# Room Acoustics for Eurovision Song Contest 1990 in Zagreb

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**Historical Perspective**

In 1990, ASC was contacted by the Croatian TV audio engineers who ultimately wrote this paper. Needless to say, we were flattered that they wanted to use our TubeTrap product for what amounted to the equivalent of the Miss America Pageant. The engineers, however, being from Yugoslavia during the period of socialist rule, had little to no money. ASC proposed to sell them our TubeTraps at cost in exchange for free TV advertising. That almost happened, but the engineers opted to build their own inferior version of the venerable ASC TubeTrap.

ASC is presenting this AES paper because we are proud of the technical achievements documented in it. With the addition of TubeTraps, the large music hall with a long reverb time was successfully converted to a television production stage. The orchestra used distributed bass traps (essentially the StudioTrap technique) to get control on sound levels and balance, facilitating multiple mic setups with low bleed levels.

The absorption curves of the Croatian TV version of TubeTraps, what they like to call “cage absorber”, was measured out in the open at 0.6 metric sabines, about 50% absorption coefficient flat from 63 through 4000 Hz. The units were not corner loaded nor did they have the midrange reflector installed. Our precursor, the “functional absorber” built in the 1950’s by Dr. Harry Olsen of RCA labs measured efficiencies of about 150% in the freefield.

**Abstract:**

The paper deals with a novel solution for temporary acoustic treatment of a reverberant concert hall which had had to serve as a live TV show studio for the Eurovision Song Contest 1990. The use of novel modular “cage absorbers” theretofore, the design philosophy and the TDS measurements in the finished hall will be presented and discussed.

**Introduction:**

The Eurovision Song Contest is a yearly television show-programme of the Eurovision Broadcasting Union (EBU). The show concentrates and presents a choice of pop-songs from some 20 countries—members of the EBU. The domicile of the contest moves every year, according to the EBU rules, to the country which was the winner of the precedent contest. For the year 1990 the Croatian Television in Zagreb was in charge to organise the show, to produce it programmatically and technically and to transmit it live to all the EBU members as well as to the other television companies which had wanted to take it over.

For such a complex project a huge TV studio is necessary along with numerous ancillary facilities. Therefore the appointed TV company usually rents a space and adapts it temporarily into a big TV studio, comprising a modern show scene with a vast auditorium, and a lot of smaller enclosures for different purposes (wardrobes, press-centre, technical and control rooms etc.).

While the other companies, at least in several preceding years, used some convenient easy-to-move-in enclosures such as grand sport halls or fair pavilions, the Zagreb television authority had decided to rent a symphony hall. And so, the concert hall Lisinski in Zagreb, well known to many artists and visitors not only in Yugoslavia, had given its hospitality to such a typical pop-music, media-orientated spectacle as was the Eurosong ’90.

This fact generated a difficult but challenging task to the appointed acousticians’ team which was constituted of local engineers specialized in room acoustics, and affiliated with the Croatian RTV company and the University of Zagreb.

The date of the Eurosong ’90 final performance was set at May 5, 1990. In this text, every relevant prior date is cited as a negative number, meaning the number of days before the event, thus: Day -12, for instance.

**The Lisinski Hall**

Lisinski Concert Hall, opened n 1974, is a purposely made building. The main hall has almost 20.000 m3 of volume and is intended mostly for musical presentations ranging from symphonic and organ music to various recitals. It is at its best, though, with classic and romantic symphony concertos, thanks to its somewhat exaggerated reverberance. In Fig. 1 the reverberation characteristic as measured with three-quarters-filled audience is shown. Its high mid-frequency reverberation time of 2.2 s (at 500 Hz) hardly has any competitors among world famous concert halls, as per Beranek [1].

The hall’s parqueted floor has a central horizontal portion, then it raises to one side gradually with the raked seat rows, and to the other side with the orchestra platform and additional choir steps. Behind the choir steps, the grand organ opening can be covered by means of a sort of harmonica-door 8 m high and 13 m wide. Both side walls are wood paneled, the panels being fixed to concrete walls by means of wooden strips and backed with a common fibrous absorber. 141 wooden splays, made of obliquely broken 25 mm panels, are fixed to the wall paneling. On the rear wall, the “Copenhagen” stripped absorbing treatment is brought. The upper part of the rear wall is plaster finished and contains a long horizontal line of windows for hall’s technical services such as lighting, sound cabin, some commentators’ cabins etc.

