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SPAIN GOES CLASSICAL - 10 YEARS OF CONCERT HALL AND OPERA HOUSES

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1. THE SPANISH MUSICAL BACKGROUND

Spain is a country with a very rich folklore, which differs greatly from one region to another. Music is therefore very familiar to any Spaniard but, if one looks back to the golden years of classical music creation, there is very little contribution from Spanish composers. Our best-known composers were born in the last 100 years (Albeniz, Granados, Falla) and some of their music was better-known abroad than at home.

Opera was more in fashion than symphonic music and by 1850 we had already a large Opera theatre in Madrid. But in a more modest size we built hundreds of theatres between 1870 and 1920, which made our "Zarzuela" (a theatrical form half-way between the Italian Opera and the Vienese Opereta) very popular. There was no town with more than 5000 people that did not have a theatre and, although we have lost many, there are still some beautiful examples of such architecture.

Those theatres were built in the classical Italian style and had capacities not exceeding 1000 people. Only Madrid and Barcelona could boast of having a proper Opera theatre at the beginning of this century, with a similar capacity to those of Milan, Viena, London, etc. but only the Liceo theatre in Barcelona maintained its designed purpose throughout the years, since Teatro Real in Madrid was most of the time closed or used as a concert hall. Only now, in a very ambitious programme is it being reconverted to its original use.

Most classical music was, therefore, performed in those theatres since, the only pure concert hall built in Spain was the Palau de la Musica Catalana in Barcelona (and, from the acoustical point of view, it was more like a theatre than a concert hall).

Music Societies and Friends of the Opera existed in every city but they could afford very few performances a year.

2. DEMOCRACY: THE TURNING POINT

The first steps towards democracy in the mid-seventies showed a change of tendency in the cultural situation in general and in the musical world in particular. The Town Council of Granada commissioned the architect Garcia de Paredes to design the first Spanish modern concert hall, in the hills of the Alhambra, next to the house where the composer Manuel de Falla wrote some of his music. The architect consulted with L. Cremer and they designed a successful medium-sized concert hall, which opened in 1978. In 1986 it was burnt down and reopened 11 months later.

The same architect was commissioned in 1980 to design what was going to be the National Auditorium in Madrid. He again contacted L. Cremer and myself and that was for me the beginning of a close colaboration in his projects (six concert halls) over 10 years until his death in 1990 and the opportunity to work in many more with prominent Spanish architects. While the project for the National Auditorium was being developed the Socialists won their victory in 1982 and with it a very ambitious programme for cultural buildings with the promise of a large hall in every Autonomous region (17 in total). To those one must add those promoted by Municipal Authorities or through special programmes (EXPO 92).

At one stage we had 25 projects running from first sketches to opening nights and it looked as if the motto was "If the Spaniards do not like classical music, it will not be for lack of halls".

3. GOOD ACOUSTICS

When an acoustic advisor must not only help to provide excellent acoustic conditions in a hall but also has to quickly shape the country's new acoustical scenario, he must have his ideas very clear. A survey from W. Sabine days to 1980 in the field of room acoustics could provide a consultant with quite a few criteria, both qualitative and quantitative that he must translate into an architectural and musical language.

SPAIN GOES CLASSICAL

In that survey there are some milestones which deserve comment:

1900 - Wallace Sabine [1]. Defines T60 ,the most important parameter in room acoustics, even today. If it is adequate, 75% of the success is assured.

1959 - L. Beranek [2]. His famous survey of halls brought up several parameters that were related to musical excellence in particular: long reverberation time, intimacy and warmth. Translated into architectural language it meant: 1. Building rooms with high Volume/Capacity ratios to have long T60. 2. Building rectangular halls since they provide more intimacy. 3. Using building materials inside that give the room longer RT at low frequencies than at medium. In other words avoiding thin panelling.

1960 - Sharoun-Cremer [3]. The project of Philarmonie (Berlin) was certainly in contradiction withthe second recommendation since its shape is anything but rectangular. The effort to provide good acoustics in such a room through terraces deserves credit but personally between the Philarmonie and the East Berlin Schausspielhauss I prefer the latter (classical, rectangular and narrow). Nevertheless, they proved that shape is not so much a problem if the architect is not stubborn about aesthetics.

