

## Acoustical and electro-acoustical sound fields - The beginning in Gravesano 1954

Ernst-Joachim Völker

*Institute for Acoustic and Building Physics, 61440 Oberursel and 23992 Zweihausen, Germany*

*www.iab-oberursel.de and www.iab-zweihausen.de*

V00509

### Summery

It was a courageous start in 1954. Professor Dr. Hermann Scherchen, as composer, conductor and technician, had invited experts from all over Europe to discuss the new and special relationship between music and technology. The UNESCO supported the work. The place was the small Swiss City of Gravesano, a quiet and peaceful location. It was just the beginning and starting point for many investigations. New concert halls were discussed, radio studios, reverberation and first reflections. Today, it is well known: The investigations and publications were the roots of many developments. In the following years, Universities became strongholds of Acoustics, e.g. in Göttingen, Berlin, Bochum, Darmstadt, Paris, Hamburg. In Gravesano, Hermann Scherchen has fulfilled his dream to bring together Music and Technique, where Tonmeisters and Sound Engineers speak the same language.

For concerts and recordings, Scherchen used multi-channel electro acoustical transmissions to support soloists, the choirs and even the orchestra in the sense of "Play back" for the very first time. He saw the advantages of an excellent sound instead of weak voices and unpleasant strings. In order to improve the sound impression, Scherchen worked with multichannel reproduction and, e.g. loudspeakers in the ceiling for surround sound. This technique had to be tested in own studios and with own facilities very close.

The Gravesaner Blätter were the journal of Gravesano School. Contributions from all over the world filled the issues. Ideas were created and picked up for more research and usage. The school of Gravesano was a necessity in the Fifties. Later many others continued with much more possibilities to research and to receive financial support. Gravesano was a child of Hermann Scherchen. In 1966, after a decade of successful work, the Nr.29 was the last issue of Gravesaner Blätter. Nevertheless, Hermann Scherchen has reached his aim in life.

### Start in 1954

The opening was impressive. When the guests entered the studio, they were greeted by Vermeulen's "Washington Post", reproduced by a big stereophonic installation. Two huge loudspeaker-combinations reproduced the two-track recording. Additional 20 loudspeakers were mounted underneath the ceiling to produce a room impression. For the recording an artificial head was used with microphones on both sides. This first opening impression was quite a surprise, almost unbelievable for the participants. Stereophony was the winner. But, even seven years later in 1961, L.Keibs of German Radio and Television Laboratory in Berlin stated that "there is neither sufficient information on stereophonic studio technique, nor is there any

international agreement on compatible two channel transmission." In the meantime, he suggested, one should use the pseudo-stereophony derived from the monaural signal /1/ e.g. with the "Stereophoner", developed by Hermann Scherchen in Gravesano in 1958 /2/. Scherchen himself changed the sound image by using 2 W86 Emphasizers of company Eckmueller and the voice-frequency filter of Albis Electroacoustics. Leibs proposal was a step backwards, since in 1956 the author had already listened to 2 channel radio transmissions in Berlin via two radios, 3m apart, each for one UKW channel /3/. Then, in 1964, 10 years after the beginning in Gravesano, experiments with stereo-reproductions at Hessischer Rundfunk in Frankfurt were strictly forbidden in order to wait until the radio is ready to start, e.g. at one of the next Funkausstellung in Berlin. For the Radio and TV stations in Germany, the compatibility had to be developed first. K. Bertram of company Telefunken presented in 1958 the M/S fader (Richtungsmischer) where the M stands for middle or monaural signals and S for the side-signals, both recorded by a stereophonic microphone with an eight and a cardioid characteristics /4/. Scherchens Stereophoner has however changed the monaural signals into a stereophonic pattern, using one input and two stereo outputs.

### Multi-channel recording and reproduction

The reproduction in Gravesano was the beginning of experiments with a dead acoustical environment. Scherchen wanted to record the "naked sound to get it dressed up later", firstly with reflections and secondly with reverberation in his specific way. He listened to his recordings in the studio like his guests during the opening 1954. He recorded speech and music and played it back. It was his intention to be totally surrounded by sound. In 1962, eight years later, the Centennial Hall in Frankfurt was opened. It was an over-damped 3000 seat hall with a dome-shape. The electro-acoustic system provided direct sound and many reflections, additionally artificial reverberation from a reverberation chamber. In Gravesano, the studios were fully packed with loudspeakers and equipment. Scherchen looked for the best acoustical impression and preferred his own studio with own installations. **Fig. 1** shows Nr.1 of his three studios, 500m<sup>3</sup>, 220m<sup>3</sup>, 300m<sup>3</sup> plus control-rooms, four reverberation-rooms in different size. Walls were covered with big carpets; sound absorbing material was everywhere to achieve a short reverberation time of around 0.3s. The ground-plan is to be seen in **Fig.2**. Today, only music recording studios have sometimes huge control-rooms as to sit e.g. in a discotheque. The same applies for large rooms for film mix-downs, for