The inner constructive ceiling carries 12 big hanging reinforced-gypsum reflecting splays, ranked longitudinally from the organ opening back to the rear seat rows (Fig. 2). All the wood paneling is chestnut veneer finished.

The seats are modestly upholstered and textile covered. The number of seats totals 1851.

The maximum (visible) dimensions of the hall are: length 53 m, width 38 m, and height 15 m. All the three dimensions are at their maximums in the middle of the hall, roughly at the intersection of the three symmetry planes.

Quite unusually and courageously with respect to the statics, the main hall’s floor lays on the third storey of the building. This appeared to be the main limiting factor for per se heavy television equipment and constructions.

**The TV equipment implantation**

According to the rental contract with Lisinski, Croatian Television had exactly 68 days left to move-in and move-out of the hall building. The bitterest snack was the main hall. Here is what it had to suffer for the sake of “Eurosong ’90.”

The scenery shell should occupy the entire front half of the hall, the stage platform covering some 450 front seats of the auditorium. The stage platform should comprise a vast plane area (for solo artists and accompanying groups), backed and bottomed by various lighting effects, and completed to the right side by a stepped podium for the 62 member orchestra. The original front and front side walls should be hidden by a tall, specially designed scenery walls containing the light lines and two Vidiwalls. In addition, from the front gypsum ceiling a battery of some eighty light bulb reflectors should be hung for running light effects.

The rest of the auditorium should further be overbridged by an iron-tube structure to carry some 15 spotlights. Another bridge should be constructed over the rear 3-4 seat rows, containing 28 additional commentators' booths. Still more smaller seat areas at the rear should be replaced by two big consoles, one for the on-site sound reinforcement system and the other for the overall lighting control.

In such a way more than 1.000 seats were sacrificed, and so many sound absorbing visitors, too.

It can be clear now that the quite reduced area for the would-be-implanted sound absorbers has been left. And yet, the average reverberation time should be set as close to 1,0 s as possible for a proper sound pickup [2], [3], [4]. This is a must, because—as put by Mr. Gerard Billeter of SSR, Swiss broadcasting company which was our direct predecessor in organizing an Eurosong spectacle: "To my personal opinion, this is not the European Song Contest, but the European Sound Contest."

The Lisinski Hall had to have degraded its acoustics for one more reason: placing the sound sources right in the middle of the hall had outperformed its established acoustical geometry since all the reflection paths have got new origins and a new, much worse distribution.

**Acoustical design philosophy**

The room-acoustical task was obvious:

- to control the newly established reflection paths,
- to lower substantially the reverberation field level,
- to separate the louder sound sources from non-belonging microphones,
- to apply as effective acoustic elements as possible,
- to prevent any damage of the hall's fine interior.

The co-work with the sound-system team generated the use of very directive loudspeaker clusters, as well as the carefully chosen stage monitors. In such a manner the whole of room acoustics could be solved only by appropriate absorbing elements. These elements should be:

- extremely effective,
- lightweight,
- quickly but securely installable (and detachable),
- possibly wide-range in frequency characteristics,
- fire protected,
- cheap.

The preliminary analysis showed that standard absorbing treatment, which combines the bass, mid- and high-frequency range units, would require about 4.500 m2 of hall surfaces to cover with. This should be definitely unfeasible under circumstances. Besides, the overall weight of such acoustics would surpass the permitted values by a factor of 10!

Luckily enough, a local production of polyurethane, foams sponsored the Eurosong '90 with 1.500 m2 of corrugated "acoustic foam" having the lower limit of absorption around 250 Hz. But the problem of mids and basses persisted.