1967 - 1972 - Marshall-Barron [4, 5, 6, 7, 8, 9]. Up to then short reflexions were important to achieve a high degree of intimacy. Many halls were filled with hanging reflectors to shorten first reflexions. Their work showed the importance of the lateral origin of those reflexions in achieving what they called the spatial impression. The sensation of being inside the speaker rather than in front of it is, in my opinion the second most-important parameter.

1974 - Schroeder-Gottingen Uni. [10, 11]. Their subjective studies showed a preference for low coherence between the signals in the ears. In practical terms, a preference for stereophony against monophonic sound. Large flat ceilings will reflect sound in a very monophonic way, whilst ceilings that do not reflect sound vertically to the audience will provide larger differences between ears.

The conclusions of that survey could be summarized as follows:
1. Medium-sized rooms (V < 20000 m3) are better than those of larger volumes.
2. Narrow halls are better than wider. Rectangular forms better than fan shape or elliptical but that should not discourage adventurous architects with even semicircular ideas.
3. Reverberant rooms are better than not so reverberant. Mid frequency T60 of 2 seconds are necessary to feel the emotion of romantic music. 4. The optimum T60 must be dimensioned to the size of each room.
5. Introduce a system, if economically feasible, to vary the RT and make the room more versatile, even for music. Pure concert halls are difficult items to sell, whilst multipurpose with variable acoustics are more defendable.
6. Rooms where the T60 at low frequencies is significantly longer than at medium and high frequencies provide a warmer sound through enhancement of cellos and basses.
7. Rooms with surfaces that diffuse sound in many directions are better than those that reflect in particular directions.
8. Halls where every seat is provided with reflected sound for both ears are much better than those where, due to audience distribution, only one ear is filled.
9. Choose an adequate type of chair which simulates a person sound absorption. Avoid upholstery thicker than 5 cm, otherwise the low frequency absorption will increase dramatically. Cloth flow resistivity should not exceed 600 New.s/m3.
10. Halls must be well sound-isolated and air conditioning so quiet as to allow the public to hear planissimos without having to play them mezzoforte.

4. THE RISK WAS REVERBERANT

As mentioned before with the exception of those concerts given in our cathedrals and churches with mid-frequency reverberation times of 6 seconds, the rest of the music was performed in rather dry conditions (T60 <1.3 sec.). Measurements carried out in Teatro Real when used as a concert hall [12] showed a T60 of 1.45 empty and 1.25 occupied, being the largest in volume. Similar measurements obtained in smaller theatres showed values of T60 under 1.1 seconds.

The public and critics in every city considered the acoustics of their old theatres very much among the best and, in Madrid particularly, they had this idea strongly in their minds. Admittedly they had never heard anything more reverberant and good weather conditions favoured open-air concerts and, therefore, when they listened to music in a theatre the change was very noticeable. Even the best known orchestras in the world played music in the open in many Spanish squares.

The most famous music critic in Madrid once wrote "The Spanish National Orchestra played in Zurich's Tonhalle not at its best due to the excessive reverberation of the hall." Excessive 1.6 seconds; what would he have said if they had played in the 2.1 seconds of Musikverein?. Even the newly - opened Granada hall had a reverberation time, before it was burnt, of 1.55 seconds at mid-frequencies and, therefore, could not be considered reverberant.

SPAIN GOES CLASSICAL

To aim for reverberant halls (T60 ≥ 1.7, preferably around 2 seconds for the largest) was a very drastic change from T60 = 1.3 or even from T60 = 0. Cremer, certainly wise, did not take such a risk with the Madrid auditorium. Between the safer 1.75 sec. and the risk of having too large a change from theatre acoustics, he chose safety. I was younger and chose the risk. Three main reasons: a) About 70% of the music programmes in Europe include romantic music that needs the 2 seconds. b) All modern recordings of symphonic music take place in reverberant spaces or are artificially upgraded to 2 seconds. c) To change from reverberant to less reverberant is much easier and cheaper than viceversa.

Figure 1 shows the criteria used for the optimum RT for mid frequencies as a function of room volume. In general terms, halls with volumes over 11000 m3 could be considered symphonic and those below as chamber music halls with some overlapping. The lowest limit of 1.4 sec for low volume halls is considered adequate for fast barroque music and the upper limit of 2.2 seconds is considered optimum for romantic music in large halls.

