuhan's notion of "acoustic space" referring to the sphere of electromagnetic waves, while inspired by architectural thinking most literally;

argument on "the micro-temporal level of reverberation time" in Alfredo Thierrmann, *Radio as Architecture: Notes toward the Redefinition of the Berlin Walls*, in: *gta papers 2* (2019) [ETH Zurich], 69-83 (81); direct link between "solid" architecture and room acoustics, where space becomes a function of time-critical response time of sonic signals: "Reverberation time, usually counted in seconds, is the duration between the emission of a sound and the decay in its intensity below the level of human perception, as it echoes in a room" = Thierrmann 2019: FN 34, p. 79, referring to Wallace C. Sabine, *Collected Papers on Acoustics*, Cambridge, Mass. (Harvard UP) 1922. From that, the propagation of electro-magnetic "Hertzian" waves drastically differs, since its temporal limit is speed of light itself - so much beyond human aural perception in terms of frequency and non-mechanical essence, that no sense of space can be directly derived from EM waves in phenomenal terms.; in that sense, McLuhan's term "acoustic" space, when referring to the electrosphere, misleading, since it confuses techno-physical categories, and it might be a limitation of the application of the term "architecture" for EM phenomena itself, not transitive, but incommensurable relation

Reverberative space

- reverberative ("sonic") memory against archival (symbolical) order
- Rupert Sheldrake, *The Presence of the Past: A theory of evolution, not based on historical development but on electro-magnetic resonance*
- "video as a virtual image" discovered in its "vibrational acoustic character" = Viola 1990: 44; "optophonic" transfer, audio-visual metonymy; media-archaeologically justified: "Technologically, video has evolved out of sound (the electromagnetic) and its close association with cinema is misleading since film and its grandparent, the photographic process, are members of a completely different branch of the genealogical tree (the mechanical / chemical)" = *ibid.*
- John Logie Baird's "Phonovision" with 30 lines image and frame repetition frequency of 12,5 secs.; such electric one-dimensional signals, when coupled with loudspeaker, still within human audible range; suggested association with sound recording (gramophone), resulting in storage of TV lines on shellack discs. Sequential imagery is transformed into sonic time; both waveforms. Different from cinematography, electronic television "analyses" the image itself. But the media archaeological core element of electronic image transmission, the scanning and transduction of light signals by selenium or photo cells (and reverse), re-enters into sound film, as *Lichttonverfahren* - which is "television" within film as hybrid, with its alien electronic momentum attached to the otherwise purely mechanical projections apparatus
- video artist Bill Viola subsuming the sonic nature of the electronic image as "the sound of one-line scanning". The video camera, as an electronic transducer of physical energy <light> into electrical impulses, bears a closer original relation to the microphone than to the film camera" = Viola 1990: 44
- "Western music builds things up" = Viola 1990: 46, synthetically, and it is accordingly measured by Fourier analysis. "It is additive: its base is silence [...]."

Indian music [...] begins from sound. It is subtractive"; electro-aesthetics of electro-acoustic synthesizer

- acoustic delay (the echo effect) inducing Aristotle to discover the "medium" of a category in itself, the "inbetween" (*to metaxy*); Emmanuel Alloa, *Metaxu. Figures de la médialité chez Aristote*, in: *Revue de Métaphysique et de Morale*, vol.106, Heft 2 (2009), 247-262

- ultrasound itself sort of dynamic memory (in suspense), applied in early computing for short-time intermediary storage of data represented by impulses: "Because the pulses travelled at the speed of sound, they were not only sorted in space but in time, too. The distance from one crystal to the other and the time that the wave took to traverse this distance provided the basic beat. In addition a clock drove the line so that symbols could be positioned within the flow of time" = David Link, *There Must Be an Angel. On the Beginnings of the Arithmetics of Rays*, in: Siegfried Zielinski / ders. (Hg.), *Variantology 2. On Deep Time Relations of Arts, Sciences and Technologies*, Köln (Walther König) 200xxx, 15-42 (30)

Still "sound"? The digitizing auf analogue audio carriers

- Technical Committee of the IASA in its standard recommendations from December 2005: digitization of analogue sound carriers from the past does not necessarily mean a loss of information about the signal, but can in fact grasp the physical signal as information much more precisely than former analog recording where non-linear distortions of the signal in the process of technological transcription from one analog medium to another takes place (esp. for some frequency bands); Nyquist / Shannon sampling theoreme already allowing that with a sufficient rate the original signal can be truly reconstructed; for archival needs a radical over-sampling up to 192 kHz does not keep the blunt sound information, but the memory of noise (scratches) as well = [http://www.iasa-web.org/IASA TC03/ IASATC03.pdf](http://www.iasa-web.org/IASA_TC03/IASATC03.pdf)

- opto-digital reading of otherwise inaccessible sound recording; "Spektrogramm einer rekonstruierten Tonaufnahme (Wedda-Gesang, Ceylon 1907)" on SpuBiTo web page

A media archaeology of the acoustic

- tracking the sonic trace with technical media; "archaeologists" in media archaeology are the measuring media, able to de-cipher physically real signals techno-analogically, and representing them in graphic forms alternative to alphabetic writing, requiring "moving" diagrams (sine sound is articulation in time): the oscilloscope

Architectural sonicity

- Digital Signal Processing and computer-based tools like wave field synthesis (which media-archaeologically recaptures Christiaan Huyghens's approach to

the nature of sound propagation) and other technical dispositives allowing for the virtual (which is: counted) reconstruction of "historic" acoustic spaces

- digitally *render back* the acoustics of architectural spaces, such as the dramatic sound within the Palladio theatre in Vicenza (Weinzierl / Sanvito) or the ancient Greek theatres; auralisation; site-specificity, previously been "measured" and explored with acoustic signals (spatial impulse responses ["Impulsantwort"], echoes to be folded upon each other ("rec 21"). Each space which is being displayed acoustically is very site-specific because of the unique acoustic features of each historical piece of (ruined) architecture; certain frequencies are emphasized or vanish as they resonate in space. Space can not be experienced as "historical" aurally, since by definition sonic articulation perishes the moment it is being expressed. "So ist der Ton eine Äußerlichkeit, welche sich in ihrem Entstehen durch ihr Dasein selbst wieder nichtet und an sich selbst verschwindet" = Georg Wilhelm Friedrich Hegel, Vorlesungen über die Ästhetik III, in: Werke vol. 15, Frankfurt/M. 1970, 134 f.; acoustic archaeology retrieving the memory of sound out of architectural spaces

- the "acousmatic" as "sound that one hears without seeing the causes behind it" = Pierre Schaeffer, *Traité des objets musicaux*, Paris (Seuil) 1966, 91. See the entry "Acousmatic sound" in: http://en.wikipedia.org/wiki/Acousmatic_sound (4th June 2011)

- Weinzierl, audio-spheric reconstruction of Bruxelles World Fair le Corbusier / Xenakis pavillon with *Poème Électronique* by Edgar Varèse

- implicit sonicity on architectural silence, a kind of sounding in latency, like a Gothic cathedral waiting for the organ to fill it with acoustic reverberations; composers of organ music actually creating works with respect to the echo (reverberations / resonances) created by the individual cathedral architecture? Architectural space adds "media" *time* to the symbolic musical notation

- phonetic articulation time-critical itself, very precisely logocentric:
"Verständlichkeit der Sprache leidet erst bei übergroßer Nachhallzeit (mehr als 4,5 oder 5,5 s)" = Diözese Rottenburg-Stuttgart, Kirchliches Bauen. Die Kirche als Verkündigungsort. sprechen - singen - musizieren, section "Akustik"; http://www.amt-fuer-kirchenmusik.de/Inhalt/Orgel/Orgel_und_Kirchenrenovierung/Orgel-und-Raumakustik_Kirchliches_Bauen.pdf; accessed 14 September 2014

- 3D-SketchUp-Modell or AutoCAD file; on that data basis, with EASE 3D-computer models, in room-acoustic simulations can be experimentally mapped

- in room acoustics, "Mensch bleibt der Maßstab" = http://www.oberlinger-architekten.de/profil_text.htm); alternatively analyze room-acoustic "communication" between organ tone and architectural frame. Organ itself, as dispositive / *Gestell*, as apparatus, an architectonic *organon*; notion of "computing architecture"

- silence itself becoming part of the archive; software for sound analysis *Audacity* actually providing an algorithm called "Silence Finder"

- actual sound from the media-archaeological archive. When an ancient "Datassette" is being loaded from external tape memory into the ROM of a Commodore 64 computer, actually listening to data music, not sound as memory content like an old persuasion-assisted song, but rather the sound of computer memory itself, that is: a software program which is "scripture" (though in the alphanumeric mode); data archive not sonic memory but inherent sonicity; interplay between technical memory and affective remembrance = Ben Anderson, Recorded music and practices of remembering, in: Social and Cultural Geography, vol. 5, No. 1, March 2004, 3-19

A new way of experiencing the sonicity of computer-architectural space

- "In bounded spaces, reflected sound folding over on itself creates resonant nodes that cause spaces to act as filters, nonlinearly amplifying some frequencies and damping others. We never hear a sounding object by itself, always an assemblage of sounding object and resonant space" = Peter Price, Resonance. Philosophy for Sonic Art, New York / Dresden (Atropos Press) 2011, 20

- different kind of "machine" at work here; acoustic resonance "a subset of mechanical resonance" = Price 2011: 21

- in architecture, reverberative time (the audio signal delay known as "echo"); "no mention of *intentionally* creating reverberation for its theological relevance" = Barry Blesser / Linda-Ruth Salter, Ancient Acoustic Spaces, in: The Sound Studies Reader, edited by Jonathan Sterne, London / New York (Routledge) 2012, 186-196 (195); cathedrals - when still existing - are rather involuntary memories of past soundscapes, thus being time machines

- space explored by time-critical sound operations; the engineering of room acoustics by measuring operations such as pulse-response (developed by Walter Sabine around 1900) has even been extended to auralization as re-enactment of the sonic past

- concept of using the building as an instrument: Alvin Lucier; takes the memory capacity of an electronic device to provide fugitive sound articulation with a recurrent index of temporal depth; an initial acoustic articulation expressed in a closed room and its phenomena being recorded; recording is played back into the room, re-recording it; operation known from echo delay by magnetic tape players; exploring a closed architectural space by means of acoustic pulses, signals folded upon themselves; second signal is a replica of the same information delivered within a temporal interval; space itself becoming a function of temporal measuring; spatial and acoustic extension time-critically falling apart; transfer this sonic analysis from concrete architecture into the "flat" and condensed architecture of digital computing

- essence of digital computing the *temporalization of mathematics* by media-operative algorithms; change the sensational mode from the visual to the auditory mode which is the (substitutional) "time organ" in human senses