The only apparent solution was to apply Tube Traps a highly effective product based upon the Olson's "functional absorber" [5] complemented with Noxon's theory of the sound-pressure-gradient absorption [6]. So we came into contact with the European dealer of Tube Traps. But unfortunately his offer had to be refused due to the limited budget, apart from the fact that the necessary quantity of Tube Traps (nearly 800 pcs.) substantially exceeds the total weight of absorbers allowed by the statical expertise.

And so, the acoustical design was still at its beginning on the Day -70.

**The Cage Absorber**

The acousticians' team wouldn't abandon the pressure gradient absorption principle. By fortune, considerably lighter materials with needed physical properties (specific mass, flow resistance, porosity, fibre structure) have been found at the home market, and this enabled a new absorber construction. After several feverish days of measuring, computing, designing and discussions with a manufacturer, the 30 prototypes were ready for absorption measurements inside the reverb chamber. The resulting octave-frequency absorption characteristic is shown in Fig. 3.

As there was no time left for closer investigation s of absorber properties, the contract with the appointed manufacturer has been signed for 850 pcs of so named "cage absorbers"; the quantity contained a reasonable safety margin.

Meanwhile, on the Day -40 the Television teams were allowed to begin works in the Lisinski hall, and only 6 days later, i.e. on the Day -34 the first amount of 150 cage absorbers was delivered at the Hall entrance ready for installation, together with the polyurethane foam stock which had been ordered earlier.

While at the time of writing this paper the patent application has been still under Yugoslav Patent Office's investigation, the author had not been empowered to disclose the internal construction of the cage absorber. The appearance of the device is presented in Figs. 4 and 5.

Having comparable absorption to the Tube Trap of the similar size, the cage absorber weighs only 4,5 kg compared to the 7,5 kg Tube Trap weight.

**Installation problems**

Both cage absorbers and foam panels had been prepared for simple hanging anywhere in the hall and interior, by means of suitable hooks, cords and other accessories. Due care has been taken to secure each fixing place from unfastening and falling down of elements. Every element and fixing part were made fire protected, according to the regulations.

The reader could now expect some sort of design mathematics, mounting schemes, position drawings and alike. Unfortunately, the only possible approach was to apply the simple Sabine formula and the acoustician's good nose (and ears, of course). There were so many limitations and uncertainties caused by many different professionals in the hall assembly that the only principle to adopt was: find a place, hook an absorber before somebody's other device appears, and be happy. Afterwards, verify your results by measuring.

The hooking job has been done literally by Alpinistic virtue since neither time nor physical possibilities had allowed any sort of scaffolding. Figs. 6 and 7 depict typical assembly views on walls and ceiling. In any case the overall distribution of absorbers has been made fairly scattered except for two zones: firstly, the walls of the scenery shell where the scene architect wouldn't permit any strange objects to disturb his artistry, and secondly, the central-highest portion of the ceiling which was by no means accessible, even to Alpinists.

In Figs. 8 and 9 the final groundplane-projected positions of cage absorbers (675 pcs) and polyurethane linings 222 m2) are shown.

It is now worth mentioning the role of 35 additional cage absorbers which were put standing, in collaboration with sound engineers, onto the orchestra podium. Up there, these units formed a sort of isolating/absorbing partitions to separate louder instruments or groups (drum kit, trombones, trumpets, percussionists) from the microphones of the more tender instruments. The result was obvious and helped both orchestra director and chief sound engineer to establish an excellent tonal balance (see Fig. 10).

**Measurements and "tuning" of acoustics**

Due to the lack of consistent design procedures, the acoustical measurements have got the prime significance in achieving the preset parameters. For this purpose, a TEF System 12 Plus Time Delay Spectrometry set was a valuable tool. Its output has been connected to the inbuilt PA system of the Hall, or alternatively to the performers' stage monitors, as appropriate.

The control measurements, intended also for the "tuning" of the hall acoustics, were undertaken on the Day -10, while the final measurements took place on the Day -2.