example with 5 channels in front and some others in the ceiling. This Gravesano installation had been adopted, e.g. by IRCAM Paris /5/ to change the room-acoustics through different heights of the ceiling, and turning absorbing wall elements, using artificial reverberation from reverberation rooms as well as adding in artificial reflections. Another example is the ZKM, Centre for Art and Media-technique in Karlsruhe, Germany /6/. The IAB in Frankfurt has 110 loudspeakers behind the sound-penetrating coverage of walls and ceiling in the non-reverberant studio /7/. Nowadays, the mixing desks are well designed with digital multitrack recorders, filters, and delay-units. The Open-air Theatre of Bregenz became famous with the huge Electro Acoustical Sound System using partly Delta-Stereophony as described by F. Fritz /8/. E.Meyer has put 20cm sound absorbing material inside the big dome of Jahrhunderhalle to obtain a short reverberation time. That was the naked sound of Scherchen's Gravesano studio. Consequence: An excellent sound system was required. F. Fritz works at the Vienna Opera with pre-recorded choir to play in /9/. The modern 5.1 technology leads the way back to more loudspeakers around the mixing desk /10/. Surround Sound creates even more speakers all around the walls to produce a wave-field with excellent sound image.

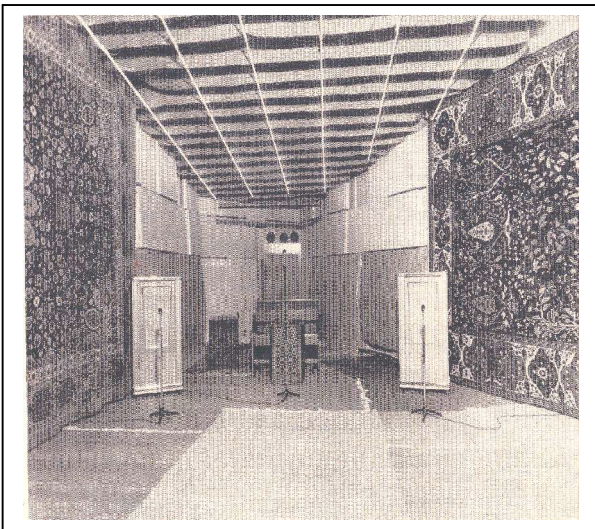


Fig.1: Studio 1 Institute for Music and Electro-acoustics

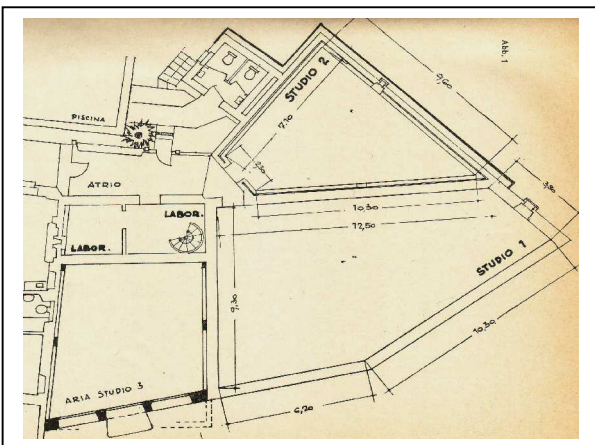


Fig.2: Studios Ground-plan in 1954

## Music and Technique

A.Moles, Paris, described in 1957 the Electro-acoustical Institute of Hermann Scherchen as to be a centre for scientific work in the field of Music and Electro Acoustics. The Institute was a reaction of the growing Music Industry. The fears existed that the music will be rolled over by the technique. In 1955 Meyer-Eppler said: "A good disk recording can be made in excellent quality without musicians. The composer can write a binary-code on a perforated band which controls generators" /1/. Conclusion: The musician should know the technical requirements and aspects. The same applies for the technician: He should know the music. There exists always a tension between music and technique. In the Journal Nr. 9 1957: "Only Hermann Scherchen as famous composer and conductor is able to combine both music and technique in one person".

In the same year 1957, the first combined University class started for Tonmeisters with both Musical and Technical Education. The author attended this first class with the typical double-study of music, e.g. Double Bass and Piano at the Hochschule für Musik in Berlin, and Electro Acoustics at the Technical University of Berlin under Prof. Dr.-Ing. Lothar Cremer, who was at that time permanently a special guest in Gravesano.