Symbolic versus technological recording of sound

- "tracing" ancient sound recording identifying the vibrational groove; signal recording, not symbolic notation; in digital sound processing, the symbolical returns: on a dynamical, time-discrete level, essentially closer to the nature of acoustic impulse trains
- implicit musicality within the computer: the rhythm of algorithms. In order to become operative in the real world, mathematical algorithms (which symbolically exist as source code lines, that is: a form of alphanumeric text) have to be implemented into real physics, usually electronic elements, to be endowed with temporal agency
- BBC World Service launching the "Save our Sounds" project, looking to "archive" unique sounds (different from reproducible records) that may soon be lost; sound compressing and filing algorithm which rules the process of sound provenience to permanent storage
- the pre-emptive archive: bias (cultural recording projects under the temporal perspective of "future in the past") pre-dated by the Berlin Phonogram Archive past 1900 (Erich Moritz von Hornbostel) for ethnological music (that is, acoustic recordings across endangered cultures); Albert Kahn's photographic and cinematographic Archives de la Planète in Paris; Paula Amad, Counter-Archive. Film, the Everyday, and Albert Kahn's Archives des la Planète, New York / Chichester (Columbia University Press) 2010, esp. 153: phonographic inspiration of Kahn's project: Archives de la Parole, founded by the linguist Ferdinand Brunot in 1911 at Sorbonne university in Paris

Sonic arts / acoustic archaeology

- by opto-digital reading of early Edison cylinders listening again to otherwise inaccessible sound recording; the opto-digital *close reading* of sound as image, accessible for human analysis only by operative techno-mathematical diagrams: spectrogram of reconstructed recording (Wedda chant, Ceylon 1907) on the SpuBiTo web page
- installation *The Physical Value of Sound* by Yuri Suzuki = www.yurisuzuki.com at the media arts festival Ars Electronica in Linz, September 2009 explicitly based on the electro-mechanics of (manipulating) records (their speed) and pick-up systems (their non-linear use)

NOTES ON MACHINE MUSIC

Kurenniemi-as-archive: Resistance against the biographical impulse

- some of Kurenniemi's digitally addressable electronic music instruments (the DIMI series, even akronymically comparable with what is known today as the Musical Instrument Digital Interface software MIDI) deposited in the Electronic Music Studio (since 1971) of the University of Helsinki Musicology Department

where it is intended to make them accessible for re-play / technological; operative re-enactment

- historians of technology traditionally using textual documents rather than artifacts in their archival reconstructions of the past = Christian Sichau, *Die Replikationsmethode: Zur Rekonstruktion historischer Experimente*, in: P. Heering / F. Rieß / same author. (ed.), *Im Labor der Physikgeschichte. Zur Untersuchung historischer Experimentalpraxis*, Oldenburg (Bibliotheks- und Informationssystem der Universität Oldenburg) 2000, 9-70 (9) not miss this opportunity for a different kind of "sources" in the case of Kurenniemi's synthesizers. In order to have them as an active archive, different from textual and audio-visual data which can be read, heard and seen, this electronic hardware itself must be kept running in order to prevent its simple historicizing and musealizing. When an electronic image on a cathode ray monitor transmits an event, the date of the event or the fabrication year of the device do not matter.; only switched-off TV set can be a "historical" (museum) object

- Thomas Wilfred's visual music named *lumina* and his color organs *Clavilux*, played by keyboard. Wilfred's objections to recording Lumia works on film (in his writings collected in *Thomas Wilfred's Clavilux*, Borgo Press 2006, making the survival of his works dependent on the re-enactability, i. e. the material existence of his machines (now mostly in the Epstein Collection = entry Thomas Wilfred <http://en.wikipedia.org>, accessed April 2013

- written records, once deciphered, re-activated by reading them literally; a techno-logical artefact in need to be in operation to be understood as medium. On the one hand, there is the archival imperative not to be invasive to the document or museum object. Thus one of the remaining options is to materially re-build or logically emulate the integrated synthesizer. There are the archive's two bodies: its material authority (to be kept intact), and is virtual "liveness"

Kurenniemi's "musical" techno-mathematics

- paradigm of electronic music (studios and composing, such as Pierre Schaeffer's *musique concrète*) has been tape recording and tape editing; in contrast, Kurenniemi developed digital sound and image control technologies.

- technological things embodying an epistemological implicit value that deserves to be expressed

- hermeneutics looking at an author's (collected) works, while discourse analysis investigates the Kantian *a priori*, the conditions which made such articulations possible at all, the systems, the rules which make the appearances and articulations. This *dispositif* (apparatus) is technical when it comes to media culture; Kurenniemi's electronic circuits (and in equivalence his own mathematical theory of musical harmonics-in-time) part of a textuality which can not be expressed by historiography and narrative but rather by the *diagrammatic archive*

- cybernetic bio-feedback and bio-musical compositions (Eaton)

- "If the images of technology cannot be shown, - and perhaps this is a blessing rather than a tragedy - what can be shown are the relationships" = E. K. (In 2048); diagram

How does one become archive?

- Kurenniemi's obsessive self-recording (starting with his audio tape and video diaries) meant to be orchestrated in a "re-run of his life" on July 10, 2048, on occasion of his 107th anniversary = Errki Huhtamo, *Kurenniemi, or the Life and Times of a Techno-Visionary*, <http://d13.documenta.de/panorama/#/research/view/kurenniemi-or-the-life-and-time-of-a-techno-visionary>; accessed 19 Oktober, 2012; the real archive of a "techno-visionary" (Huhtamo) such as Kurenniemi is his electronic devices which are not body-related but mind-related embodiments of his thoughts; Kurenniemi's synthesizers *are* archives themselves already: their blueprints and diagrams, and Kurenniemi's design for new musical scores, that is: the symbolical (archival) order. But the novelty of electro-technological media inscribed itself into cultural memory by using signals instead of symbols; *sound* of Kurenniemi's synthesizers, the articulation of the medium as sonic memory worth of tradition - in fact, the technological witness; recordings of the Silbermann organ at Freiberg cathedral in times of the GDR stating record label ETERNA preserve how the organ sounded in the 1980s

- "operative diagrammatics" understanding techno-logical objects as materiality and algorithms in action; what Kurenniemi's film *Electronics in the World of Tomorrow* shows.

- regarding technical apparatuses through the approach of an engineer - a specialist in the diagrammatics of circuits; diagram becoming what could be described as a "literal crossing-point between epistemologically wired humanities analysis of technical media and the engineering enabled understanding of and tinkering with operationally" = Parikka, 2011: 65; through the diagram that temporality - or time-criticality- is being executed on the various micro levels of technology; humans operating through the diagrams of the machine = *ibid.*

- diagram not simply something inserted into the machine, but generating it through its operation. "The operative diagram is the machine in motion, understood from the time-critical, micro-temporal point of view. In fact, is it the implementation of the symbolical order (the archive) into the electro-technically real (hardware)" = Jussi Parikka, *Operative Media Archaeology: Wolfgang Ernst's Materialist Media Diagrammatics. Theory, Culture & Society*, vol. 28, no. 5 (2011), 52-74 (66); this diagram which deserves and demands the archive.

- not simply turn Kurenniemi's live into a "multimedia database" (Huhtamo), transforming into a virtual databody, but remember his hardware embodiments as well; his memory and after-live implemented in the wiring, diagrams and programs of his electroacoustic instruments

- Dimi-O (1971) based on an optical interface, the original purpose of which was to read sheet music graphically like Iannis Xenakis' UPIC system

- Dimi-O instrument can also be played with a conventional keyboard - the content of a new medium tends to be the previous one as a re-mediative concession to the user -, or via a video camera. Somewhat in alliance with Lev Theremin's interactive radio-instruments like the *Terpsion*,

- such instruments truly media-archaeological not only in the sense of "earliest electronic musical instruments" = Ojanen et al. 2007: 92, but in their aesthetic archaism, reducing form to the essential hardware function as proto-typical aesthetics

- Erkki Kurenniemi's Film *Electronics in the World of Tomorrow* showing cable spaghetti, integrated circuitry - analog until digital = http://www.ubuweb.com/film/kur_electronics.html; close to the actual electronics, visually accompanied and superposed by light patterns created by the very machine which is "dissected" (DIMI synthesizer)

Transparency of the circuit diagram instead of user-friendly interface metaphors (case Kurenniemi)

- electro-mechanical Fender Rhodes Piano originally developed by Harold Rhodes as a transportable substitute piano; substitutional mechanism with all its deficiencies compared to the sound of the fully acoustic piano resulting a sonic aesthetics of its own. The keys strike tuning forks tightly coupled with a resonating Tonebar, with the tone itself being picked up by a magnetic device like with an electric guitar

- Digital Signal Processing and Physical Modeling of acoustic instruments; any "e"-instrument electro-magnetically transsubstantiating (technical term in Christian liturgy) the essence of sound from mechanical vibration into an essentially completely different, but mathematically analogue form of existence - from sound to sonicity

- Kurenniemi's device DIMI-O employs a video camera for opto-phonical signal input allows for a keyboard interface. DIMI-O includes a memory unit with a 32-step sequencer, with the memory locations being presented on a television screen from which the player can read the contents of the memory. "A cursor running over the screen tells which location is played at the moment" = Ojanen 2007: 91

- Kurenniemi furthermore designed instruments based on bio-feedback reflecting the cybernetic paradigm, f. e. 'Dimi-S (known as Sexophone, 1972), "wheresound generation is based on the electric conductivity of the skin, and 'Dimi-T (aka Electroencephalophone, 1973), where the sound control is based on a signal generated by the electric activity of the brain" = Wikipedia, accessed November 2012; DIMI-T brain wave sonicator: Kurenniemi's draft design (and minimal circuit) for that device; *a priori* of such fabrications is electrophysiology; "cat microphone"; based upon signal processing, *not* the symbolical order

Signal analysis instead of symbolical notations: Kittler's synthesizer modules

- alternative to the symbolic order (in the sense of alphabetic records and their archival tectonics) is signal-based memory such as the phonographic record of voices and music.