**The control measurements showed the following:**

Firstly, the strong, high-Q upper-bass ringing has been noticed (Fig. 11). The only probably source of this ringing appeared to be the broad stage platform with no dampening underneath. In subsequent days the 76 cage absorbers and 56 m2 of polyurethane foam have been brought under the platform and there evenly disposed. The final measurement confirmed the correctness of the diagnosis, and Fig. 12 shows that the bass ringing subsequently sunk into the overall reverberation field.

Secondly, the mean reverberation characteristics roughly confirmed the calculated values of brought-in absorption in the hall. By this time, the empty hall's RT of 2,7 s fell down to around 1,6 s.

Thirdly, the inspection of measured ETC curves showed some strong spurious reflections and 17 precise positions of "hot spots" on the walls and ceiling were identified with respect to the two key positions of interest: a) the position of the soloist microphone on-stage, b) the seat of the sound reinforcement Tonmeister.

Unfortunately, only 9 out of 17 "hot spots" were accessible, so that 7 cage absorbers and 2 foam panels could be hung at these spots. The efficacy of this procedure can be proved e.g. by comparing the ETC diagrams taken on the Day -10 (Fig. 13) and Day -2 (Fig. 14) at the same position of the solo vocal.

If we look at the Fig. 13, the two almost equally strong reflections are apparent after the direct sound, the first one delayed 58 ms, and the second one 128 ms. These time delays correspond to 20 m and 44 m distance differences, respectively. By tracing the possible paths in the space one finds the exact location of a "hot spot" in a reflective partition and after such a treatment the first strong reflection has sunk some 8 dB (relatively) and the second one 12 dB. (The differences in the overall flow of the ETC curve can be attributed to the growth of the devices of TV technology brought in to the hall in the meantime.)

For the sake of a broad survey of the attained hall acoustics, the measuring microphone has been successively set to 10 different locations throughout the hall. The TEF 12 Plus has evaluated plenty of data but we have chosen for this presentation just the reverberation time octave-bands characteristics (see Fig. 15) because they can give the closest comparison with the early 1974 measurements from Fig. 1. Yet, comparison of the two isn't quite visibly possible since on the Day -2 we had no audience. We believe that the hall on the Day 0, during the show, had its RT500 close to 1,1 s, thanks to the absorption of some 820 visitors, 62 orchestra members, average of 4 performers and the numerous technical crew in the hall

**The rest**

Several small rooms which needed an acoustic treatment have been built or adapted for different purposes, namely:

- main television control and switcher,
- final sound control room,
- switcher for the telephone voting of EBU members' juries,
- viewing and listening of rehearsals for performers,
- TV interview studio.

But, since it was a routine acoustical job, it will not be discussed here save by the fact that cage absorbers did a very good job in these enclosures thanks to their ability to control room modes.

**Instead of conclusion**

When the show was over, a close final analysis showed that the cage absorbers alone could entirely fit the absorption needs and replace combined standard absorbers. If for comparison we put 100% for a standard wall treatment with approximately same amount of absorption than the cage absorbers are at:

- 35% of price,
- 10% of weight,
- 20% of partition surface that they occupy.

One unit of cage absorber cost Croatian Television the equivalent of 98 DEM or approximately 65 USD. Besides, the whole quantity has been applied after takeout from Lisinski Hall in our everyday studios and control rooms.

**Acknowledgements**

The authors wish to thank Messrs. Mladen Škalec and Stevan Sučević, technical producers of Eurosong '90, for their continuous support during the almost one-year efforts.

Thanks are also due to our colleagues in the acoustical team: Prof. Dr. Branko Somec of Electrotechnical Faculty in Zagreb, and Mr. Hrvoje Domitrović, Croatian Radio.

