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The Delta Stereophony System (DSS) in the City Hall Of Stade and in the Open-Air Theater Trachselwald

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THE DELTA STEREOPHONY SYSTEM (DSS) IN THE CITY HALL OF STADE AND IN THE OPEN-AIR THEATRE TRACHSELWALD

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Abstract: The multi-purpose hall sound system "DSS" introduced to the AES in 1980 (London) and further developed is described now in its newest application in a multi-purpose city hall "STADEUM" which is used for theatre and music performances (in Stade near Hamburg). Another interesting application is the use of the DSS for open-air spectacles for more than 3000 visitors in a beautiful valley in Switzerland (Trachselwald). Methods and results are described.

1. The DSS sound system in the City Hall "STADEUM"

1.1 Introduction

On Sept. 23, 1989, the new City Hall "STADEUM" was inaugurated in Stade (about 60 km from Hamburg, FRG).
Because of the very varied and complex profile of utilization, the building contractor (the City of Stade) decided to use the DSS in order to achieve, in every case, optimum sound quality. The system was implemented between April and September 1989 by Siemens AG with the cooperation of the DSS team of the RFZ who has designed the concept now explained.
Licensing was effected by Elektro-Consult Berlin (DDR).

Notwithstanding the unusually short design and implementation time, all requirements to the sophisticated designed sound system have been met, and after a comprehensive training of the operating staff, the DSS certificat has been granted when the Hall was inaugurated and put into service.

Utilization profile of the "STADEUM", a centre of culture and meetings:

- Theatre, opera and operetta performances (performances by visiting actors, i.e. single performances);
- Symphonic concerts, chamber music performances;
- Pop, rock and folk music performances;
- Broadcasting and television performances;
- Meetings, conferences, congresses;
- Balls, fashion shows, banquets.

The configuration of the hall can be adapted to the specific performances by using a displaceable backwall. According to fig. 1, therewith two versions are possible : a large version (6200 m^3) or a smaller version (about 4000 m^3).
In addition to this possibility, a maximum version is feasible by incorporating also the foyer by removing the backwall.
In this case, the effective volume is about 10 000 m^3.

1.2 Room acoustics

With the room-acoustical concept (Prof.Dr.Maronn, Hamburg) the aim was to reach an upper limit of the reverberation time considered adequate for this purpose, i.e. 1.6 to 1.8 s at about 1 kHz.

When the Hall was realized and the sound system equipment installed, room-acoustical adaptation measures became necessary in order to reach a "harmonization" between room and electro-acoustics. For this purpose, appropriate recommendations were given by the RFZ (K.Huhn).
The results of reverberation measurements effected in the empty hall (auditorium, large version, rows of seats) on Dec. 14, 1989 are given on fig. 2, curve 1.

The result to be expected with the auditory present is shown on curve 2 (calculated) of fig. 2.
The reverberation curve obtained in the stage house, curve 3, appears to be critical for the microphone pick-up and monitoring. With the help of further absorption measures taken in the stage house and in the roof space above the proscenium and by an optimal configuration of the side walls of the auditorium, the room-acoustical conditions shall be improved in such a way as is considered appropriate for the majority of performances where sound reinforcement is needed. Therewith, it is proceeded from the fact that also in concerts, a certain acoustical support (enhancement of spaciousness and prolongment of reverberation) is required for the auditory.

1.3 The concept of the sound system

The complex utilization requirements are calling for a flexible sound system of high quality and technological comfort.
For all hall versions envisaged, the following requirements could only be fulfilled by the use of the DSS:

- Uniform sound level distribution;
- High clearness (Deutlichkeit) and intelligibility;
- True direction and distance-related sound reproduction;
- Inclusion of the auditorium into different acoustical situations by sound field structures of different shape;
- Maximum sound level of at least about 108 dBA which, in case of emergencies, even allows the use of an allowance of 10 dB, i.e. a maximum of 118 dBA.

These requirements can only be realized by means of an area-covering de-centralized loudspeaker arrangement which can be supported by additional loudspeakers in the ceiling of the hall and in the side walls for special sound effects, for enhancement of spaciousness (by means of additional reflections and artificial reverberation) for surround/panorama sound reproduction etc.
As basic solution, the DSS has been used which can be combined with other partial sound systems. Thus, also the tracking of moving sources (singers, moderators) is made possible.