- sound that is stored *inside* technology, inaudible for human ears. An analog signal recording in an Edison phonograph cylinder contains physical traces of the past, but a Nintendo "Game and Watch" handheld electronic game from 1981 also does: its electronic circuitry, its ICs and its loudspeaker enable to experiment analytically, algorithmically recreating the same auditive events that the device would have produced when it was first sold; experimental listening to the *audible past* [Sterne 2003], making it imperative to work with the original hardware versions of the electronic toys under discussion

- Kittler's code, written in Assembler on the hard disc drive of his personal computer, must be kept running - not be performed by a book which can document but not compile a source code; fig. in Kittler 2006 *Aphrodite*, 300 ff. (on recursive functions)

- Kittler's modular synthesizer and his computer hard drive, when simply put into an archival storage shelf, can not be analyzed like reading a traditional archival record. It rather demands for a kind of vivisection - which means, not just de-constructing its electronics in inert state, but to set it under currency, under voltage, in a running platform again: not just material, but processual philology, an exegesis of Kittler's thoughts by circuit grammatology or rather: operative diagrammatics

- Jan-Peter E.R. Sonntag, photo cycle "apparatus operandi - Anatomie" (2012/13). Structure analysis of the primary VCO circuit board of the basis cube; conceptual art project in different formats, argumenting media-archaeologically, with hardware close to the process, oriented at its performative essence

- for electro-acoustically generated signals, the re-animation of a "dormant" (German: "still-liegenden") modular synthesizer - either by re-informing the original hardware, or (for curatorial reasons respecting the un-changable "original" - not even exchange of rotten condensers) by constructing a replica, or virtually (that is: algorithmically) within the programming platform SuperCollider

- among Kittler's "archived" source codes, one for generating a sinus tone; like a musical score this can be literally "interpreted" by a computer at any time, while re-activating his modular synthesizer allows for the experiencing the sonic uniqueness of the technical artefact - its *temp/aural* individual articulation - a non-historical mode of re-presencing: dynamic primordially; "equitemporality" (German "Gleichursprünglichkeit"), known from the concept of "historically informed performance" in re-staging music from the past which is a kind of operative historicism. It is "contextual" not in the classical sense of

historical research which reduces the context to the ensemble of available textual records in the period archive, but this time the materiality is the context itself: the apparatus in operation, Kurenniemi's second body much more alive than any archival data recorded on hard disc; Peter Heering / Falk Rieß / Christian Sichau (eds.), *Im Labor der Physikgeschichte. Zur Untersuchung historischer Experimentalpraxis*, Oldenburg (Bibliotheks- und Informationssysteme) 2000, esp. 9-23 (on textual vs. artifactual evidence), and 142 (on the ideosyncracies of the experimental setting ("Eigendynamik")), and *eigenzeit*

Electrolytical recording of "touch and tone" in piano play: Welte-Mignon

- discrete piano keyboard, combined with the "analog" dynamics of the player's touch, results in a hybrid sound mechanism

- in 1926, Emil Schilling's patent for a "Steuerungsvorrichtung für Rechenmaschinen"; retrospectively turns out as a precursor of programmable computing "im Geiste des automatischen Klaviers" (Ralf Bülow)

- piano play still an artistic technique, with the *Pianola* automaton it turns into media art: "Kunsttechnik wird zur Technikkunst" = Arno Reinfrank, from his poem on the *Pianola*, in: *Bilder einer schrägen Welt. Poesie der Fakten 9*, Rohrbach (Peter Guhl) 1996

- Welte-piano rolls for pianos driven by folded strips or rolls of paper with indentation since 1904 resulted from a mechanical apparatus for the notation of contingent individual musical articulation, providing for identical re-play not only of piano key on/off (like in MIDI) but tempo and dynamics as well = Gottschewski 1996: 26 ff.

- Welte-Mignon an analog-discrete hybrid. Designed in 1904 to capture the "temporally dynamic sound of an interpretation" (Stern 2004: 67), a piano containing a recording machine rolled out paper; whenever a note was struck it drew a line on the paper; thereby the individual play could be faithfully recorded in their temporal style as the real message of interpretation from musical score. "Afterwards, the lines that the notes made while the artist was playing were cut out, leaving an indented paper that could be played back on a specially adapted player piano and produce a replica of the actual interpretation, with all the vitality affects characteristic of the performer" 0 Daniel N. Stern, *The Present Moment in Psychotherapy*, New York / London (Norton) 2004, 67, referring to Benhôte, 1972

- Welte-Mignon almost co-originary to the phonograph; this is no coincidence in cultural history, but embodies two originary epistemological alternatives. Phonographic record can replay the acoustic event, not its production in the machine (piano) itself.

- Gustav Mahler, Ferruccio Busoni, Claude Debussy, young Vladimir Horowitz "verewigten sich" on piano rolls of Freiburg company M. Welte & Söhne (production between 1904 and 1932), like a "frozen" performance; *via* a

complex mechanics special reproduction pianos and -organs "reading" the information punched into the paper rolls, and the keys on the player piano move like from a invisible hands ("wie von Geisterhand")

Player Piano / piano player (Welte-Mignon / Glenn Gould)

- Welte-Mignon reco(r)ding oscillating as hybrid between analog and digital signal transduction / processing

<https://www.hkb.bfh.ch/de/forschung/forschungsschwerpunkte/fspinterpretation/wievongeisterhand> (c/o Roman Brotbeck, project 2007/08)

- mechanism actually liberated piano play from the human hand - just like Henry Fox Talbot, as expressed in his book *Pencil of Nature* (1844), celebrated his invention of negative photography as liberating the self-imaging of nature from the idiosyncracies of the painterly hand. This is an ultimate escalation of the pianist individual dedication to the machine.

- Glenn Gould notably preferring performance in the electronic studio to live recording in the concert hall, for its productional (not only post-productional) options of analytic manipulation; in his interview by Tim Page for *Piano Quartely* (autumn 1981), Gould celebrates that technology has made the live concert superfluous, since it creates a "climate of anonymity" which liberates the artists from his performative restrictions like nerve reactions and finger restrictions towards an improved aesthetic enunciation, eliminating the contingencies of an actual concert. The core operation of post-performative studio recording and editing has been the magnetic tape splice and cutting of "tape segments varying in duration upward from one twentieth of a second", that is: below the human hearing threshold of a continuous tone. This is not a completely "dehumanizing technique" (as criticized by the "antirecord lobby"), but rather a "schizophonia" (Schaffer) of a different kind, since here "inevitably [...] the functions of the performer and of the tape editor begin to overlap - which for the subsequent listener can not be neg-entropically differentiated any more, just as in montage cinema" = Glenn Gould, *The Prospects of Recording* [from: *High Fidelity* (April 1966)], in: Tim Page (ed.), *The Glenn Gould Reader*, New York (Alfred A. Knopf) 1984, 331-353 (337 and 339)

Punched piano rolls and the "digital"

- Musicology at Hochschule der Künste in Bern (HKB), research project (2010/2011) "Recording the Soul of Piano Playing" (c/o Kai Köpp) = <https://www.hkb.bfh.ch/de/forschung/forschungsschwerpunkte/fspinterpretation/recordingsoulpiano>; current digitizing of the "soul" of Welte-piano music rolls achieved by a scanner, which is in fact a second order digitization of a previous binary coding: punched hole / non-hole, providing to "telegraphic" access to music as performed by a pianist in the past

- digitization conversion of such data into MIDI files and / or archiving them as raw data, inducing new options of algorithmic reserach into historical interpretation such as micro-timing

- non-invasive replay allowing for separating the archival (authentic) materiality of Welte rolls from its binary information

- Welte-Mignon system a non-historical time-tunneling back to early 20th century piano play; the discrete recording of piano key touch and the interpreter's dynamics results in communication between musical performance culture around 1900 and contemporary re-enactment in terms of communication engineering itself (Shannon 1948).

- punched piano rolls "digital" recording *avant la lettre*; but no algorithmic processing (non-recursive)

"Musical" micro-timing

- Richard Beaudoin, The Principles of Microtiming and Musical Photorealism, manuscript <http://nrs.harvard.edu/urn-3:HUL.InstRepos:3415685>; since 2009, aided by Hochschule Luzern, composing notated, acoustic works based on millisecond-faithful *transcriptions* of recorded performances = temporeal transcription; output from the Luzern Audio Recording Analyzer (LARA), showing the millisecond-faithful measurement of four bars of Chopin Op. 28/4 in the recording of Martha Argerich from October 1975 = idem / xxx Kania, A Musical Photograph?, in: Journal of Aesthetics and Art Criticism; millisecond-level measurements of sound unfolding through time; composing with microtiming by taking millisecond-level measurements of the rhythm in a recorded performance; based on these proportions a transcription of sounds into music notation. "This new musical object can then be manipulated, reorganized and otherwise altered" = <http://www.richardbeaudoin.com/microtiming>; time-critical studies

Piano (re-)play: a cybernetic approach

- with Welte-Mignon encoding, "historically-informed performance" becoming informational. The Welte-Mignon piano play recording on punched paper rolls and their re-play oscillates between the human and machinic interpreter. "I have just heard myself playing", Rachmaninov proclaimed in 1923 immediately after hearing his recording from a Welte-Piano roll = quoted from: Allen Feldman, Der menschliche Touch. Zu einer historischen Anthropologie und Traumanalyse von selbsttätigen Instrumenten, in: Gabriele Brandstetter (ed.), stress. ReMembering the Body, Ostfildern-Ruit (Hatje Cantz) 2000, 224-259 - a time-delayed acoustic mirror

- "cybernetic" approach to "historically informed music performance" which treats the human-piano configuration as tight / loose coupling, between medium and form (Fritz Heider), to a system, just like the pilot in the airplane, together with the instruments in the cockpit, results in a human-nonhuman communication system, accessible to "harmonic" (Wiener) or stochastic (Shannon / Bode) analysis of human behaviour and limits of physical mechanics. The instrumental piano, as mechanism with a discrete keyboard

input, pre-determines the range of human expressions; as a technology, it remains invariant against "historic" (mental, cultural) change for ages

- "historical" interpretation just one (narrative, discursive) parameter of re-enacting the past, which only symbolically refers to time - while in signal analysis, the time objects actually happen

- analog/digital difference between punched card mechanical notation (discrete, "digital") vs. continuous time-varying recording (wave form).

- re-enacting ancient hardware from music museum instruments;
http://www.sim.spk-berlin.de/aus_dem_depot_1667.html

- media-archaeologically informed, *operative* performance: automata themselves become the "player" in time-invariant behaviour, as derived from medieval Arabic musical automata and the escapement-driven clock: re-producing time itself

Transcribing machine "music"

- Conlon Nancarrow creating "computational", original compositions for player piano which is not derived from recording human play any more like Paul Hindemith's original compositions for gramophone, or Moholy Nagy's immediate scratching sound on film. Player Piano no "dead medium" which has been displaced by phonographic signal-recording; in a different sense of sonic media archaeology, re-activated device, "[...] um neuartige kompositorische Ideen unabhängig vom Leistungsvermögen von Interpreten zu entwickeln und sie gleichzeitig so präzise wie gewünscht auszuführen" = Moniko Fürst-Heidtmann, Booklet zur Compact Disk Conlon Nancarrow, *Studies and Solos*, Wergo: WER 66702, p. 3

- turning the notion of "historically informed interpretation" upside down, two female pianists, in kind of *reverse media archaeology*, "humanising" Nancarrow's compositions in four-hands play

- Norwegian composer Christian Blom's record of Lyrical Pieces, based on Grieg's lyrical pieces and initially on the Schmetterling which he himself recorded on a Welte-Mignon piano. Spencer Chase's collection of music recorded on Welte-Mignon; makes MIDI files for sale. In 2007, 100 years after Grieg's death, national broadcasting company asking Blom to experiment with Grieg's recordings and make a new work; took the MIDI file that Chase provided and produced a music "where Grieg's very free phrasing is fairly intact but all the notes are slightly out of place, it is better heard than explained. In the record this is performed once by a sampler I made for the occasion and on the other side the music is performed by a human, the pianist Ellen Ugelvik [...]. So, here there is also a case of man and machine interpreting the same material, just in two versions rather than the oscillating in a single performance" (communication Christian Blom, January 20, 2017); listening to these records on an "obsolete" player in the Media Archaeological Fundus: a moment of cognitive confusion on which parts are "human" and which are "machine" until became clear that apparently the two records had been placed

in reverse cover; for the listener it is vital not to confuse side B with side A, and to play the Al Khowariznmis Orkester not at 33 RPM; that (unintentionally) adds to the compositional idea; the CD version of Bring Me that Horizon, transferred to the experimental setting of Lyriske Stykken: all the difference if the "mechanical", computer-generated version (side B) is played from vinyl which makes is analog signals; from CD, on the other hand, the side A version (human pianist) would be digital signals nevertheless