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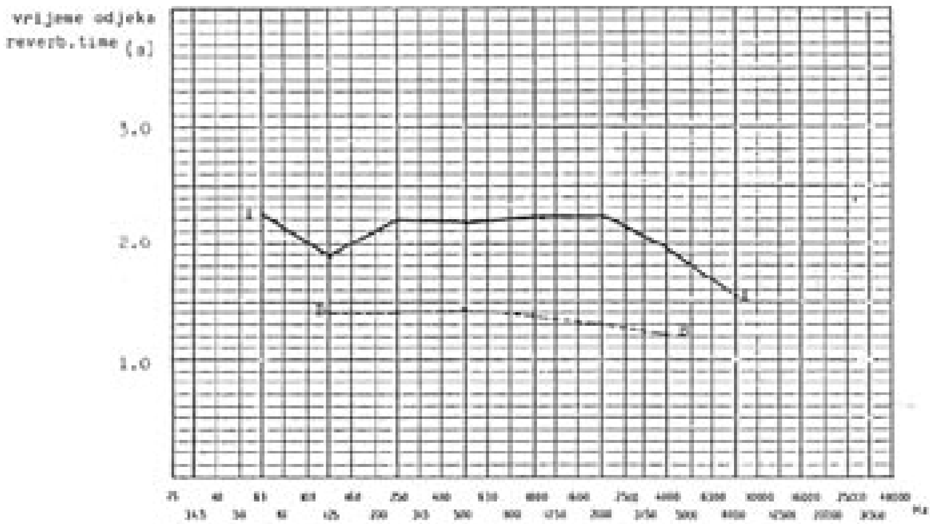



LISINSKI CONCERT HALL, ZAGREB

A - measured Sept. 8, 1974, 75% audience, standard setup

B - measured May 30, 1990, empty hall, setup for Eurosong '90 with additional acoustic treatment

Fig. 1.

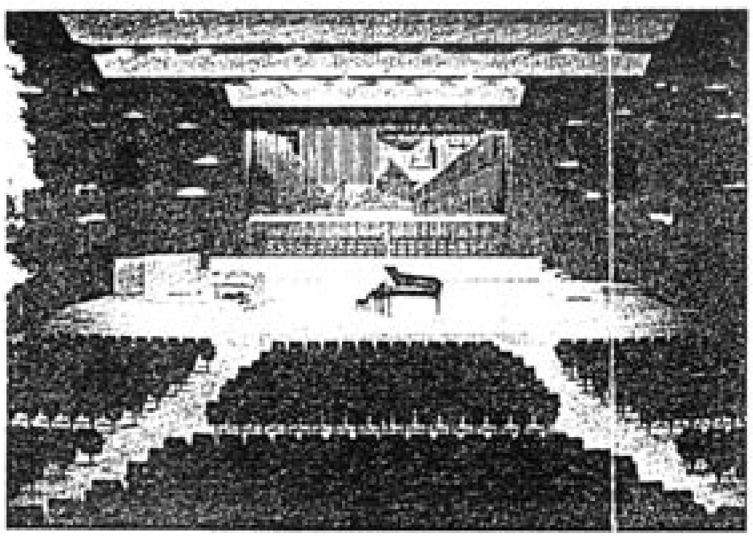


Fig. 2. Lisinski hall interior

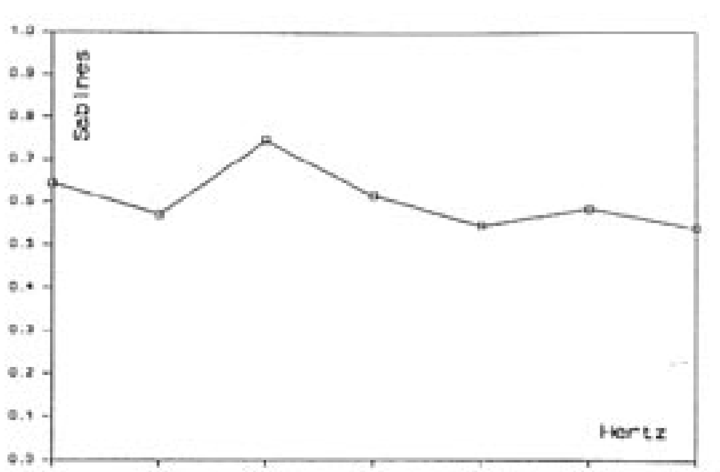
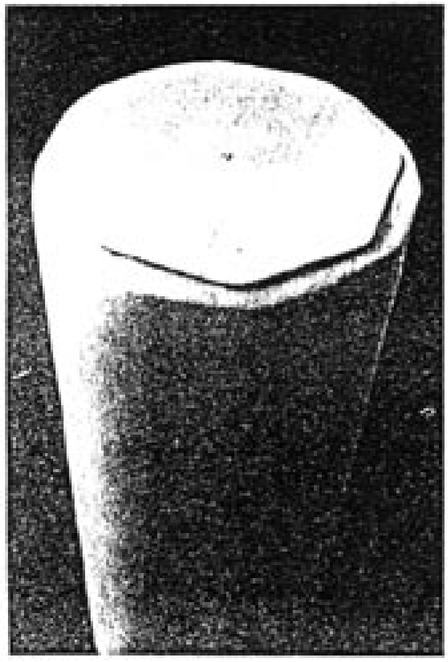