The equipment technique as well as the arrangement of the loudspeaker groups has been chosen such that - if requested - a combination with the loudspeaker boxes is also possible brought along by the different musical groups and artists desiring to create the sound impression they are used to, as "reference sound field" in the stage area and to ensure the required loudness and uniform sound level distribution in the hall by the so-called main sound supply, i.e. the fixedly installed ceiling loudspeakers of high efficiency.

Thus, an important advantage for the benefit of the listener is achieved. The principle of the DSS and the attainable sound level distribution which is still uniform despite of the combined equipment, allows a much smaller sound portion from the stage as is usual with music groups without using the DSS.
The sound level of the "reference sound" coming from the action area - which is decisive for true localization and first timbre impression - may be up to 10 dB below the level of the (ceiling) main sound supply in such a manner that the high loudness and annoyence concentrations in the first rows do not exist which inevitably occur in case of left-right front loudspeaker towers which, unfortunately, are still common practice. /6/

Since the Delta Stereophony System (DSS) has been explained at former AES Conventions from different aspects /1/ to /7/, it shall only be recalled here that the acoustical-physical working principle is based on the useful and practice-oriented application of the precedence effect (law of the first wave front/ Haas effect). By an appropriate dimensioning of the delayed signal portions in relation to the desired number of loudspeakers it is ensured that always the first and thus direction determining sound wave from the relevant original sound source or its simulation arrives at all listening positions and only after that the sound waves coming from the loudspeakers distributed all over the auditorium (which themselves emit all source signals with the same intensity!).
In order to obtain the functional quality and security of the DSS, a careful adjustment of timbre of all loudspeakers is necessary.

Therefore, the high-power subsystems (main sound supply system and reference sound system) were equipped with uniform loudspeaker types (SIEMENS) (DELTA MAX 1122).

For the low-power subsystems (stage edge system, effects system and ambiophony system), the newly designed type DML 2062 has been used for the stage edge and the type S 80 for the other systems.
The positive results achieved have proven this fundamental and consequential approach.

1.4 Arrangement of the loudspeakers

To ensure a uniform sound coverage, the positioning of the single loudspeakers/groups, following an examination of several versions by computer simulation, has been checked taking into account their directional characteristics.
Final adjustment was made with level and timbre adjustment in subjective tests with the help of room correction filters (equalizers).
In fig. 3 and 4, all loudspeaker groups mentioned below are shown.

Main sound supply

- 3 loudspeaker groups each with two boxes superposed (designated with P1, P2, P3) for the main stalls area (front stalls)
- 6 single loudapeaker boxes R1 to R6 for the upper (rear) stall area
- 6 single loudspeaker boxes F1 to F6 for the foyer area
- 2 loudspeaker groups in the mobile portal side towers, left and right to the proscenium. They may be used in a variety of ways, either for main supply or reference sound field in the action area or as near-field loudspeaker for performances on the proscenium (prologue, playback and others) (designated with PS1/1, 1/2, 2/1, 2/2).

Depending on the configuration of the hall (small, large or maximum version) all or only part of the groups can be connected the necessary level assignment being preprogrammed for each case.

Simulation and near-field loudspeakers for the reference sound field

In order to support low-intensity sources on the stage as simulation or (in a time-staggered arrangement) as near-field loudspeakers, 12 single loudspeaker boxes are available. Thanks to their mobility, they can be integrated arbitrarily into the scenery or be used in the foyer or for (studio) performances organized in the stage house. In many cases, the carefully configurated near-field may also assume the task of monitoring for the artists.

Stage edge loudspeakers

For this purpose, 7 compact small-sized single loudspeaker boxes (DML 2062) are available which have been especially designed to adapt the timbre to the main loudspeaker groups (DML 1122). They can be disposed either at the proscenium edge or - with lowered orchestra pit - attached to the front side of the orchestra pit. They ensure good sound coverage of the first rows in addition to the source simulation loudspeakers and enhance clearness and localization definition.

Woofers

For the low-frequency range below 120 kHz - which is not permanently necessary - four special woofers (SH 1800) are available wich, in normal case, can be disposed within the stage area left or right or in front of the portal side towers.

Monitoring system

By the use of the DSS, the number of purely monitoring loudspeakers - as has been mentioned earlier /6/ can be minimized. In those cases where nevertheless an additional sound reinforcement for individual artists is required, up to 5 special monitor loudspeakers can be disposed (FM 1202 which in respect to timbre is largely equivalent to type 1122).