- Norwegian composer Christian Blom's record using "chance operations and computer algorithms to write the music, then it is performed by a physical mechanical orchestra on the one side. The recording of the mechanical orchestra is then recomposed/transcribed for a sinfonietta (16 instruments) which is presented on the other side of the record. One gets a sort of comparative listening situation where the versions serve as reference for each other, each heavily adapted to its formats and standards" (communication Blom, January 2017)

Fingers, numbers, MIDI notes: "digital music"

- difference between score typewriter (Musikinstrumentenmuseum SIM Berlin) and Various methods of storing sound information for self-playing musical instruments: pinned barrel (Stiftwalze), perforated cardboard

- 1872 Alexandre Amédée develops an electrically driven score writing apparatus

- alternative kind of "phonography" of piano play: Binet / Courtier 1896, article "Recherches graphiques sur la musique", suggesting continuous capturing of dynamics in play = Reinhart 2005: 76

- form and function of the *Rollenschreiber* resembling the inscription device in Morse telegraphy = Ludwig Peetz, Das Welte-Mignon-T100-Aufnahmeverfahren: Aktuelle Forschungsergebnisse zur Dynamikerfassung, in: Dangel (Red.) 2005, 92-105 (99); cp. Embossy Telegraph triggering the Edison phonograph invention

- The typewriter keyboard is media-archaeologically derived from a) piano keyboard, b) telegraphic letter statistics. For character recognition, little differences in tone and time and inter-space make no decisive difference; for piano key attack, addressed to the time-sensitive ear, small temporal change makes all the "musical" difference

- piano not a type-writer (Wolfgang Scherer, "Klavierspiele"); piano keyboard, from which the typewriter dispositive itself has been developed, one the one hand relates to discrete, "digital" notation. But different from alphabetic writing, "touch and tone" dynamics belong to the piano performance as well. Does the pianist become a Turing-machine when coupled into (processing coded information) circuit of score / pinao keyboard?

With/out keyboard: electronic synthesizer

- piano key-board as interface to electro-acoustic synthesizer dissimulating the sound-processing medium technology; Don Buchla's modular electronic synthesizer system *without* key-board (the difference to Moog) as input device / interface = Trevor Pinch / Frank Trocco, *Shaping the Synthesizer*, in: *The Sound Studies Reader*, ed. Jonathan Sterne, New York (Routledge) 2012, 254-264 (257 f.); transient vs. intransitive

- incorporation: transition between musical intention (in Shannon's diagram: "source") and body-physical implementation / coupling to the instrument; player at that moment of contact as well being played by the instrument

- with the input device of the keyboard, even the "analog synthesizer", media-phenomenologically, a "digital" instrument - even if, strictly speaking, it was only the Musical Instrument Digital Interface (MIDI) standard of 1981 which - embodied in the Yamaha DX7 (since 1983) achieved the break-through to digital synthesizers.

- Tellef Kvifte, *Musical Instruments and User Interfaces in Two Centuries*, in: Frode Weium / Tim Boon (eds.), *Material Culture and Electronic Sound*, Washington, D.C. (Smithsonian Institution Scholarly Press) 2013, 203-230; methodological dichotomy between media archaeology and media phenomenology

- discrete input *via* interface vs. pure gospel of analog, "immediate" control; truly "voltage controlled" Analog Computer vs. Digital Computer

- direct circuit control closer to the electronic device, corresponding with a truly media-archaeological aesthetics of techno-logical (pitch control / coding) immediacy and transitivity

- Pinch / Trocco differentiating synthesizer aesthetics of Buchla and Moog respective to the patch cords they used: "Patch cords are the wires that allow the operator to flexibly connect up the different modules on a synthesizer. [...] Buchla felt that his separation of signal from control voltages made more sense electronically" = Trevor Pinch / Frank Trocco, *Analog days. The invention and impact of the Moog synthesizer*, Cambridge, Mass. / London (Harvard UP) 2002, 45

- towards a truly medium-specific aesthetics; message of the medium electronic synthesizer (in terms of McLuhan) closer to the real (both electro-physically and physiologically); *not* (yet) "beyond" media-specific aesthetics, as claimed in the introduction of Liv Hausken (ed.), *Media Aesthetics* (2013)

- in music automata, sound emanating from mechanical combs: a "digital" procedure *avant la lettre*, a mechanized score with punctual, discrete coding like the punched card. Then came the phonograph, enabling analog, wave-form signal recording. Finally return of the digital, in compact disc recording. Pits are here engraved like in the punched card before, read out by laser light, deciphered again as zeros and ones. The bit streams are then being computed into musical information and can be experienced as sound after digital-to-analog conversion via transduction in loud-speakers. But once sonic

information has been likewise computed, it has changed its essence completely, even if it still sounds like sound; its inherent sonicity is vibrational matter no more

- keyboard culture (discrete input) vs. ribbon (German *Bandmanual*): the (literally) "digital" vs. the intuitive "analog" hand (finger) input = Pinch / Tocco 2002: 60 ff.; both the Ondes Martenot and the Trautonium applying ribbon control to produce continuous changes in pitch = Pinch / Tocco 2002: 337, note 6

- Museum of the Massachusetts Institute of Technology exhibits a modular analog synthesizer, "patched" by xxx Paradiso: alternative to Graphical User Interface aesthetics in contemporary computing; technical infrastructure lying bare, for immediate usage: no "pre-sets", just the actual state: patched sound, singular in its configuration

Transparency of the circuit diagram instead of the metaphors of user-friendly interfaces (case study Kurenniemi)

- Kurenniemi's electro-acoustic devices demanding engineering skills from the musician operating them; mostly experimental prototypes, "the user interface does not hide the inner design of electrical circuits, and, indeed, the circuits themselves have clearly had a strong influence on the user interface design of these instruments" = Mikko Ojanen et al., Design Principles and User Interfaces of Erkki Kurenniemi's Electronic Musical Instruments of the 1960's and 1970's, in: Proceedings of the 2007 Conference on New Interfaces for Musical Expression (NIME07), New York, NY, http://www.nime.org/2007/proc/nime2007_088.pdf; techno-archive *opened for access*

- Kurenniemi's electronic instruments reflecting the technical functionality "at the hardware level" = Ojanen et al. 2007: 92 - media-archaeological layer indeed, with the input mechanism being mainly the 'plug in' interface

- electronic analog computers as "twins" of electronic synthesizers, even closer to algorithmic user interfaces like MaxMSP or Pure Data today

- Kurenniemi's austere resistance to apply conventional control interfaces like a keyboard prefers the pure doctrine of electronic synthesizer access; expresses the discontinuity which takes place in conventional vs. electronic music instruments instead of hiding it in the sense of Marshall McLuhan's (content of a new medium always the previous medium. Kurenniemi "did not choose to use a conventional musical instrument user interface (e. g. a keyboard)" = Ojanen et al. 2007: 92, resisting the temptation to interfacial metaphors

- series of Kurenniemi's "Digital Musical Instruments" from the 1970s, from: Ojanen et al. 2007: http://www.nime.org/2007/proc/nime2007_088.pdf: Dimi-A and diagrammatic Dimi-A touchpad layout = Fig. 3 in Ojanen et al. / Dimi-O (photography) with peripheral in/out interfaces (key-board and video monitor = Fig. 4 in Ojanen et al. / Dimi-S with sensory input device = Fig. 6 in Ojanen et al.

- human hand loses its supremacy in controlling the surrounding machine world in favor of a multi-sensatory display

- *live coding* / With-Time-Programming

- according to Heidegger, objects and properties not inherent in the world, "but arise only in an event of *breaking down* in which they become *present-at-hand*. [...] A breakdown is not a negative situation to be avoided, but a situation of non-obviousness, in which the recognition that something is missing leads to unconcealing [...] some aspects of the network tools that we are engaged in using" = Winograd / Flores 1986: 36. "This creates a clear objective for design - to anticipate the forms of breakdowns and provide a space of possibilities for action when they occur" = 165

- truly media-archaeologically, interface "instead can become a zone of difference and potential conflict"; irritation reveals the medium (Heidegger's "ready" vs. "present at hand")

- Lev Thermen's design of *Terpsiton*; re-enactment (improvement to knowledge machine) Berlin: Haedicke; difference intuitive (continuous *glissandi*) and discrete (intonation), closer to typewriter / scalar musical instruments

- patch & tune: "tuning" of the analog computer / synthesizer = parameter modulation, vs. discrete (quasi-numerical) = analytic key-board approach (music instruments / computer interface); "counting" with differences: intuitive tuning and hand-moving instead of "digital" finger counting"

A sonic medium and its epistemic message: the monochord as instrument of knowledge research

- in a prehistoric bone flute, archaeologists seek its cultural "meaning", media-archaeo-acoustics focuses on wavelengths and reverberations; Francesco d'Errico / Graeme Lawson, *The Sound Paradox: How to Assess the Acoustic Significance of Archaeological Evidence?*, in: Chris Scarre / Graeme Lawson (eds.), *Archaeoacoustics*, Cambridge et al. (McDonald Institute for Archaeological Research) 2006, 41-58

- Martin Heidegger, *Sein und Zeit*, 385: "Die Wiederholung ist die ausdrückliche Überlieferung, das heißt der Rückgang in die Möglichkeiten des dagewesenen Daseins"; listening to the instrumental argument itself which is not subjected to musical composition (not used as a musical instrument) but a knowledge uncoverer (sound-archaeologically); circumstances, even the ways of listening and the psycho-physical tuning of ears, is different; still the monochord is a time-machine in a different sense: share / participate ("communicate") the original discovery of musicological knowledge; in technology, the repeatable *is* the original, while in phenomenology the "event" is a singular and instant act which can not be subsumed under general terms; media-archaeological experimentation (simulation as opposed to historiographic historicism) providing access to the invariant elements of knowledge in time

- vibrational mechanics becoming intransitive with electro-acoustic wiring as materialized diagram; finally algorithmic programming, more "musical" in terms of composition which is variant in electro-technical implementations (such as different "execution times")

- technical repeatability allows for an almost a-historical functional re-enactment; experience of high-tech media time is closer to the criteria of experimentation in natural sciences than to the historicist idea of empathetic history. The technological reproduction of a sequence of sound succeeds in exactly the same way as the original, even if it successively uses modern formats. What difference is between a functional technical component of previous generations and its actual embodiment? In most cases, the performance is as good, exactly because techno-logics is basically operative and not performative - *gleichursprüngliches* re-enactment

- Nicola Vicentino's 1555 *L'antica musica ridotta alla moderna prattica* designs an "Archiorgano" which provides for 31 tone grades per Octave, mechanically almost impossible short-cut to contemporary algorithmic realizations of micro-tonality; research project Studio31 at Basel Academy of Music actually (re-)building that diagram; time-delayed engineering = active media archaeology, final (partial) realization of Babbage's Difference Engine No. 2 by Science Museum London (Doron Swade)

Sonic memory's two technological embodiments: physical signal and archival symbol

- in their physical existence, both mechanical and electronic storage devices allowing for time-invariant replay of audio signals; increasingly subject to macro-temporal entropy over time such as the material deterioration of Edison cylinders or magnetic tapes. "Analogue" sound recording media like phonographic, gramophonic and magnetophonic records are subject to entropic time themselves; they "degrade over time in quality with every copy and in themselves.

