Introduction

When standing back and looking at the various subject matters which have been dealt with at our institute over the past 35 years, one suddenly becomes conscious of historical context. One recognises the slow movement from electrical engineering and electronics to our present-day digital technology. Problems encountered in the 60's have since become dis- tinctly almost incomprehensible. Often, results from the past will today be greeted only by amused chuckling - of course people in the year 2010 may also greet our present-day efforts in a similar manner. In looking back, however, we should not always expect to discover technical "sensations" - especially not where art is concerned! Sensations are short-lived. Their importance quickly fades away and they remain with us only as vague images of the spirits of those past times. For this reason, we will be dealing here only with those research and development projects which were and remain artistically, musically or humanly relevant, and which - most importantly - have left their traces somewhere in musical thought. Certainly we must welcome research which corre- sponds to art; one which enables artists to communi- cate with technicians and vice versa.

Research work done at our institute may be catego- rised according to various themes. Within under- graduate studies, as is customary in Germany, both a mid-yearly and a final diploma thesis are required; in post-graduate studies a single Masters' thesis is re- quired (our department of communication science has been authorized to offer studies at the Masters level since 1979). From 1958 to 1985, before our depart- ment was able to offer official studies at the post- graduate level, we were concerned exclusively with work by students from our own faculty (and also from the field of electrical engineering and somewhat later also from the field of computer science). Al- though communication science is a rather broad sub- ject of study one can, from a practical viewpoint, cate- gorise most work done within our department as be- ing concerned with one of the following areas: electri- cal engineering, electronics, acoustics, computer sci- ence or musicology.

In the approximately 300 thesis titles which have been presented as either mid-study, first- diploma, masters or doctoral dissertations, it becomes apparent that in the beginning - that is to say in the 1950's - work was predominantly concerned with the development of technical equipment.

Examination of thesis reference material also re-veals information about the researchers themselves. As regards personnel, our situation has definitely im- proved over the years: in 1970, five staff members were employed as compared to today's 14 permanent staff and 11 additional members who are involved in third-party projects. As a unifying thread through our almost four-decade history, one recognises the name of Dr. Manfred Krause who, following several years as teaching assistant, was appointed a full professorship at the institute in 1979. He followed Prof. Dr. Fritz Winkel who in 1954 had founded both the depart- ment and the studio. Upon his retirement, Krause became responsible for all research and teaching at the institute and is himself engaged to the field of speech research and studio technology.

In 1970 digital technology and therewith computer science entered into practical research work, and since that time it has step by step replaced practically all analogue techniques. Activity in the area of computer music was initiated at our institute in 1981 through the purchase of a Synclavier II, and was enhanced in 1984 by the acquisition of a VAX 11/780 computer. These acquisitions contributed to a considerable heightening of activity in software development and digital signal processing.

Significantly enough, the first entry in our thesis index of 1958 reads: "Frequency shifter (Siemens)" (additive shifter with two ring modulators). This entry arises repeatedly in our records - along with the ring modulator it gained a certain world-wide popularity among specialists.

A few examples of activities will now be described in more detail and with historical references. These examples are considered of special general interest and have had, for the most part, artistic resonances.

spatial sound - sound spaces

The Osaka Project

At the 1970 Worlds Fair in Osaka, the Federal Re- public of Germany presented music to a world public in a specially-designed pavilion. Between them, some preliminary differences of opinion, agreement was reached to perform predominantly contemporary music. Even as late as the summer of 1969 original concepts for the pavilion underwent changes, but the pavilion's basic architectural design - which had been drawn up by Fritz Bornemann and based on sugges- tions by Karhnecke Stockhausen for a spherical hall - remained in tact. It was decided however, that along with the music of Stockhausen, other contemporary German composers also should be heard. Erhard Greidkopf, Eberhard Schöner, Gerhard Zecher, Brand Alois Zimmermann and Boris Blacher were commis- sioned works.