Sound effect system

Since, due to the outward position of the side walls, there are nearly no natural lateral reflections becoming active for the auditorium, it will be necessary in many cases to add additional artificial reflections derived carefully from the microphone signals. This is done via the system of 16 effect loudspeakers E1 to E16 (S 80). They allow, moreover, the reproduction of certain sound effects (for instance with experimental and electronic music) or for surround sound using appropriately controlled connections.

For prolonging the reverberation time and generating diffuse-ambient sound structures, the ambiophony system is used consisting of 25 compact loudspeakers (A1/2 to A12/2) S 80, which are statistically distributed over the ceiling area and are controlled in groups (because of sound incorrelation and safety for failure).
If required, both systems can be interconnected.

The equipment and technology used

The block diagram of the signal paths of the sound system is shown in fig. 5.

The arrangement of a mixing console in the hall at the acoustically most favourable position is essential for a correct supervision and control of the sound system functions,

especially also in case of use of the DSS, in order to be able to track for instance the movements of single sound sources acoustically in correct conformity with the original.

For the equipment used in the STADEUM - taking into account the requirements of the building contractor aiming at minimum impairment for the auditory in the hall - the following solution has been chosen:

A sound mixing console with digital control allows the installation of the purely control/operating devices (in form of a compact remote control unit) at an optimal position in the hall and the accomodation of the functional units (in analogue technique) for sound signal processing, such as level setting, mixing, filtering, compression, limiting etc. in racks or in a complete sound mixing console installed in the control room above the hall (see fig. 3, longitudinal section). Moreover, it appears useful to accomodate also all operating elements for the computer-controlled matrix, an audio frequency analyser and corresponding special filters designed for a correct filtering of the audio signal, and the necessary audio-visual control devices in the hall remote control unit designed for the sound channel processing units, and also the CD players, cassette players etc. which can directly be handled for synchronuous play-back tasks.

In the control room, besides the large sound mixing console, also the functional units for all sound signal distributors (matrixes, cross switchboards), remote-controllable studio magnetic tape recorders, digital delay units etc. are installed. There, premixing, own productions and many other monitoring tasks can be done which must be carried out independently and/or without being disturbed by the events going on in the hall. Depending on the complexity of the performances, the sound reinforcement and reproduction tasks can be accomplished by an operator in the hall or in team work from the hall in common with the control room.

The use of several computer systems enables an efficient operation of the equipment by means of preprogrammed set-ups;

- Computer-assisted setting of the individual parameters of the sound channels and scene-by-scene setting, storage and recall of complete mixing console set-ups;
- Computer-assisted summing, distribution and level alignment of the delayed signals to the loudspeaker groups by any single settings as well as of complete groups;
- Computer-aided determination of the optimized delay times of all loudspeaker signals by means of the "DELTA" computing program, as a function of scenic requirements;
- Computer-aided tracking of single sound sources by level adjustment by means of the trackball controls;

(the DSS processor DSP 610 - AKG /5/ which is also suited for this purpose, could not be used in the STADEUM for different reasons at the required date, especially because of the great number of sound channels required).

In particular, the highly variable interconnectivity of the whole equipment system, of the microphones, the line-level signals (via split amplifiers or split transformers for additional signal supply for broadcasting, television and film) via jack plugboards and matrixes can be seen in the block diagram.

The separated sound signal processing for the main sound supply and for the reference sound field is ensured by a subdivision of the delay time units and matrixes.

Each loudspeaker group has its own equalizer, controller and power amplifier so that a careful adjustment of timbre and level is possible.

For the connection of a sufficient number of wired or wireless microphones and high-level sources, a widespread network is available between the performing areas and all technical rooms and with the terminal board for the remote control units in the hall.

2. Use of the DSS in the Open-Air Theatre Trachselwald

2.1 Premises and architectural conditions.

In the summer months of the years 1988 and 1989, the historical drama "The black spider" (adapted from a short-story by Jeremias Gotthelf) was performed in the natural open-air theatre Trachselwald in Emmental (Switzerland) which was especially set up for this purpose. The architectural and dramaturgic dimensions of this mise en scène could only be realized with the use of the DSS. The scenery was divided into the following areas which thus required different dramaturgical and consequently different acoustical treatment (see fig. 6):

- The lateral fixed position (Q1) of the narrator accompanying the whole performance;
- The large performing area (Q2 to Q8) in the foreground and background of the scenery (dimensions about 80 m x 80 m);
- Two remote positions (F1 and F2) for effect and noise reproduction (maximum distance up to about 300 m).