Fig. 3. Absorption per one cage absorber unit



Figs. 4. and 5. Cage absorbers look-out

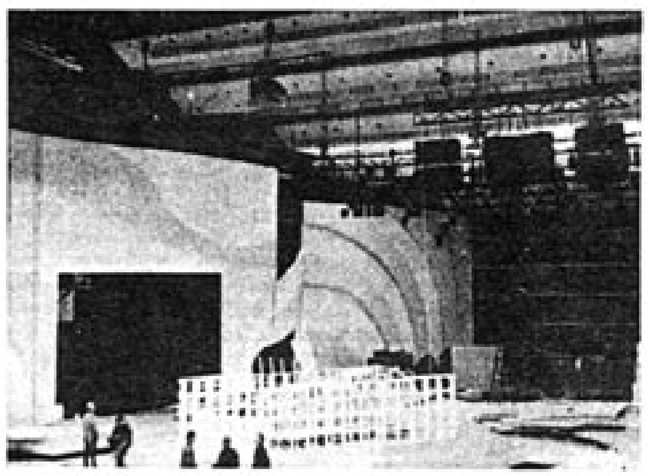


Fig. 6. Rows of suspended cage absorbers on ceiling splays

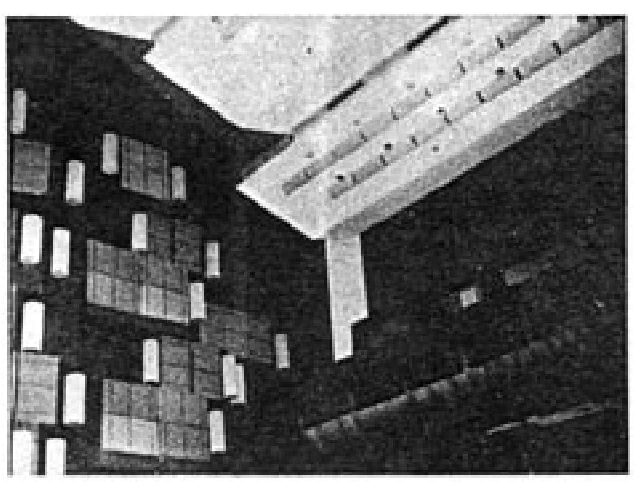


Fig. 7. Rear portion of the hall: absorptive treatment of walls and ceiling

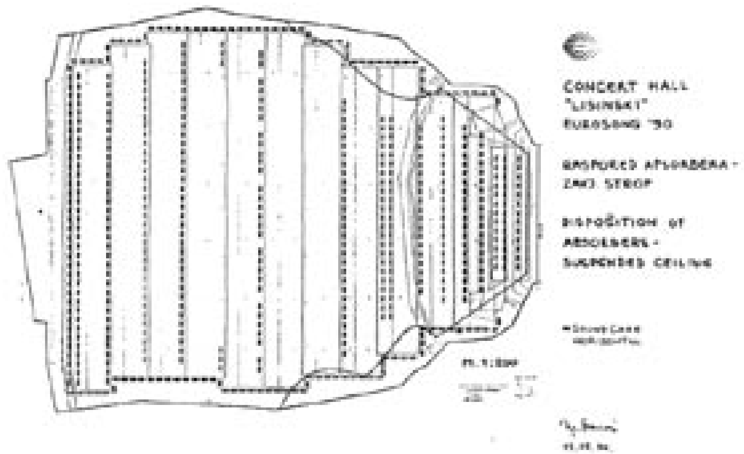



Fig. 8.