The initial planning of technical aspects by the Siemens company, which provided for an eight-chan-
Sound-space research

The desire to create sound spaces and spatial sounds in music is enormous. Unfortunately, most projects of this sort have been limited to calculations of intensity, and thereby have generally yielded unsatisfactory results - primarily due to the importance of time-related localisation. Non-real-time calculations, on the other hand, which allow one to take all possible parameters into consideration, yield better and more realistic results. Such systems are employed at our institute (for example in DCM). Following the Osaka project, the institute did not return to making developments in the area of sound-space control until 1985 - except for the realisation of a "movement simulator" which was developed in 1987. Along with intensity calculations this simulator could produce rather convincing Doppler-shift effects. The diploma thesis of Janin Schabtisch concerned a computer-controlled 4 x 24 matrix based on a multiplying DAC. This graphically-supported application permitted the generation and recall of various sound figures which, through sequencing and overlapping, could then be played as a sound-space score. Because switching times were not entirely instantaneous, this concept was abandoned. The other option, namely the use of V.L.A.s, was subsequently investigated. After finding support from outside the university, research in this area - headed by Werner Schaller - led to the creation of a matrix, stand-alone system named the RKS. Also, parallel to the research and development of this comfortable yet expensive solution, another system was being developed by the IRG. This second system had only four channels of sound output but could be produced at much lower cost. The system is easily captured and led by MIDI data which involves MDACs, it excludes the previously problematic switching times (with the use of zero cross detection), for this "MDA mixer", which distributes up to 15 sources to four loudspeakers, Thomas Forlig developed a graphical environment at the ATRAI. Here, spatial paths for the different 15 sources are simply drawn on the screen; paths may be edited and are synchronised to the music in real-time while being shown as moving points on the screen.

A further sound space project headed by Werner Schaller concerns ediphonics as well as orthophonic processes. With ediphonics according to Schiering, a fast sampling of the environment, with electronically-controlled direction characteristics is produced in special stereo intensitiesmicrophones, subsequently decoded signals can be reproduced over any number of loudspeakers. This process does not however seem to deliver satisfying results. Orthophonic on the other hand employs a four-membrane microphone for first-order applications (one with omnidirectional and three with perpendicular-amplitude figure-eight characteristics). As is also possible and common with stereo technology, any three-dimensional direction can theoretically be characterised by the weighting and addition/subtraction of the four microphone signals. A decided advantage of this arrange-
ment lies in the fact that the number of speakers used for replay does not need to be determined until the time of reproduction. An exact replay is possible over any number of speakers from 6 to 32. For better, higher-order orthophonic results necessary microphones also must be developed, and this is a goal of the research as well. Orthophonic signals - even higher-order ones - also can be calculated from mono- phonic sources. In this particular area of orthophone- ticus the novel application of an orthophonic mixer also is imagined.

**Sound visualization**

Even as early as 1947, so-called "visible speech" processes existed. Our institute possesses one of the first sonograms (from the Key Electric company) and employed this not only for speech research but also in the research of musical and various other sounds. Sonograms deliver quasi three-dimensional images of sound with the horizontal axis representing time, the vertical axis representing frequency and degree of darkness representing the amplitude of sound. For certain applications this form of representation is inappropriate or awkward; a second type of solution seemed to be required: a running on-screen representation of sound in real-time.

So came into being in 1979 the first version of the "sonoscope" - a diploma work from Hubertus Becker. As a result of this real-time application, arranged with the use of analogue filters, it was delivered to the Heinrich-Schroedl-Stiftung of the SWF (Southwest Radio), and eventually became known for its many years of faithful service. The sonoscope had at its disposal 21 third-of-an-octave filters in a band ranging from 70 to 3500 hertz. The viewable window as with sonograms) of 2.5 seconds, was made up of 128 samples from the output of the input signal surpassing a selectable input threshold. The image moved from right to left across the screen. Darkness and brightness intensity was represented in 4-bit grey scale (2.5 dB per step). The main disadvantage of the equipment was said to be a certain temperature-related instability and its rather cumbersome filter adjustment.

The use of this technique - namely rendering sound and its temporal structures easily readable - seemed so convincing that in 1987 with the aid of new computer technology and through the development of specially-designed hardware and software, work on the project was taken up again. However, this time the framework of the project was to be concerned with the visualisation of music but rather with that of speech - specifically as a training aid for the deaf. System requirements related to this application in the area of speech analysis were: preemphasis; an analysis band ranging from 50 to 7000 Hz; 10-bit resolution; linear segmentation; the realisation of variable analysis bandwidths according to frequency groups; special considerations concerning differentiation in represent-
logarithmic amplitude scale; the functions copy, paste and move have not yet implemented. New points and tracks may be added by the user at any time. Of course one also may realize a purely synthetic score without the initial use of analysis data at all. Individual points can be numerically edited by hand or displaced through "dragging" with the mouse. Results of an editing session can subsequently be synthesized with the "adiab" program.