- Technical Committee of IASA in its recommendations from December 2005 insisting that the originally intended signal is just one part of an archival audio record; accidental artefacts like noise and distortion part of it as well - be it because of faults in the recording process itself or as a result of later damage caused in transmission; both kind of signals, the semantic and the "mémoire involontaire", message *and* noise, to be preserved in media-archival conservation ethics

- between mechanical and electro-magnetic audio recording, not just a technical, but as well an epistemological difference. While the phonograph belongs to what Jules-Étienne Marey once called the „graphical method“ (analog registering of signals by curves), the magnetophone is based upon the electro-magnetic field which represents a completely different type of recording, in fact a true „medium“. What used to be invasive writing has been substituted by electronic recording; writing now re-returns as digital encoding in different qualities.

- Bill Viola, in his essay on what he calls the *sound* of electronic images, pointing out "the current shift from analogue's sequential waves to digital's recombinant codes" in technology = Viola 1990: 47; sampling and quantizing of acoustic signals techno-analytically transforming the time signal into the information of frequencies which is the condition for technical re-synthesis (Fourier transform). Digitalization means a radical transformation in the ontology of the sound record - from the physical signal to a matrix (chart, list) of its numerical values. Media culture turns from phonocentrism to processual mathematics.

- digital data in need of constant up-dating (in terms of software) and „migration“ (in terms of hardware to embody them). From that derives a change from the ideal of frozen eternity to permanent up-dating: dynamic preservation; material transfer not just the function of a more or less linear time base any more, but a basically atemporal dimension opens, under-tunneling the familiar time arrow of cultural tradition

- Nyquist / Shannon sampling theorem of digital sampling analog signals betrays the naturalist (physical) criterium of indexicality, by proving that (at least for the range of human sensual perception) a continuous signal can be quantized and time-discretely be digitized and still be reconstructed without loss of *information* when this is done with a frequency which (at least) doubles the highest frequency contained within the signal.

- oversampling phonographic records allowing for archiving the noise of the apparatus itself as well

The *a priori* of the sonic time machine: re-encacting electronic music / piano rolls electronically

- Alexander Bell, experimenting with electric voice transmission, occasionally inventing his tuning fork telephone. "You can easily perform this same experiment" today, writes Ed Evenson, author of *The Telephone Patent Conspiracy* of 1876, and addresses his reader in an online "re-presencing" (Sobchack) of the experiment as heuristic "operationality": an arrangement which short-circuits the human ear and the vibrating tuning fork / hand *via* electricity through water as conducting medium = <http://www.antiquetelephonehistory.com/sciencefork.html>, accessed July 23, 2014

- analogy between mechanical and electric "resonant circuit"; Barkhausen, *Schwingungslehre*); re-performance of electronic music

- emulation of an analog electro-acoustic synthesizer by digital software a quotation since even digital signal processing and the sampling theorem remains on the symbolic functional level

- world of difference between functionally simulating or emulating a previous computer game console on a contemporary computer platform; simulation about including the temporal idiosyncracies and material frictions of the "original" computer as well, not simply its computational function (the

algorithm), but its real implementation, the physical embodiment of its mathematical logics. A particular webpage design of media art functions in different times when simultaneously accessed from machines with different clocking; a given chunk of code may be executed faster or slower as computational processors and operating systems vary (suggestion by Marcus Bastos, September 9, 2016) - a playful target for time-critical Internet Art (Jodi, Vuk Cosic), but a challenge for the concept of preserving the cultural heritage of the computational present by future emulation. *Re-presencing* (Vivian Sobchack) the technological past depends on machine times and program lifecycle phases such as compile time, link time and load time

- sound technically emanating from an ancient Edison phonograph cylinder contains physical traces both from the past recording for time-delayed replay, *and* the present noisyness of the machine - a "temporeal"; its cracks, architecture revealing its entropic destiny = Karl-Eugen Kurrer, *Zur Geschichtlichkeit von Bauwerken*, in: *Stahlbau* vol. 70 (2001), no. 9, 159, kind of *écriture physique* inbetween structural order and entropy

- whereas the circuitry of a Nintendo *Game and Watch* handheld electronic game from 1981 keeps its contemporary sound as implicit information; its electronic circuitry, its ICs and its loudspeaker enabling analytical investigation, recreating the same auditive events that the device would have produced when it was first sold; re-generated techno-logical sound differs from simply transductive replay such as the pick-up of phonographic records; the device itself allowing for a co-originary experience

- Collingwood's notorious claim that historians have to "re-enact" the past event partly deriving from his astonishment that a present performance of a musical piece composed at some earlier time can still be understood at all. This requires that the auditor performs it again in imagination; different from historical imagination in its literal visual sense, "the *sine qua non* of writing the history of past music is to have this past music *re-enacted in the present*" = Collingwood's 1928 lecture "Outlines of a Philosophy of History", published in: R. G. Collingwood, *The Idea of History* [*1946], rev. ed. Oxford et al. (Oxford University Press) 1993, 441; practice of re-presencing (known in its technological equivalent as hardware and software replication and emulation in Retro Computing culture today) escalating in audio recording media such as the phonograph

- analogy between musical instruments and electronical media essential: both "time-based" in their function. They come into being only as "time objects" (German *Zeitobjekte*, according to Edmund Husserl's phenomenology). Only "re-enactment" of such (media-)archaeological artifacts allows for an operative analysis of such techniques; at the same time, it brings the user/player/researcher in a rather non-historical relation to the past. "Hands-on" such instruments is the ahistorical gesture *par excellence*, different from hand-written historiography: "Anders als die Mediengeschichte geht die Medienarchäologie davon aus, die historischen Geräte zwecks Klangerforschung und Entwicklung neuer kompositorischer Konzepte in Betrieb zu nehmen" = Peter Donhauser, *Österreichische Pioniere der "Elektrischen Musik" und die Medienarchäologie*, in: Gethmann (Hg.) 2010, 73-96 (92)

- history-defying short circuits, invariant towards change in time or space, presuppose that the physical and electromagnetic laws (and the actual circuitry) known to previous engineers can still be set in operation today. "Mathematically encoded laws of nature, then, occupy the place once held by the place of the music of the spheres [...] of quasi-angelic timelessness, into which those of us equipped with the required computational expertise can momentarily escape" = Geoffrey Winthrop-Young, Kittler's Siren Recursions, forthcoming in: xxx; actual URL: xxx

- techno-logical sense of time everything but *metaphysical*; media-archaeological research is rather rooted within the physicality of technical media. Within the physicality of technical media past settings can endure or re-occur. Therefore the "re-enactment" of (media-)archaeological artifacts such as electronic music instruments brings the player in a rather non-historical relation to the past. "Hands-on" such instruments is the ahistorical gesture *par excellence*, different from hand-written historiography of culture and science.

- colossal Wurlitzer cinema organ has to be operated frequently "hands-on"; otherwise the electro-magnetic contacts would corrode with time and thus block the musicality of the *organon*; physical entropy it materialized time at work her on the most essential level. Not being reduced to a musical-cultural jewel but looked at as a machine such an instrument behaves just like a steam engine from the age of the early Industrial Revolution on a technical museum.

- obsolete computer programs and electronic hardware a challenge for conservation; Chiara Marchini Camia, Digital Art Works. The Challenges of Conservation, Karlsruhe (ZKM) 2012; Simon Emmerson, In What Form Can "Live Electronic Music" Live On?, in: Organised Sound 11, no. 3 (2006), 209–219

- at Lucas Research Group laboratories of Brunel University in England, an Electric Leo Marconi computing machine, filling several cabinets, with both punched card and perforated tape inputs, allowed for acoustic output of data, "ostensibly so that the programmers could get an idea of what was going on." Apparently "it was relatively easy to cause the machine to do various useless things for a long time during which a certain sound would be made. Thus it could, in a way, make music, because the punched cards could be stacked up so that it almost made a scale, or some other recognizable sequence. Once assured that no harm could be done to the machine, I was struck with the idea of shuffling the cards (random sounds) and of ordering them according to ideas other than the sounds they made" = White Heat Cold Logic: British Computer Art 1960 - 1980, edited by Paul Brown, Charlie Gere, Nicholas Lambert, and Catherine Mason, Cambridge, MA (MIT Press); pdf 393

NOTES ON A MEDIA-ARCHAEOLOGY OF SONIC ARTICULATIONS

Phonographic recursion of the phonetic alphabet

- 1878 Edison describing in a patent one of the possible uses of the phonograph as speech generator, "to teach the relationship between each letter of the alphabet and its sound: a set of typewriter keys, each labelled with a single letter, activated the playback of individual sections of a long

cylinder that contained the spoken forms of those particular letters" = Hugh Davies, A History of Sampling, in: Feedback Papers 40 (Juli 1994), 2-15 (4) - a media-archaeological (rather than "historical") recursion of a cultural technique, since not immediately reflected in cultural terms - when the invention(s) of the discrete alphabet (as opposed to ideographic writing systems) cut down the human language into smallest elements which are meaningless in themselves, from house (*beta*) to "B", so to say. At this moment the machines take over, since only machines can perform symbolic operations without any semantic referentiality (which hinders effective data processing), purely syntactically; signal processing rather than semiotics, mediatic operativity rather than cultural "performance"

Historical versus media-archaeological reconstruction of sonospheres

- novel from 1880, *L'Eve Future*, Vielliers de l'Isle-Adam: before the phonograph any sonic expression (be it speech or music) had to be symbolically transformed into music notation in order to survive in time; with technical recording sound immediately becomes inscribed into a non-historical, non-human, signal-based material medium which literally has to get in motion (like the turning disc or the hard drive) in order to get re-presented. By electroacoustic recording, "the concept of a linear flow of time becomes an anachronism" itself = Barry Truax, *Acoustic Communication*, Norwood, N. J. (Ablex) 1984, 115; formerly "historic" relation between presence and past replaced by resonance; *sonicity* refers to the implicit tempor(e)ality which is connected with vibrating, oscillatory and frequential articulation; Steve Goodman, *The Ontology of Vibrational Force*, in: same author, *Sonic Warfare. Sound, Affect and the Ecology of Fear*, Cambridge, Mass. (MIT Press) 2009, 81-84. If the signal being transmitted is *continuous* ("as in oral speech") rather than being formed of *discrete* symbols ("as in written speech"), this fact affects the message (Weaver, 1963: 8)

- Marcel Proust making the reader think *of* bygone times, but when hearing Kirsten Flagstad as Isolde, with the Royal Opera House Orchestra under the leadership of Sir Thomas Beecham, her voice *is* concretely present to the perceptive mind. "The intellect tells me that the recording is 72 years old and stems from Covent Garden, but for my senses, she is with me in space, here and now." Jakobsen 2010: xxx