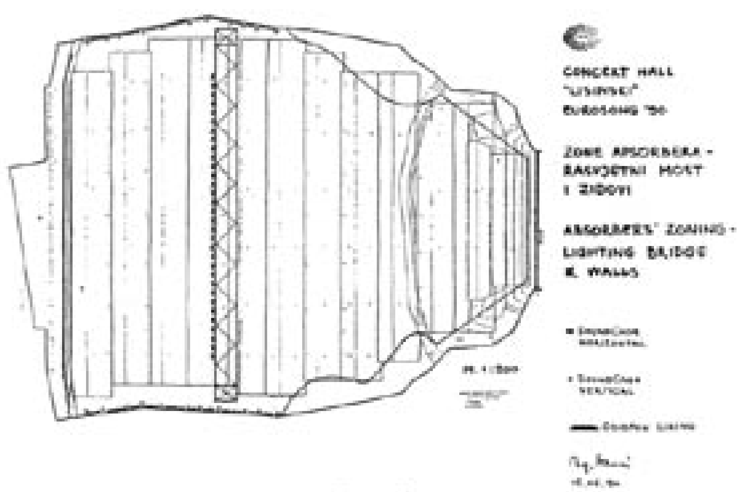



Fig. 9.

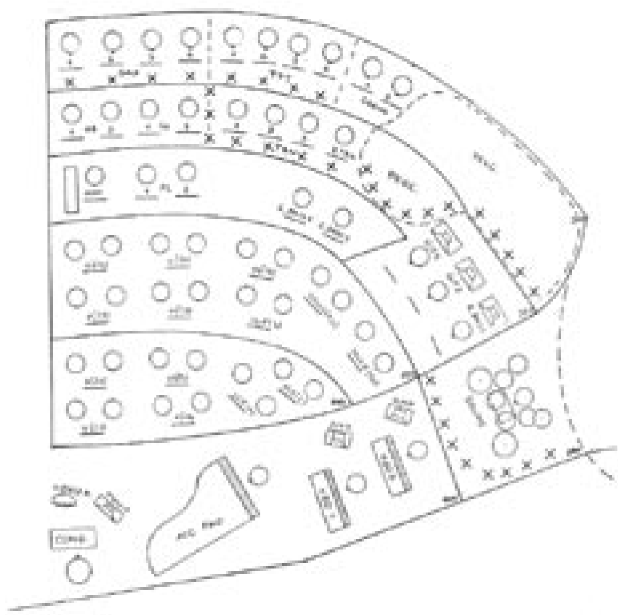
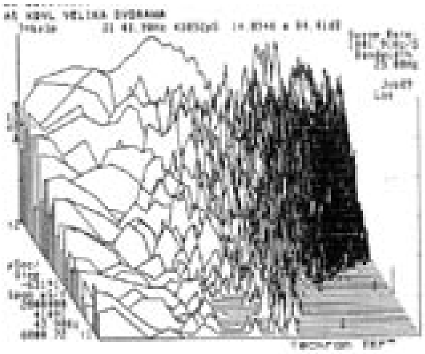
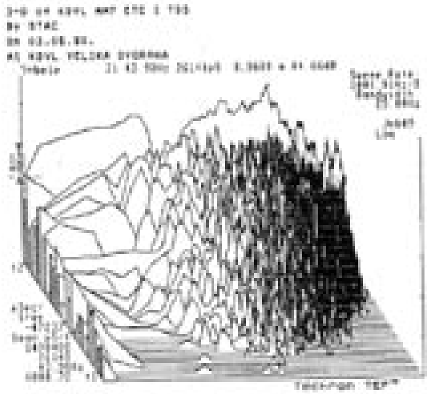
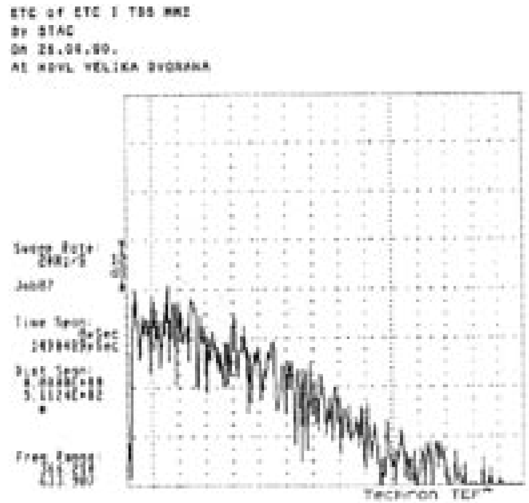