The audience area was "embedded", so to speak, in this valley in form of a large tubular steel tribune (dimensions about 30 x 50 m^2, more than 3000 seats).

2.2 Sound system concept and arrangement of the loudspeakers

The performing area has been subdivided into eight main action areas in conformity with the principles of function of the DSS which each wereequipped with own source loudspeakers QS1 to QS8 made invisible to the spectators by skilful hiding.

The reference sound field built-up from these source loudspeakers to ensure exact sound source localization was supplemented by a de-centralized system of 12 or 18 distributed coverage loudspeakers (loudspeaker groups B1, B2, Z1...Z8) disposed in the auditorium (more than 3000 seats) in conformity with the principles of the DSS so that a uniform sound level distribution (deviations smaller than $\pm$ 2.5 dB) free of echoes with high intelligibility in the whole large-area auditorium was garanteed.

The use of fixed-position microphones was practically excluded because of the large geometrical dimensions, the actors being unable to keep to designated positions during the frequently turbulent scenes, and because of acoustical disturbances being unevitable in the open air (wind noise, natural noise).

The sole condition of the DSS for the actors who were equipped with 12 wireless microphones and who could freely move within the whole performing area, consisted in orienting in their large-space movements to this established source areas and avoiding (longer)stayings at any intermediate positions in order to enable optimal acoustical tracking with the help of the DSS and to ensure at any time coincidence between optical and acoustical perspective.

Important integral part of the mise en scène were also the more than 70 effect and noise play-back reproductions (beginning with the musical leading motif separating the different scenes, through the background noise supporting the dramaturgical intentions up to the naturalistically impressive thunderbolt in original intensity) which were offered under different spatial-acoustical perspectives.

2.3 Technical realization

The solution of this sophisticated sound system requirement made necessary the use of high-efficient audio equipment supplied by J.Dudda AUDIO-SERVICE, Berg.-Gladbach/FRG.

- Studio multi-channel mixing consoles (the 32 channel console employed was used up to the last channel);
- DSS-related processing of the sound signals by means of digital delay units as well as the DSS signal matrix supplied by the licenser;
- high-efficient, high-power loudspeaker stations of different but sound-compatible type (the types UPM, S 500, MSL3/System MEYER-SOUND were used) equalized by high-variable filters as a function of their positions.

- and finally a widely branched intercom system for the various working places (sound control, lighting control, action area, remote stations).

The computer-aided dimensioning as well as the acoustic-technical support up to the première was ensured by representatives of the licenser. For the optimum installation of the sound system using all functioning advantages of the DSS, close and cooperative collaboration between the director, the actors, stage technicians and the sound system team was an essential prerequisite during the preparation of the mise en scène. In doing so, the project "Black spider" evolved to be the largest use of the DSS in a scenic performance hitherto ever made.

Legend

Fig.1 Ground-plan of the whole Culture and Congress Centre of "STADEUM"

Fig.2 Reverberation characteristics of the theatre hall in the "STADEUM"

Fig.3 "STADEUM" -Ground-plan of the theatre hall

Fig.4 "STADEUM" - longitudinal section of the theatre hall

Fig.5 Sound signal block diagram Culture and Congress centre "STADEUM"

Fig.6 Map of the DSS arrangement for the theatre play "The black spider" (open-air theatre Trachselwald/Switzerland)

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- AKG Acoustics, Vienna
- Audio Service J.Dudda, Berg.Gladbach
- Siemens AG