- Greek vocalization of the Phenician alphabet symbolically emulates, by recording (grammo-phonically), the musical character of oral poetry (notably the epics of Homer); even the phonograph reaches its limits when it comes to record the purely physical noise: "Ansi, j`eusse blâmé, par exemple, le Phonographe de son impuissance à reproduire, en tant que *bruits*, le bruit ... de la Chute de l'Empire romain ... les bruits qui courent ... les silences *éloquents* ..." = Edition Lausanne (L'Age d'Homme) 1979, 36

- signal semantics in Steve Reich's minimalist composition *Different Trains*: acoustic memories of former train journeys, indexical *train sounds* combined with human testimonies (*voices of train porters*)

Indirect transmission of sound (the vocal alphabet)

- Aristotelean correlation of time-number-movement; the over-countable in-between (dynamic *to metaxy*); phonographic signal recording in privileged alliance with the physically "real" acoustic articulation = Friedrich Kittler, *Die Welt des Symbolischen - eine Welt der Maschine*, in: ders., *Draculas Vermächtnis. Technische Schriften*, Leipzig (Reclam) 1991, 58-80 (68), unter Bezug auf: Jacques Lacan, 1973-80, in: *Schriften*, hg. v. Norbert Haas, Olten-Freiburg/Br., Bd. I, 24

- "chronotechnics" in adaption of Aristoxenos' term *chronoi* as smallest units of time in rhythm: long, short, intervals; extend / re-actualize to digital computational cycling units; See introduction Lionel Pearson, to: Aristoxenus, *Elementa Rhythmica. The Fragment of Book II and the Additional Evidence for Aristoxenian Rhythmic Theory*, Oxford (Clarendon Press) 1990, xxxiv. Pearson ergänzt: "One of the difficulties in reading Aristoxenus is to distinguish the special or technical use of a word from its general meaning. Greeks of his time were devising their own technical and scientific terminology" = *ibid.*, note 20

Sound archaeology

- sampling rate of 48 kHz with quantization of 16 bit linear storage

- listening to human voices which exterminated hundred years ago, by applying laser reading of the wax cylinders which do not destroy its source in the act of re-play; play-back in exactly the same quality as the Indian natives could in 1907. An example of the opto-eletronic archaeology of sound can be appropriately experienced right in the World Wide Web = <http://www.gfai.de/projekte/spubito/index.htm> - now expired, see archive.org "Wayback Machine". What do we hear: Message (the formerly recorded songs) or noise (the scratch; recording primarily memorizes the noise of the wax cylinder itself - which is not cultural-historical, but cultural-technological, a different kind of impression of the real. Media archaeology opens our ears to listen to this as well, not to filter this out against the "cocktail party effect" of hermeneutics

- by media-archaeological operation of opto-digitally reading of inscribed traces, otherwise unaccessible sound recording audible again. Synesthetically, see a spectrographic image of sound memory; spectrogram of a reconstructed recording of Wedda chants in Ceylon 1907 on the SpuBiTo web page; micro-physical *close reading* of sound dissolving any semantically meaningful archival unit into discrete blocks of signals. Instead of musicological hermeneutics, the media-archaeological gaze is required here - a reminder of light-based sound inscription in early film

- noise, the scratch of the wax cylinder the pure message of the medium; inbetween, the human voice is literally incorporated. But what has been continuously been preserved by analogue recording technologies, becomes quantified in the transfer to digital recording (CDs). When sampling a continuous wave with an analog-to-digital converter, sampling rate controls how many samples are taken per second; the sampling precision controls how

many different gradations (quantization levels) are possible when taking the sample

Technologies of sonic tradition: a signal-to-noise ratio

- what articulates 'it'self in human / nonhuman communication in any transmission channel is noise, against which Shannon developed a primarily "mathematical theory of communication" *alias* digital media; extending Shannon's theorem to transmission in time as well, that is: tradition. In such noise articulates itself what baroque allegories showed as the nagging „tooth of time“ - the articulation of physical entropy, the manifestation of the temporal arrow; according to the Second Law of Thermodynamics each system tends, over time, to increasing dis-order. Noise, here, is a signal of entropy. Against this noise of the real culture (especially techno-logical, that is: „digital“ culture) poses a negentropic insistance, a negation of decay and passing (away)

- digital copies of digital records indeed producible almost without loss of data (except the quantization noise). Music on Compact Disc or a digitale video reproducible frequently with stable quality which was utopian in recent times of analoge recording on magnetic tape; secret of this temporal invulnerability is that it is just (physical representations of) numbers which are written on the Compact Disc; even after a thousand copies thus a zero stays zero and one remains one = Rudolf Taschner, *Der Zahlen gigantische Schatten. Mathematik im Zeichen der Zeit*, Wiesbaden (Vieweg) 3rd ed. 2005, note 77

- natural sound evasive, liquid, in itself unrecordable beyond the bodily range, but technical media (different from alphabetic phonetic writing which "freezes" the human voice into a range of a very limited symbolic code) able to de-freeze recorded voices in almost all frequencies (that is, the Lacanean "real" of the voice) by re-play. After two millennia of the phonetic alphabet there is a new kind of cultural technology as sound recording

Berlin Lautarchiv

- target of sonic analytics not individual speech in terms of meaningful content, but subsemantic insights which can be derived from the very materiality of sono-cultural articulation: *phoné* (German "Laut"); phonographic collection of early voice recordings (Lautarchiv) based at Humboldt University Berlin, an ideal subject for such a sonic archaeology; Lautarchiv encompassing three groups: a) Famous voices (which for political reasons were partly neutralized or even destroyed after 1945); b) truly archival recordings of local speech dialects, based on a set of artificial word sequences in order to achieve formal comparability (so-called Wenker-sentences) with the speed of the recording being controlled by a supplementary oscillographic time code, and c) recordings for musical ethnology (mostly Africans and Indians from the French and British Army in the World War One *Halbmond* prisoner camp at Wünsdorf south of Berlin)

- almost complete list of the both phonographically and symbolically registered recordings online: <http://www.sammlungen.hu-berlin.de/sammlungen/78>

- phonographic recordings since April 1920 integrated as Department of Phonetics (*Lautabteilung*) into the Prussian State Library in Berlin to be reproduced on schellack discs *and* as transcription for educational distribution = Lautbibliothek: Phonetische Platten und Umschriften, ed. by the Lautabteilung der Preußischen Staatsbibliothek, 1920 onwards; original relation between spoken orality and its *grama*-phonic derivative (the phonetic alphabet) reversed again by the intrusion of real audio signals into the symbolical order of the librarians' Gutenberg world of letters, resulting in a kind of animated phonetic library: "Die toten Buchstaben und Büchertexte werden hier durch die Ergänzung der Lautplatte lebendig und verkörpern eine wirkliche Lautbücherei" = Wilhelm Doegen, Die Lautabteilung, in: Fünfzehn Jahre Königliche und Staatsbibliothek 1921, Berlin (Preußische Staatsbibliothek) 1921, 253-258 (253)

- architectural front facade of German Library in Leipzig (Deutsche Bücherei), founded in 1913, displays a monumental quote from a Schiller poem: "Körper und Stimme leiht die Schrift dem stummen Gedanken [...]"; printed text as it were starting to "speak" from a gramophonic storage medium which (different from the alphabet) does not discriminate between signal and noise any more: "In Graphie und/oder Phonie des Titelworts `Sprache´ steckt die Lautverbindung 'ach'" = Friedrich A. Kittler, Aufschreibesysteme 1800 / 1900, München (Fink) 1985, 48. *Lautabteilung* consequently accumulates natural and artificial noise („Geräusche natürlicher und künstlicher Art und andere“) such as the sound of tree leaves in the wind. What had started as interlinear auditory hallucinations in romantic literature becomes real in sub-symbolic recording media. The gramophonic recording method for waveforms in the so-called *glyphic system* on wax discs inscribes even sonic warfare into the new cultural memory as *écriture automatique*: "Gewehrfeuer (gun fire) for a theory of sonic explosion, and the sound of air planes ("Fliegergeräusche") = Doegen, op. cit.

- detecting minute variances and to eliminate subjective inexactitudes in listening to the recordings of foreign dialects and voices; limits of hand-written phonetic transcription become obvious, leading instead to the application of visual oscillograms and Fourier Analysis of the phonetic wave forms: Alois Brandl, Lebendige Sprache: Beobachtungen an Lautplatten englischer Dialektsätze, mit einem Anhang von Wilhelm Doegen, Zur Lautanalyse aus dem Klangbild des englischen Dialektwortes "man", aus der Lautplatte gewonnen nach dem elektro-oszillographischen Verfahren, in: Sitzungsberichte der Königlich Preußischen Akademie der Wissenschaften, Phil.-hist. Klasse (1928), 72-84

- when explicit listening replaced by technographical measuring of sonicity, gap between cognitive musical understanding and physical recording (the material, tonally *integrative* engraving of a musical event in the phonographic groove) opens. Just like the point of the gramophone needle can make only one movement at one time, "the illuminated disk of the oscilloscope shows only one line, no matter how many tones are sung into the microphone simultaneously. [...] what the apparatus registers as *one* wave, we *hear* as *multiplicity* of tones - and as a organized multiplicity. [...] mathematical analysis of the shape of the line permits us to deduce the individual waves that are combined in it. Yet [...] our ear accomplishes, effortlessly, continuously, and instantaneously, what

costs the skilled mathematician a considerable expenditure of time and energy" = Victor Zuckerkandl, *Sound and Symbol. Music and the External World*, New York (Pantheon) 1956, 333 f. - until Fast Fourier Transform algorithm achieving in real-time digital computing of sound. Even the much more detailed spectral voice analysis which had just been developed in Zuckerkandl's generation subjected the complex dynamics of sonic events once more to the visual knowledge regime since sonagrams, though expressing delicate micro-temporal variations, tend deciphered analog to alphabetic writing; tempor(e)ality of sonicity can never be caught in a frozen state but always points beyond the moving still - as discussed by Bergson's critique of chronophotography and the cinematographic illusion of "movement"

- ancient phonetic oscillograms today represent the truest media-historiography of that time - while at the same time challenging the historical narrative of their recording context. The real archive of sonic articulation emanating from such recordings is no longer literary stories but numerical analysis - finally resulting in digital sampling of the analogue records which is the transduction of ghostly voices into computability

- focus of sonic analysis in a *Lautarchiv* on the materiality of sound equally valuable in its acoustic and its technological sense. In modern Greek radio broadcasting is called *radiophonia*. Analog to telephony, not speech or music as semantic content is named here, but the phonetic materiality (ancient Greek *phoné* / German *Laut*) of any kind which is transmitted by a neutral medium called radio. In terms of a (media) archaeology of acoustics, the nature of sound is spectral, just as the letters in an alphabet only symbolically relate to the physicality of actual speech phonemes which are as "differential" (Arseny Avraamov) as the *glissandi* of the Theremin Vox constructed as the first mass-reproduced electronic music instrument by Leon Theremin in revolutionary Soviet Union = Andrey Smirnov, *Sound in Z. Experiments in Sound and Electronic Music in early 20th Century Russia*, London (Koenig Books) 2013, 44. With sound production which is subliminal to human perception, sonicity (different from sonority) starts.