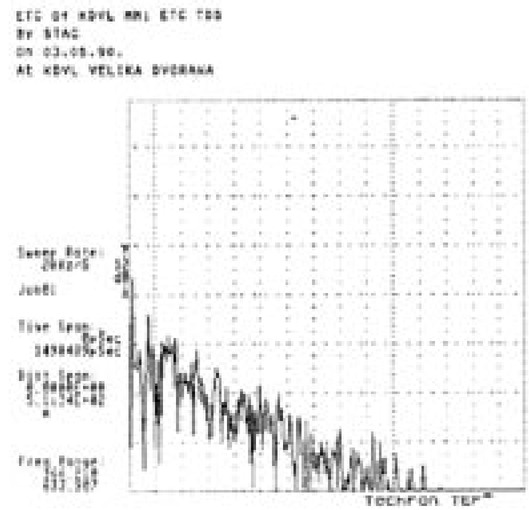
Fig. 10. Orchestra setup. Crosses indicate positions of cage absorbers




Figs. 11. and 12. Waterfall displays before and after dampening of sub-stage volume




Figs. 13. and 14. ETCs at solo vocal's position before and after 'tuning'

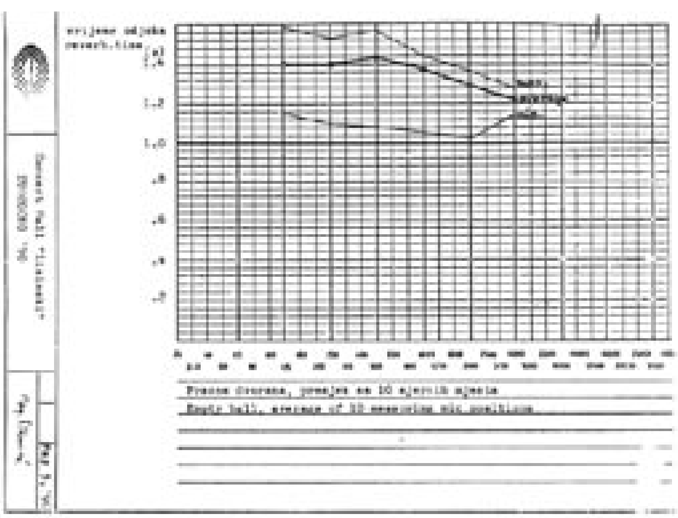


Fig. 15. Final survey of empty hall reverberation times

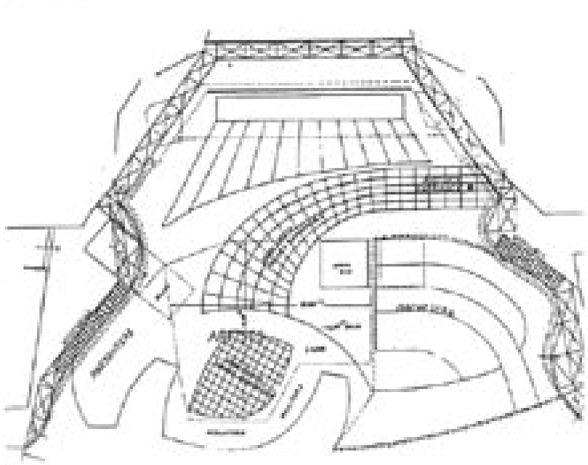


Fig. 16. Stage plan