## Direct sound and reflections

In the first issue of the Gravesano Blätter 1955, Karlhans Weisse pointed out that nobody knows the basics and the aims for the first room response (attack) before the reverberation starts. He saw the importance of studio Gravesano in this respect to find answers. Weisse was the acoustical consultant for the concert hall of Hessian Broadcasting Corporation in Frankfurt. He knew the sound reflections, which arrive at the microphones and had to decide how to direct them towards a good "Acoustics". He stated: "If we had knowledge about these reflections, we could design rooms for speech and music simply in the right way. Instead, we must copy the first reflections, e.g. from existing famous historical concert halls." Under these circumstances he used reflectors behind the 96 000 wooden bars on walls and ceiling. Scherchen went another way. He made "naked" recordings in his "dry studio" and added delayed sound by using tape recorders with several heads. The delay time depended on the speed of the tape and the distance between the heads. Cremer und Kuhl reported on these experiments during the Koloquium 1956-05-17/23 /11/. A first reflection was added between D and R with a delay of 35ms. The reverberation followed with 50ms. It was stated: This was a clear improvement of the sound image.

The Gravesaner Blätter, beginning 1955 up to 1966, do not contain any investigations on reflections, their frequency response and levels, although R. Thiele had already in 1953 defined the Deutlichkeit D as the ratio of sound energy within the first 50ms and the total energy /12/. Reichardt saw a breakpoint at 80 ms and defined the Clarity /10/. Thiele explained the arriving reflections with his "hedgehogs" where a prickle indicated the direction and the level of arriving sound detected by a parabolic mirror. Scherchen

knew already that in the stereophonic picture first reflections arrive from different points. He changed its frequency response and amplified different parts in the left and right channel as to be seen in his "Stereophoner". That was pseudo-stereophony. Scherchen did not use any impulse sound to look into the structure of sound, although Thiele and Cremer had already used high voltage cracks and pistol-shots and saw the reflections on an oscilloscope. But, 20 years later in 1974 the author used the same method for investigations in studios for radio and TV /13/.

## V-Criterion within 15ms

Hermann Scherchen should have seen the acoustical installation in the non-reverberant studio of IAB in 1994 where the first 15ms after the arrival of the direct sound were investigated. The subject: The control-room for high quality listening should not be affected by strong first reflection arriving from reflecting surfaces on walls or the ceiling. Therefore, a reflection free zone as V-criterion was defined. With the impulse measurement technique including Fast Fourier Transformation FFT, single reflections can be measured and indicated as shown in Fig.3. After the arrival of the direct sound a gap must be provided, which is free of reflections. Subsequently more and more reflections appear. Reverberation starts. The purpose of these results is the control of disturbing reflections and their avoidance by acoustical measures both in studios and in home living rooms /14/15/.

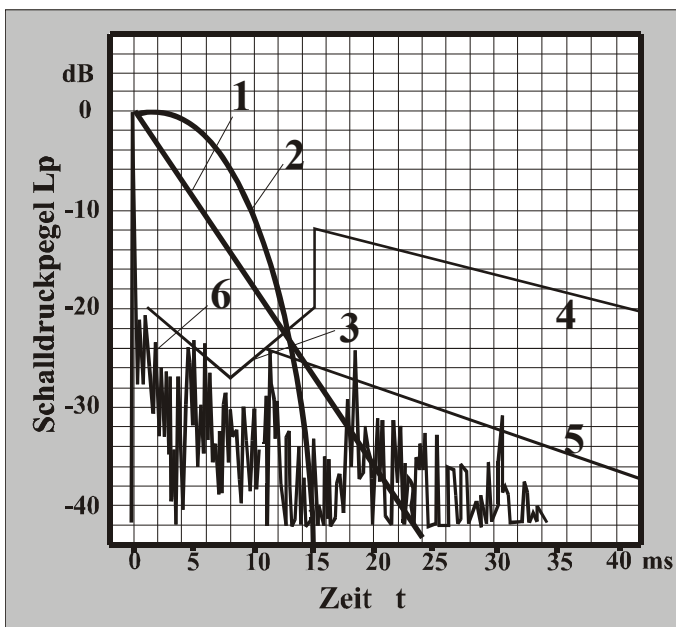


Fig. 3: Sound pressure level at listener's position in a control-room of a recording studio

1: Sound of a violin/ 2: First, very early reflections/ 3: V-Criterion/ 4-5: Permitted range of reverberation for different test (e.g. more reverberation) /6: Room impulse response, measured with TEF