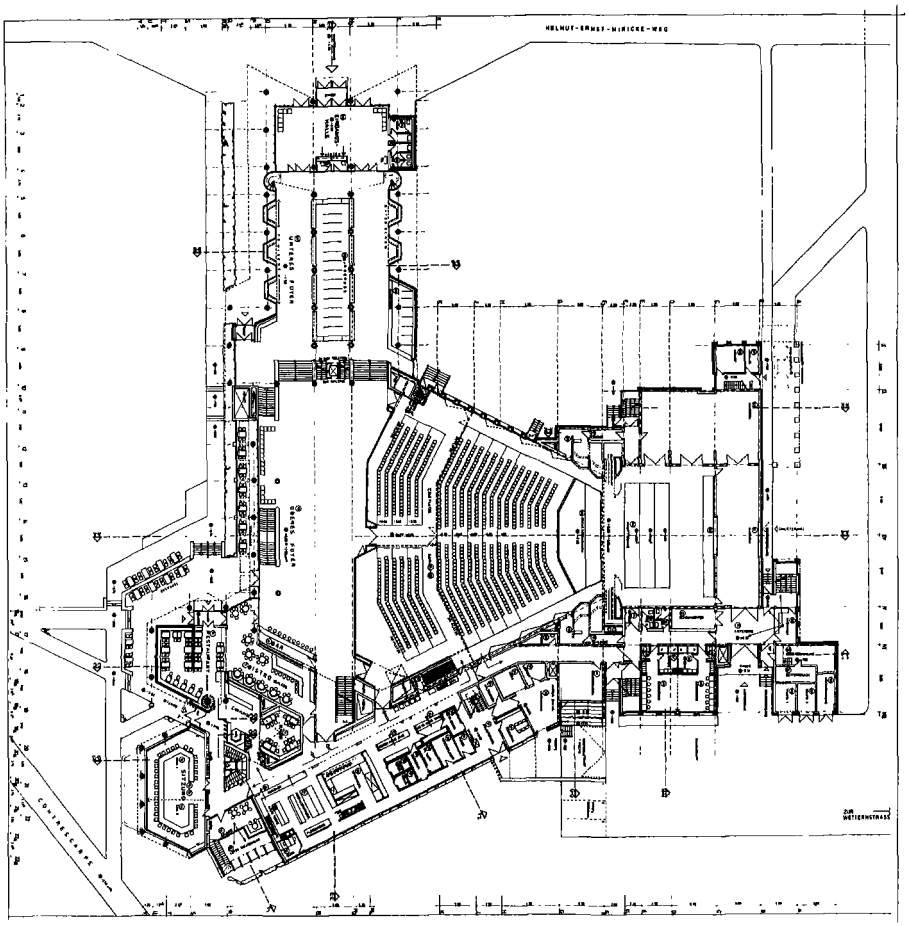

FIG. 1

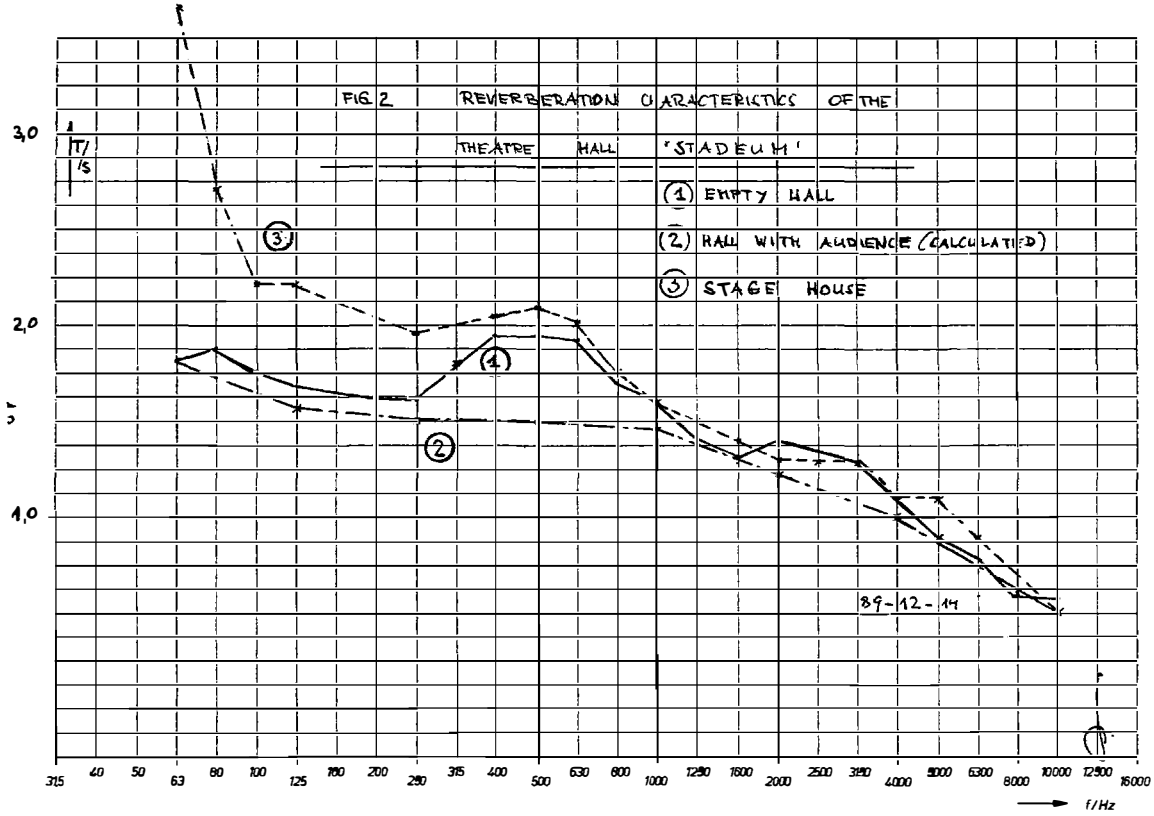
FIG 2 REVERBERATION CHARACTERISTICS OF THE
THEATRE HALL 'STADEUM'
(1) EMPTY HALL
(2) HALL WITH AUDIENCE (CALCULATED)
(3) STAGE HOUSE
T/s
3,0
2,0
1,0
89-12-14
315 40 50 63 80 100 125 160 200 250 315 400 500 630 800 1000 1250 1600 2000 2500 3150 4000 5000 6300 8000 10000 12500 16000
f/Hz