(Archaeo-)Phonography *avant la lettre*

- "archival" operation extends from restoration and conservation to re-animation and thus becomes a true media-archaeological operation; in novel called *Time Shards*, the science fiction author Gregory Benford imagines a research laboratory which reconstructs "fossil voices" out of the grooves of mediaeval pottery

- Patrick Feaster and David Giovannoni succeeding in re-sonifying the preserved phonautographic engravings ("Schallbilder"), beginning with Scott's recording of a sound folk tone of 435 Hz in the year 1859. 150 years later science realized that with optical "reading" of such acoustic signal lines sound can be re-synthesized, and all of the sudden a children's song sounds again

- what metaphorically looks like the pick-up of sound images by a "virtual, digital gramophone needle" = Harald Haack, *Die erste Klangaufzeichnung. Eine Audiografie*, <http://newsbattery.blogspot.de/2008/05/07/die-erste->

klangaufzeichnung-eine-audiografie; something media-epistemologically different, a picking-up of a completely new kind: digital sampling

- technical media (different from alphabetic phonetic writing which "freezes" the human voice into a range of a very limited symbolic code) able to de-freeze recorded voices in almost all frequencies (that is, the Lacanean "real" of the voice) by re-play; after two millennia of the phonetic alphabet a new kind of cultural technology as sound recording

- literally retrieving *signals* from the past, new privileged ways of connecting to the past *via* the communication channel rather than by the coded symbols (the traditional archival record). But this signal channel is cut by the digital sampling of such records, such as the software IRENE which reads out graphical grooves by the „virtual stylus“ and audifies them (at the Berkeley Laboratory, by Carl Haber) = argument in Patrick Feaster's lecture "Sound Archives *avant la lettre*: Audio Collections of the Nineteenth Century (1850s-1890s)", conference *Listening to the Archive. Histories of Sound Data in the Humanities and Sciences*, 11-13 February, 2016, Berlin, Humboldt University / Max Planck Institute for the History of Science

- performed with the free, open access software ImageToSound - which at the same time, media-archaeologically, recalls the technical epistemology of the sound film (*Lichtton*)

- inbetween the alphabetic metaphor and signal reproduction, the "Graphophone" has been the name for play-back device for phonographic records

- phonographic groove is a „graph of a sound over time“ (Feaster): mathematical derivative (*Ableitung*) over time; a kind of analog computing

- can time rate of the retrieved sound be defined if there is recording of an accompanying pilot tone as well, such as on Scott de Martinville's phonautograms by means of a tuning fork

- reading out from handwritten archival „manuscripts“ the modulated overtones which vibrated (when speaking while writing aloud, like in early Greek and Medieval times): overlay; separate by Fourier analysis

- revolving form of the Edison cylinder respectively the gramophone disc is necessary for machine reading since a time signal unfolds, different from human reading which can be non-linearly arranged line-wise on the geometric writing page

- audifying very first phonographic recordings efforts by Édouard-Léon Scott de Martinville resulted in indiscernable noisy patterns: *Message ou Bruit?* from what moment expression „first sound“ or „speech“ records making sense? media-archaeological momentum starting to irritate human cognition. Media-archaeological work which steays close to the signal is non-hermeneutic "understanding" of cultural expression

- archaeonautics of the acoustic; sono-drama of temporal patterns which unfold

in differential variations; potential in musical compositions that bridge distance in favor of immediacy - even if all digitally processed in transmission

Active media archaeology: Sonic revelation (articulation) from the past (*Au Claire de Lune*)

- historical research academically a text-based science, opposed to a science of signals which has opened a new field of research not just as an additional source for historical inquiry; with photography, the phonograph and with cinematography an alternative field of agenda set

- so-called Humanities (as defined by Wilhelm Dilthey) not sufficiently concerned with the physically real - due to the limits of hermeneutics as text-oriented method, to the privileging of narrative as dominant form of representation and because of an essential lack of non-symbolic recording media of the real. Battles have been described and interpreted, but the real noise and smell of a combat could not be transmitted until the arrival of the Edison phonograph = Bernhard Siegert, *Das Leben zählt nicht. Natur- und Geisteswissenschaften bei Dilthey aus medienschichtlicher Sicht*, in: Claus Pias (ed.), *Medien. Dreizehn Vorträge zur Medienkultur*, Weimar 1999, 161-182 (175), referring to: Wilhelm Dilthey, *Die Abgrenzung der Geisteswissenschaften. Zweite Fassung*, in: same author, *Gesammelte Schriften VII*, 311

- phonography not just helping historiography to higher precision; rather explores new forms of tempor(e)ality on the level of the physically and mathematically real (techno/logy); get tuned to this new epistemology, not by texts and the spoken word, but by a French childrens' song: *Au Claire de Lune*. In an act of active media archaeology by the computer itself it has been achieved that the graphic recording of Léon Scott's analyses of the human voice could be re-transformed into acoustic articulation

- phonogram by Léon-Scott, recorded 8th April, 1860, Paris: song "Au clair de la lune, Pierrot répondit"; <http://www.firstsounds.org/sounds/1860-Scott-Au-Claire-de-la-Lune-09-08.mp3>

- from such an operation, re-discovery of a song expected, but what primarily acoustically emanates is noise - just like the first (archived) recording of sound in Norway, a tinfoil flattened to a "document" and annotated by a remark by a former collector who claims this has been the first Norwegian recording of music on Edison cylinder; digital reading of this record (at a laboratory in Southampton) lead to nothing but noise

- What articulates as almost Freudian "it"self is noise such as can be expected in any transmission channel according to the theory of communication developed by Claude Shannons - a theorem which can be extended to transmission in time as well, that is: tradition. In such noise articulates itself what baroque allegories showed as the nagging "tooth of time" - the articulation of physical entropy, the manifestation of the temporal arrow; according to the Second Law of Zweiten Thermodynamics each system tends, over time, to increasing dis-order

- against the noise of the really physical world, culture (especially technological, that is: "digital" culture) posing a negentropic insistance, a negation of decay and passing (away).
- symbolic temporal order of "history" (i. e. almost time-invariant "tradition") differing from the entropic deterioration of the electric charge and chemical carrier of the magnetic tape in real physics
- analog sound carrier, which is in-formed physical materiality, can still be identified according to the criteria of the historical method; digital signal transfer primarily is information in its communication engineering sense (given by Shannon), that is: unbound from energy and matter (as Norbert Wiener in his *Cybernetics* insists)
- really first recording of sound (in the media-archaeological sense) preserved as relic (in Droysen's sense "Überrest"), which is as un-intentional tradition (a Proustean *mémoire involontaire*, a Bergsonian "counter-archive" as defined by Paula Amad) originating from Léon-Scott's "Phonautograph" on a turning cylinder (the Kymograph as universal epistemological recording medium of 19th century), once invented not for purpose of replay or for transmission posterity, but just for immediate phonetic analysis (techno-linguistics)
- in media-active signal research, technological apparatus itself the archaeologist proper; Patrick Feaster and David Giovannoni succeeding in re-sonifying the preserved phonautographic engravings ("Schallbilder"), beginning with Scott's recording of a sound folk tone of 435 Hz in the year 1859. 150 years later science realized that with optical "reading" of such acoustic signal lines sound can be re-synthesized, and all of the sudden a children's song sounds again

Sonic arts / acoustic archaeology

- enunciations from an Edison wax cylinder, as once expressed by Michel Foucault in a slightly different context: "Message or bruit?"
- opto-digital reading of early Edison cylinders allowing for listening again to otherwise unaccessible sound recording; the opto-digital *close reading* of sound as image, though, dissolves any meaningful unit into discrete blocks, which are accessible for human analysis only by operative techno-mathematical diagrams:
- "spectrogram of such a reconstructed acoustic recording as an analytic, media-archaeological deciphering
- the "media-archaeological ear", as an alternative to the cultural emphasis on musical semantics; installation by Yuri Suzuki at the Ars Electronica in Linz, September 2009, *The Physical Value of Sound*, explicitly based on the electro-mechanics of (manipulating) records (their speed) and pick-up systems (their non-linear use); www.yurisuzuki.com; micro-physical *close reading* of sound; dissolves any semantically meaningful archival unit into discrete blocks of

signals instead of musicological hermeneutics; reminder of light-based sound inscription in early film

- to media-archaeologically sharpened perception, an animated figure on a computer screen will never be confused with a living being since such a mind is conscious of the algorithms of which such an animation is a technomathematical, processual function

- against the scarcity of instrumental artefacts and doubtful textual evidence from ancient music theory, anachronistic option of computational re-calculation of Aristoxenean arguments (dissertation Carlé)

NOTES ON ARCHIVAL SOUND

Is there a "sound of the archive"? Listening to silence with media-archaeological ears

- software for sound analysis *Audacity* actually providing an algorithm called "Silence Finder". In the negative sound, its silence, we listen to the past in its truest articulation

- not only implicit (sonicistic) but as well actual sound from the media-archaeological archive; when an ancient "Datassette" loaded from external tape memory into the ROM of a Commodore 64 computer, actual to data music: not sound as memory content like an old persuasion-assisted song, but rather the sound of computer memory itself, that is: a software program which is "scripture" (though in the alphanumeric mode); Ben Anderson, Recorded music and practices of remembering, in: *Social and Cultural Geography*, vol. 5, No. 1, March 2004, 3-19; listening to the data archive which is not sonic memory but sonicity

Material entropy of the signal versus symbolic (archival) endurance of sound recording

- Bill Viola's essay on the implicit *sound* of electronic images; "the current shift from analogue's sequential waves to digital's recombinant codes" in technology = Viola 1990: 47; sampling and quantizing of acoustic signals analytically transforming the time signal into the information of frequencies which is the condition for technical re-synthesis (Fourier transformation). Digitalization means a radical transformation in the ontology of the sound record - from the physical signal to a matrix (chart, list) of its numerical values. Media culture turns from phonocentrism to mathematics

- the techno-mathematical *archive*; transfer techniques of audio carriers from technically extended "writing" such as analog phonography to calculation (digitization), not just another version of the materialities of tradition, but conceptual change; basically atemporal dimension. Against the noise of the real culture (especially techno-logical, that is: „digital“ culture) poses a negentropic insistence, a negation of decay and passing-away

- digital copies of digital records produced almost without loss of data (except the quantization noise). Music on Compact Disc or a digitale video can be reproduced frequently with stable quality which was utopian in recent times of analoge recording on magnetic tape. The secret of this temporal unvulnerability is that it is just (physical representations of) numbers which are written on the Compact Disc; after a thousand copies thus a zero stays zero and one remains one = Rudolf Taschner, *Der Zahlen gigantische Schatten. Mathematik im Zeichen der Zeit*, Wiesbaden (Vieweg) 3. Aufl. 2005, note 77

- past sound not just "restored" by applying digital filters; rather wants to be remembered with all the traces of decay which has been part of its tradition, its media-temporal (entropic) characteristics must be archived as well; remain close to the physical record which is achieved by over-sampling; stay tuned to such non-archival sonicity

Automatic music transcription (AMT)