In 1954 when Gravesano was opened, Hermann Scherchen had surprised his guests with a stereo reproduction and 20 speakers in the ceiling to create a room impression. Later he used a spherical speaker (150kg) with more than 20 single

systems irradiating the sound equally while two hemispheres rotate separately with 10 speakers each. Due to rotation it was a mixed vibrating sound, as it was called by the participants. The sound was therefore more reverberant. Reports of listening tests do not exist. Weisse had installed 4 of these heavy spheres underneath the ceiling in the Frankfurt concert hall already in 1954, yet without rotating parts. The intention was to irradiate diffuse sound into the hall. Scherchen later mounted this sphere in a smaller size on top of a low-middle-ton-loudspeaker of a height of 1.5m to provide the control-room with diffusor sound from all directions. This emphasis of diffuse sound had an influence on studio-monitors but also on home Sound Systems with diffusers behind furniture, e.g. located in corners. Harz and Kösters described this control-room speaker with the sphere on top as the best diffusor. They stated: "The acoustical impression is characterized by the gain of a greater spaciousness of the reproduction." /16/

In 1958 the author absolved a practical training during his study at the Technical University of Berlin in the radio station Sender Freies Berlin and was permitted to take part in demonstrations in one of the control-rooms. The big control-room speaker with the sphere on top was shown with one channel reproduction. The question was: Good enough for stereo? Another important studio device was explained: A one third octave filter with pushbuttons for every filter. In the same year 1958, the Albis Filter was advertised in the Gravesaner Blätter /17/. It is surprising that no reaction followed in the Gravesaner Blätter. Any changes within one-third octave bands were an important step forward. Instead, the "Stereophoner" was of interest. H. H. Fantel wrote /18/: "A single effect, however, highlights the importance of this invention: The stereo effect is obtained from monaural sources. Ordinary monaural records and tapes, or ordinary single-channel radio broadcasts are the "raw material" for Dr. Scherchens type of stereophony".

## Artificial reverberation in a dry environment

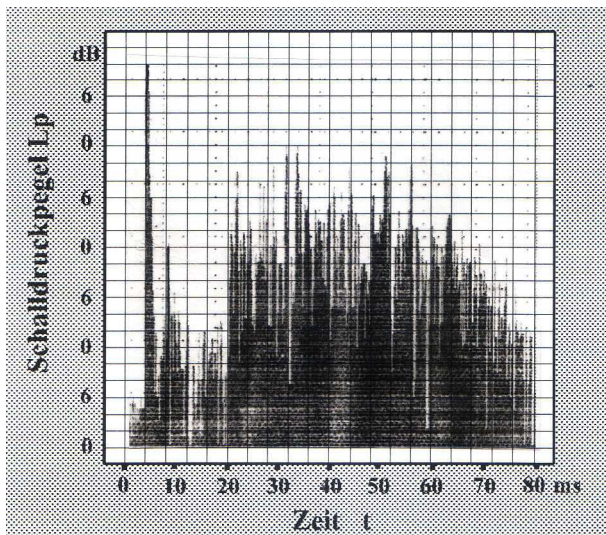
Scherchen has used 4 reverberation chambers and single loudspeakers on many places in the studio, 20 underneath the ceiling. At the listening position D, R and reverberation arrived from all sources due to different distances. Scherchen could not see the time structure. But, he has heard it. The reflectogram in Fig 4 is measured with D, R and later reflections from 100 loudspeakers on the listening place at IAB. Using a crack in front of the microphone and an oscilloscope at the listening position, the reflectogram was preserved. Instead, an impulse sound was used here from TEF equipment (Time Energy Frequency) in accordance with Dick Heyser /19/.

## Unusual

The author was involved in these exciting developments in the sixties. He was impressed and affected by these technical revolutions and challenges. Gravesano had started in 1954 with a studio for experiments, with a great Musician and an excellent Engineer. Hermann Scherchen was a Composer and Conductor and has invented the



Stereophoner, a device to split a monaural signal (e.g. from a Piano) into two stereo signals left and right. For his recordings he used sometimes 10 Stereophoner for the single microphone ways, additionally the multi-track recording. This was still way apart from stereo with M/S technology.



**Fig. 4:** Reflectogram with D,R and Reverberation

The direct sound arrives from one of the stereo monitors followed by a strong reflection after approx. 5ms. This is the gap of V-criterion up to 15ms with weak reflections. Then reverberation starts with around 0,78s. This fairly long reverberation depends on the test, here with much diffuse sound. Many sound engineers prefer the almost non-reverberant room-acoustics.