FIG. 2

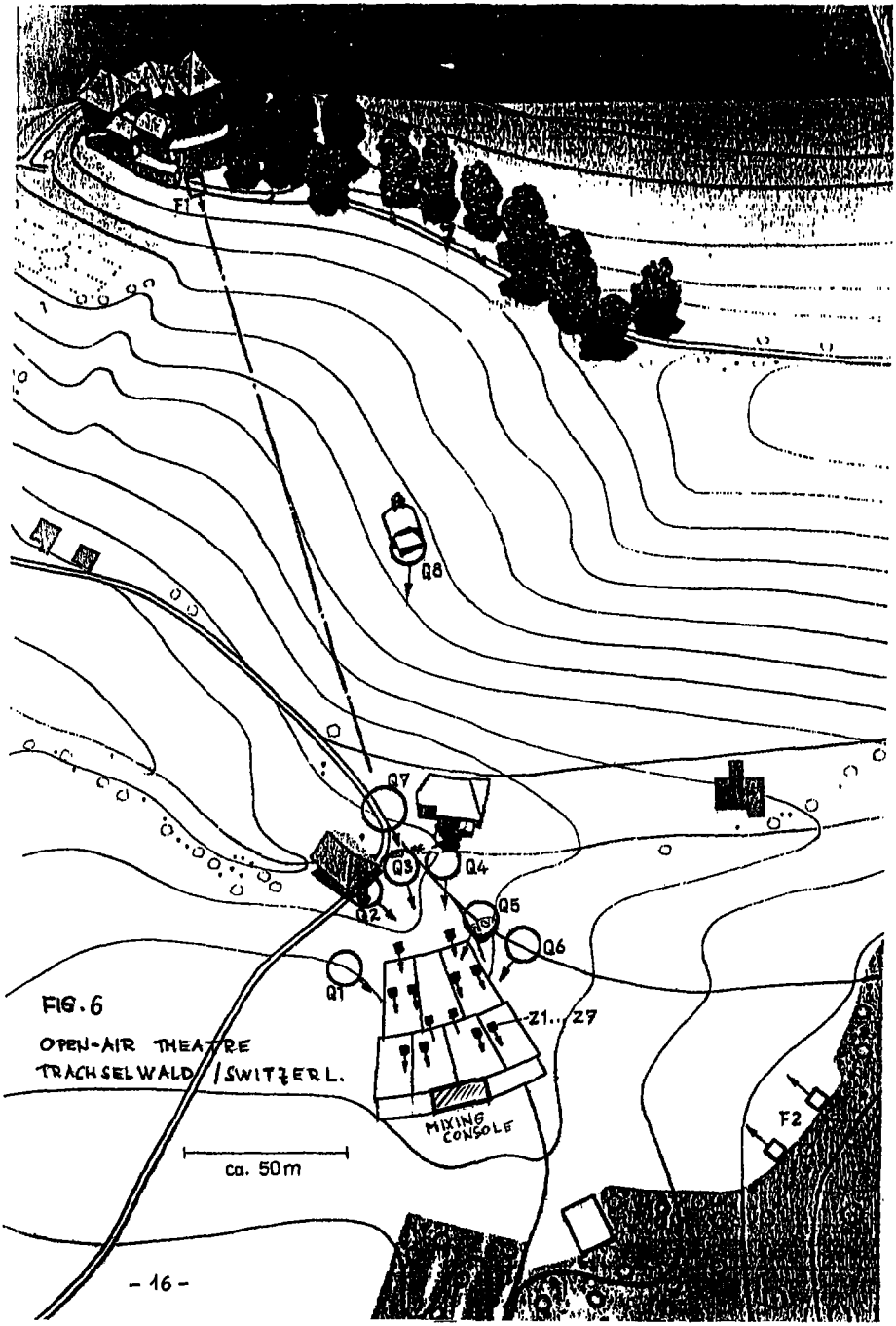

FIG. 6

OPEN-AIR THEATRE
TRACHSELWALD / SWITZERL.