- Software trAVis (Musikzentriertes Transkriptionsprogramm für AV-Medien); see Christofer Jost, *Computer-Based Analysis of Audiovisual Material*, in: Dimitri Zakharine / Nils Meise (eds), *Electrified Voices. Medial, Socio-Historical and Cultural Aspects of Voice Transfer*, Konstanz (Unipress) 2012, 359-375

- *sonic* signals previously requiring human decoders to be transcribed into *musical* scores; for media-archaeological ears of data processing devices, audio signals can be automatically turned first into digital samples - with the digital audio signal $s(n)$ representing a transformed time signal by means of the time index n

- sampled audio signal can be processed into formats like the spectrogram, and/or be printed as conventional musical score by the digital Score Generator. What has been first developed for automated speech analysis is extended to the musical field. The "Onset Detector" recognizes the beginning of regular notes; primarily this automated analysis gives access to the temporal realm of the sonic event by identification of micro-temporal structures, beats and rhythm; real time components of such a software creates waveforms to be analyzed by Discrete Fourier Transformation and then is (re-)translated (re-mediated, in fact) into culturally familiar categories of musical time structures like Harmonic Analysis. "Grundlegend ist die Tatum-Erkennung. Dieses Kunstwort wurde von 'Time Quantum' abgeleitet und bezieht sich auf das kleinste im Eingangssignal gefundene Zeitintervall. Hierauf baut der Beat (*Tactus*) auf, welcher mit dem wichtigsten wahrnehmbaren Puls gleichgesetzt wird" = Roland Stigge, *Automatische Musiktranskription (ATM)*, paper from June 16, 2003, developed at the chair for Signal Processing and Pattern Recognition at the Institut of Computer Science, Humboldt University, Berlin; accessible *online* <http://www.antcom.de/~stigge/studium/amtarticle.pdf> (Zugriff Juli 2013); apply to even higher levels of sonic dramaturgy (which is the culturally familiar "musical" ordering of time)

- accidental sorting of sound and images: between signal-based similarity and symbol-based logocentrism

- "dynamic algorithmic access replacing the static classification of the traditional catalogue; coexistence of different orders without destroying the material structure - *relational* databases and *random search* (familiar in "hashing" in the the administration of computer storage, a kind of *order in fluctuation*. which is the radical temporalization of order itself

Indexical recording: sound from the real world

- Barthes describing the affective experience of looking at an ancient photography as *punctum* - a short-cut between past and the present: a punctual moment, while in acoustic recording by gramophone there is a processual, time-based signal; its re-play generating a different sense of the past; for Ludwig Wittgenstein when associating a tune recorded for a gramophone "this is the most elaborate and exact expression of a feeling of pastness which I can imagine" = Ludwig Wittgenstein, here quoted after: Gregory Ulmer, *Applied Grammatology*, Baltimore (John Hopkins University Press) 1985, 110

- even if less of a difference in phenomenological (human) perception, sound, when being re-generated out of electro-magnetic latency, embodies a tempor(e)ality different from the almost scriptural engraving in the gramophone groove

- as engraved index (in Peirce's semiotic sense), a sound forming a sharp contrast to its symbolic notation. *Indices* represent their objects "by virtue of being in fact modified by them", in a truly analog way = Charles S. Peirce, letter to P. E. B. Jourdain [*1908], in: Carolyn Eisele (ed.), *The News Elements of Mathematics*, 3/2, Berlin (Mouton) / Atlantic Highlands, NJ (Humanities Press) 1976, 879-888 (887); gramophone groove literally in-formed by sound, but this is still a material, physical shaping, whereas digital information is no question of matter or energy any more; acoustic signal not losing its temporal indexicality when being recorded; aggressive acoustic signal even in its media-technological reproduction retaining its physically *effective* and physiologically *affective* reality, being co-originary in terms of its frequency values

- "schizophonic" (Schaeffer) effect of sound coming out of loudspeakers from a technical record; response to the real non-narrative signal

- Walter Benjamin identifying kind of "optical unconscious" which reveals itself only to the camera eye; analogous for sonic phenomena: phonographic records unintentionally co-registering a whole world of additional information, starting from background noises; no "message" from the past; Soundscape Project in Vancouver

Media as active archaeologists: SpuBiTo

- item in Berlin Lautarchiv no. (ID) 9311 (type "Plastisches Objekt"): two electromagnetic pick-ups, as media-archaeological, material condition for past sound analysis at all

- necessity of digitizing phonographic records against physical decay, epistemological option emerges; SpuBiTo project = www.gfai.de: "The retrieved sound documents can directly be stored on digital media (e. g. CDs) for archiving or processing"; "big data" generated by retro-digitization of analog sound archives; surplus value in the algorithmization of these data, not pure quantity; unstructured data as such useless
- real archaeologists of sound past technical measuring media which are able to de-cipher physically real signals techno-analogically, and to represent them in graphic forms alternative to alphabetic writing, requiring "moving" diagrams as sinusoidal articulation in time, such as the oscilloscope
- dis-closure; opto-digital image processing of sound tracks on early Edison cylinders allows for listening again to otherwise inaccessible sound recording, by a hybrid of mechanical stylus (haptic transitivity) and optical scanning
- below the phono-archival regime, media decoders become active archaeologists of "signals from the past" themselves.
- glyphic voices on the analogue, vulnerable storage medium of wax cylinders are currently being de-frozen by digital means; Berlin Society for Applied Informatics has developed a method to gain acoustic signals from negative traces of galvano-copies from Edison-cylinders by opto-endoscopic „reading“ - scanning its "visual" (glyphic) information into sound; making stored acoustic waves actually sound not demanding rhetoric imagination but on the contrary a hermeneutically distant gaze, an exteriority of interpretation
- opto-technical scanner only can provide for a distant *aisthesis*; media Archaeology as specific method of "Digital Humanities". Technical media provide a different option of reading: reading without (premature) understanding. The archaeological gaze mimicks this ascetic confrontation of signals, resisting the narrative temptations of figuration
- *Phonogrammarchiv* at Ethnological Museum, Berlin, partly consists of *negatives* of early wax cylinder recordings (copper galvanos) which like Talbot's negative photography require a conversion into positive sound signals again. With such a technical operation (in visual and in audio memory), an attitude to remembrance of the cultural past is trained which differs from historical narrative: negative-to-positive conversion, transforming a latency into manifest re-enactment
- system not damaging the unique negatives, therefore allowing for a truly *archival* reading; retrieved sound documents can *directly* be stored on digital media for *secondary* "archiving or processing" = Gfal - where in fact the archive is coupled to algorithmic manipulation itself, thereby undergoing a complete metamorphosis (from intransitive to transitive) of its traditional state as monumental *stasis* and *distinct* heterotope of the present. "The central part of SpuBiTo is the height detection algorithm measuring the height of the tracks, computing the movement of the diamond stylus and reconstructing the acoustical information" = "SpuBiTo - From Image to Sound"; <http://www.gfai.de/english/projects/image-processing-industrial-applications-projects-/spubito.html>; German acronym for "Spur - Bild - Ton"

- "sonic analytics" referring to the technological analysis itself (different from the subsequent humanist "cultural analysis" of the resulting audio signal findings)

- close reading of sound *as image* dissolving any continuous wave form into discrete blocks, which are accessible for analysis only by operative techno-mathematical diagrams - a media-archaeological deciphering of sound from the past

Acoustic archaeology

- Edison wax cylinders from the beginning of the 20th century containing background recordings of environments that were never intended for memory; within the temporal figure of resonance, an earlier event can recall a later one. What once has been considered as undesirable noises may from a different perspective (or better: hearing) turns out as a kind of acoustic cinema. This leads to the counter-historical idea of simultaneity, the co-existence of two different times, including the now-time of listening (Moore / Kiefer)

- differentiate between the cultural "social" respectively "collective" (Halbwachs) memory of sonic events and the actual (media) recording of sonic articulation from the past. For an archaeology of the acoustic the human auditory sense does not suffice; therefore track the sonic trace with genuine tools of "media studies" which is technological. One way of "acoustic archaeology" is to play a musical score on historic instruments. But the real archaeologists in media archaeology are the media themselves - not mass media (the media of representation), but measuring media which are able to de-cipher physically real signals techno-analogically, and representing them in graphic forms alternative to alphabetic writing, requiring "moving" diagrams (since sound is articulation in time): the oscilloscope

- storage-and-transfer techniques of audio carriers changing from technically extended "writing" such as analog phonography to calculation (digitization); "graphical method" (Marey) still in accordance with the recording and representation practice of event time as a function of historiography); not just another version of the materialities of tradition, but a conceptual change. From that moment on, material tradition is not just function of a linear time base any more (the speed of history), but a new, basically atemporal dimension (acceleration), short-cutting the emphatic time arrow and demanding for a partial differentiation (just like the infinitesimal calculus was introduced by Leibniz as a measure of non-linear change *within* speed)

Sonic Media Archaeology

- transmitting sonic information to future ages by coding (Carpo on Alberti), allowing for a later re-sonification, not by direct audification (like the phonographic record) but in terms of parameter mapping, has been the musical score - depending, though, on a physical "medium" - be it the human voice or the appropriate music instrument - to be re-implemented into the physical

world. Another variance is the survival of original instruments from the past which allow not for the exact re-play of every melody which has been produced upon it but at least to re-produce the fidelity of the defining and definite sound spectrum = "Model-based sonification" as described by Florian Dambois, *Sonifikation. Ein Plädoyer, dem naturwissenschaftlichen Verfahren eine kulturhistorische Einschätzung zukommen zu lassen*, in: Petra Maria Meyer (ed.), *Acoustic turn*, Munich (Fink) 2008, 91-100 (92)

- media installation *Voice of Sisyphus* under Legrady's artistic direction, methods of "digital archaeology" (operative image analysis) are being used to sonify the image-as-memory itself. A black & white photographic image from the 1970s displaying a hotel scene "At the Bar" is filtered by a computer program which then reads the segments and produces sounds out of them resulting in a continuously evolving composition; no deliberate, but a algorithm-based, rule-based, in Foucauldean terms *archival* transformation; like for digital image compression, an image region is selected, this block then "linearized" and "read" for FFT like a analog TV signal, line by line. Giving a voice to the image; <http://vimeo.com/30238729>; with sound: <http://vimeo.com/34859885>; VOICE OF SISYPHUS: AN IMAGE SONIFICATION MULTIMEDIA INSTALLATION presented at The 18th International Conference on Auditory Display (ICAD-2012), June 18–22, 2012, Atlanta, USA; paper: http://www.mat.ucsb.edu/Publications/McGee_ICAD_2012.pdf

- term *archeo-acoustics*; "pre-historic" not in the temporalhistoric but *structural* media-archaeological sense of non-discursive (cultural), rather implicit sound; situation Sirenen expedition

- cultural appearance of acoustic echo, digested as Greek mythologem, re(oc)curing (equi-temporally) by electro-mechanical, technical, afterwards computational means: generative echo resp. reverb, *without bodily source*

- tecsound signal rather than sign; "sonicity" as implicit sound, non-human dimension of sound

- Anthony Hempell, "The Resonating Interval. Exploring ..."; McLuhan differentiating between "pre-" and "post-Euclidean" acoustic space