To follow the scientific way with all the highly motivated inputs and necessary motivations is a challenge. But, the same applies for the music, to be totally involved in feelings, in stories, in melodies and mental dependence. This is what many feel when they combine Art and Science. Hermann Scherchen was a man of this kind. He was big in his musical ambitions. He was driven by technical necessities, which became a part of his musical work. Nobody could provide him with these facilities and with this equipment, to record sound in his own studios with state of the art sound systems. He has put all his reputation and efforts together to reach the top, to have music and technique under one control, to organize both his musical and his technical life. The bridge is small. How to be on top in both lives? Or: Is there the danger to lose on both sides?

The Gravesaner Blätter indicate that in the early days of 1954 Scherchen was very active, especially in basic Electro acoustical questions. He recorded himself on the mixing desk and changed the sounds through careful listening. He alone was able to tune his "Stereophoner". Hermann Scherchen created for the first time acoustical and electro-acoustical sounds in his own studios next to his house. He saw the necessities of combining Music and Technique and was the father of Tonmeisters. The first class began at the Technical University and the Hochschule für Musik of Berlin in 1957.

## References

- [1] Keibs, L.: The outlook of Three-dimensional Broadcasting, Gravesaner Blätter, Jahrgang 6 (1961) Heft 22 S.41-59
- [2] Kolben, R.: Zur Entwicklungsgeschichte des Stereophoners, Gravesaner Blätter Nr. 13 (1959) S. 55-62
- [3] Völker, E.J.: Stereofone Versuchssendung mit 2 UKW Empfängern in Berlin, Sendung des SFB Radiosenders 1956
- [4] Bertram, K.: Kompatible Stereophonie, Radio Mentor 24 (1958) H.9
- [5] Peutz, V.M.A.: Variable Acoustics- Mechanical and electro-acoustic realizations, Centre Pompidou Paris, IRCAM, Institute for Research and Coordination in Acoustics and Music, DAGA (1982)
- [6] Völker, E.J.: Digital and analog audio transmission for a studio and theater complex – plannings, installations and measurements, ZKM, 104<sup>th</sup> AES Convention in Amsterdam (1998) preprint
- [7] Völker, E.J.: Zur Akustik in Orchester Proberäumen-Raumvergrößerung durch verzögerte Schallreflexionen, Fortschritte der Akustik, DAGA Bad Honnef (1990)
- [8] Völker, E.J.: Visiting Bregenz, Discussions with H. Fritz, Tonmeister Big sound system for 6000 people, large control room, partly play back, sound following the different sources on stage, many time delays etc.(2004)
- [9] Völker, E.J.: Visiting Vienna Opera, Discussions with H. Fritz, Tonmeister, small window to the stage, supporting the choir by play back, reading the score by watching conductor's TV
- [10] Völker, E.J., Teuber, W., Bob, W.: 5.1 im Wohnzimmer – zur Akustik bei Mehrkanalwiedergabe, 22. Tonmeistertagung (2002), Tagungsband
- [11] Cremer, L. and Kuhl, W.: Künstlicher Nachhall und erster Rückwurf, Zusammenfassung der Ergebnisse des Colloquiums vom 18.-23.5.1956, Gravesaner Blätter Nr. 5 (1956) 17-20
- [12] Thiele, R.: Richtungsverteilung und Zeitfolge der Schallrückwürfe in Sälen, Acoustica 3 (1953)
- [13] Völker, E.J.: Beeinflussung der Mikrophonaufnahme durch Schallreflexion, Klangfärbung und Aufnahmetechnik, Fernseh- und Kinotechnik Nr. 8 (1974)
- [14] Völker, E.J.: Zur Bedeutung der ersten 15ms bei der Beurteilung von Schallaufnahmen im Regieraum, Dissertation an der Technischen Universität Berlin Nr. D8 (1996)
- [15] Völker, E.J.: Zum Nahfeldhören bei häuslicher Mehrkanalwiedergabe – Ist die Akustik des Wohnzimmers ausreichend? Tonmeistertagung in München, Tagungsband (1998)
- [16] Harz, H., Kösters, H.: Der neue Kugellautsprecher für Regieräume, Technische Hausmitteilungen des NWDR 3 (1951)
- [17] Albis filter, company Albis in Zürich, Voice Frequency Filter, Gravesaner Blätter Nr. 11 (1958) p. 62
- [18] Fantel, H.H.: Visit to Gravesano, Gravesaner Blätter, Nr. 11 (1958) p. 127ff
- [19] Heyser, D.: Acoustical measurements by Time Delay Spectrometry, JAES 15 (1967)