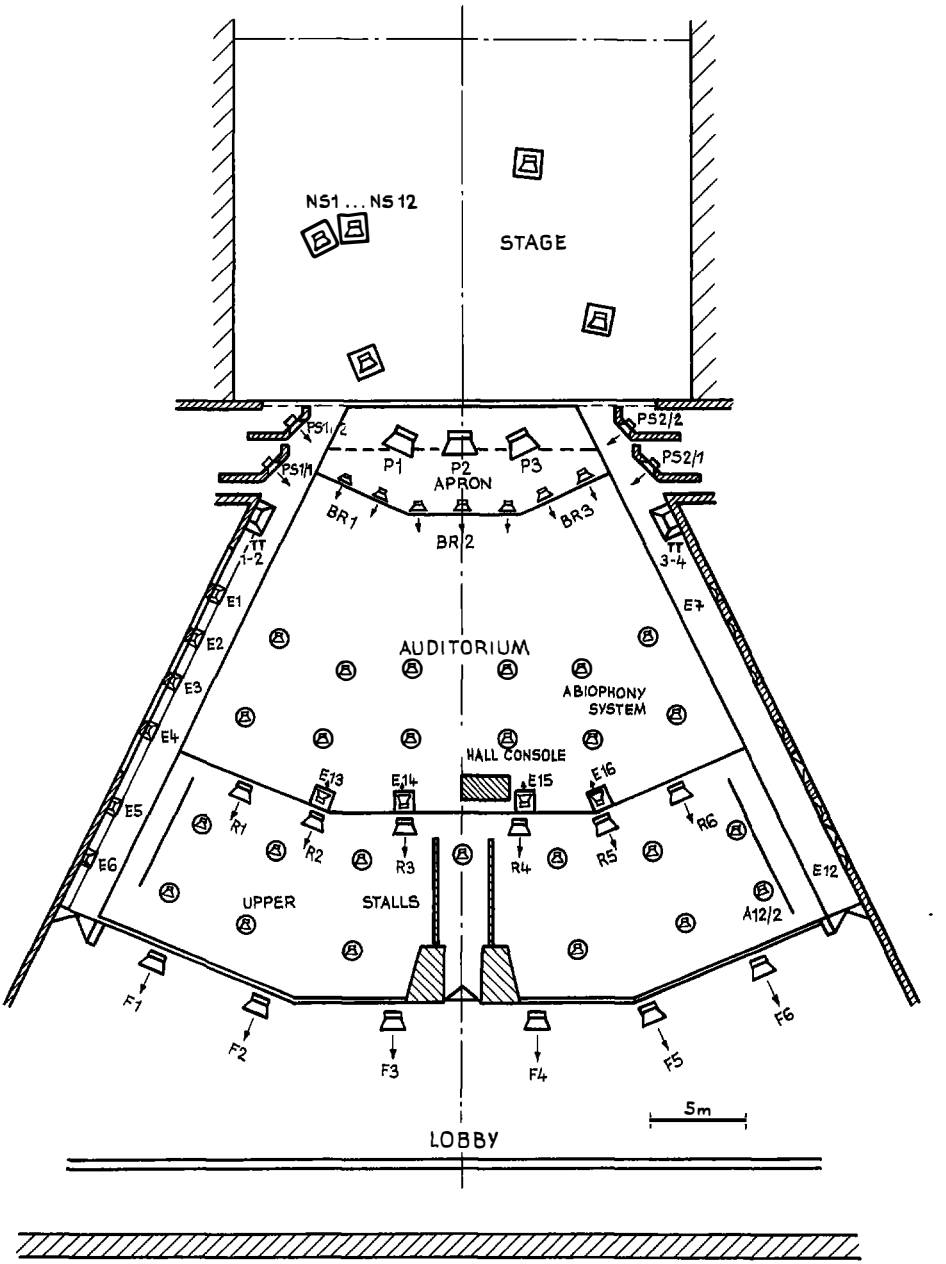

FIG. 3 STADEUM GROUND - PLAN OF THE THEATER HALL

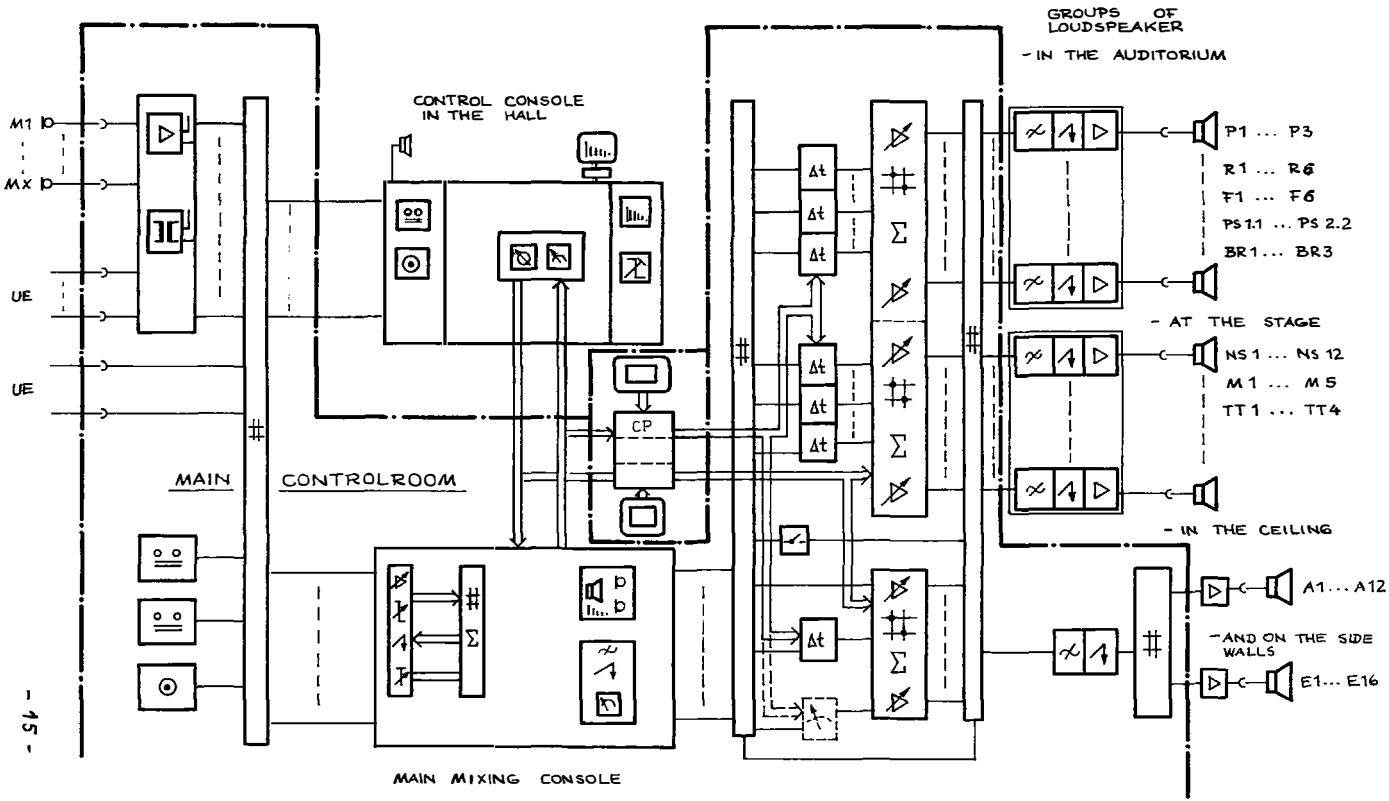

FIG. 5 SOUND SIGNAL BLOCK DIAGRAM
CULTURE AND CONGRESS CENTRE „STADEUM"

FIG. 4

STADEUM – THEATER HALL

LONGITUDINAL SECTION