In reference to this subject the reader is referred to further CARL-system developments, for example a graphic four-channel 32-track mixing editor (centre-4); a soundfile editor (sofEd); a channel- vocoder (crosyn).

Other Activities

Firstly, in connection with research at our institute, certain cooperations with other institutions and research establishments should be mentioned. A contract of cooperation between the TU and Hochschule der Künste specifies our involvement in the formation of IKG composition students. A contract with the DAAD specifies the accessibility of our facilities to DAAD guests in exchange for which there is financial compensation as well as the right for us to award a four-month stipend in the studio.

Aspects of research also enter into consideration in our planning of artistic activities. At the INVENTIONEN festival - as well as at other international events presented under our direction - there have been numerous symposiums, workshops and publications with research-oriented content. In this manner Berlin also has become familiar on a hand basis with the music and activities of other studios such as INaGR, IRCAM, EMS, STEIM, CARL, Les Ateliers UPic, Studio Basel, ZKM. Among publica-

tions - apart from the INVENTIONEN program books which themselves contain a wide variety of in-
formation and essays on music research - is the pro-
ject and publication entitled the "Documentation of Electroacoustic Music in Europe". The book bearing this title contains data about European studios con-
cerning the production or research and teaching of electroacoustic music, as well as data about works which have been produced or conceived in these stu-
dios. The documentation contains two different sorting Work Lists, and a Studio List with the mailing addresses, telephone, FAX and email numbers of 261 European studios (including 31 in Italy), and with in-
formation about studio equipment and additional spe-
cial notes. The Studio Work List includes 5,991 pro-
ductions from the 55 more major studios. The Composers Work List contains all 8,157 of the docu-
mented works, including works from private studios and "independent" composers which do not appear in the studio work list. An index referencing studios and composers, as well as a list of abbrevia-
tions used are found in the appendix. The documenta-
tion can be ordered through our studio.

(trans. Robin Mutter)

Equipment (excerpts)

Mixer
Soundcraft SB800 (36 / 8 / 2), Case, 2 HiFi-Mix (16/4/2)

Speakers
four K&H QZ2; four OBE; soundcheck: dBbL four F1, two B1

Tape recorder
1-inch M15A 8-t; 1-inch MIO-10-t; optional 8-t PB-head; 1/2-inch M15-4-t
1/4-inch: two MIA 2-t; two Studer A820; TEAC A-3440 4-t; others
Noise-Reduction 20 Telcom, 8 Dolby-A, 4 dBx; Zeta 1-Synchronizer
two PCM 701 with two Unicam, two Beta, Beta-HiF; SVHS HiF

RDT: two Panasonic SV-3700, transportable Sony TCD-D10, AIWA Excelia
Publication 119, 5.1 sec; 2 Drawson M2, 1 Xiof K4 404, EMT 445 (21 sec).

Microphones

MKE

Analog synthesizer SynLab (4 VCA, 5 VCO, 4 JDSR, 2 VCF, 2 RM, 2 S&H, 2 noiseG&F, 2 Env.Follower), 4 DC-Potentiometer-Gebber, 16 MIDI to 12-Bit-DAC

Digital synthesizer
MIDI-devices
Syntec- II (16 voices. Sample to disk, VT 100, 20 MB Disk)
two Akai 1040ST; Akai S1000 (16 MB); Roland A-50; Yamaha DX100;
MIDI-Mixer; 16 MIDI-DAC's 12 Bit; YESS audio-MIDI-Filter; Cooper CS-10

Macintosh

Quadra 950 (36/230 M48), 3 GB ext., ProTools 16 ch, Centris 650 (250 MB), 1 GB ext. ProTools 8 ch. ID (80/32 MB), ESI120 (48 MB); two 40 MB ProDrive, C3-BoM, Personal LaserWrier NTI; Roland CP 40

Mac-Software

DEC-VAX

Mics+VAX 3600, two RA 82 (600 MB), RA 81 (450 MB), Lineprinter LP 26

VAX-Software

ULBS-software
IRCAM-Software
CARL-Software

Chant and MOSAIC

Soundcheck; reverb; Ultras 12; internet; Forth F77; C; XWindow;

Player, phasecorder

ICM Proceedings 1993 321 48.3