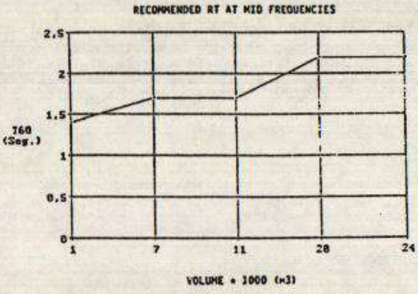

Fig. 1 Recommended RT at mid frequencies

Reverberation time at low frequencies should be longer (1.1 times that at 500 Hz for 250 Hz and 1.2 times for 125 Hz). Those requirements together with my conviction that halls with more than 2200 seats are very difficult to optimise acoustically, a strict control of noise from internal sources, a low background noise (below NC20), the necessity to provide every seat with early reflections, preferably from both laterals and the requirement that the acoustic consultant participates in the selection of the chairs, formed the non- negotiable conditions.

More subtle convictions like the presence of public on the sides of the orchestra or even behind it or the incorporation of variable acoustics could be negotiable with Architect and the Owner.

5. ALL SHAPES AND SIZES

The fast programme set out by the government meant that initial designs came to our office with many forms, volumes, capacities and requirements. The golden rule widely spread among Spanish architects, that the best hall would be Epidaurus with walls and roof, had to be eradicated and even a few added some domes to the roof. Instead we emphasize our recomendations of: 7 to 10 m3/seat acording to size; distances between players and the audience < 40 m; convex walls rather than concave o even flat; reflectors that send sound to the audience rather than to the back wall, absolutely no carpets or heavy curtainns and shapes that do not create too many acoustical problems i.e. rectangular, romboid or terraced fan shapes. First drawings are checked for compliance with those recomendations and alternative proposals are studied by geometrical means until one or two definite alternatives are selected.

Model techniques have been used extensively in the analysis and studies of the Architect's proposals. In our case, to build and acoustical model at a scale 1:10 or 1:20 was out of the question for economic reasons as much as for time reasons. Using optical models, at larger scales (1:50) was of course less expensive and certainly faster. With the help of aluminium foil and a laser beam, one could see where sound rays will end after one or at the most two reflections. It was exclusively a qualitative study and could help only in locating and orientating reflectors and ceilings. But it proved to be very propular with Architects and journalists, particularly impressed with the "laser".

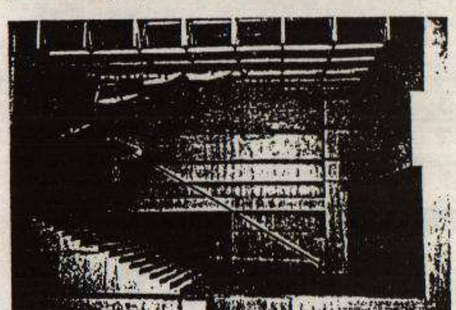

Fig. 2 Use of laser in models

The next step was to try to introduce some quantitative measure in the optical model. Using white light, from and array of simall bulbs, and flat light resistors, 5 mm. in diameter, placed in the

SPAIN GOES CLASSICAL

audience area, the relative light intensity in thatarea could be measured and compared to that arriving at other areas. The light emitted from the stage could be made quite directional by using black tubes of different lenghts, over the bulbs.

The existance of darker areas could be apreciated visually, but with those light resistors the degree of darkness could be measured. Different ceiling sectors and wall reflectors could be compared and their shapes designed to cover certain audience areas.

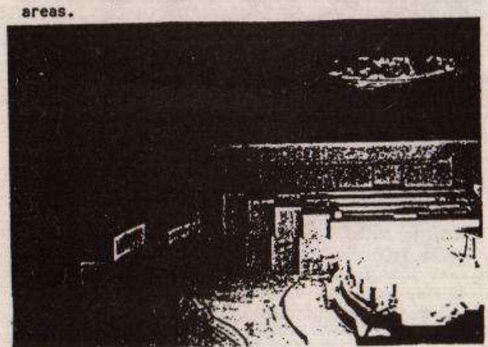

Fig. 3 Use of Photocell in models

This technique was further improved with the use of small photodiodes that could be made very directional and placed in four directions to measure light intensity arriving from the front (simulating direct sound), both sides (simulatating the ears) and the top. A small BBC computer with and ADC, was used to measure the intensity arriving at every photodiode with different alternatives for ceiling, wall or reflectors.

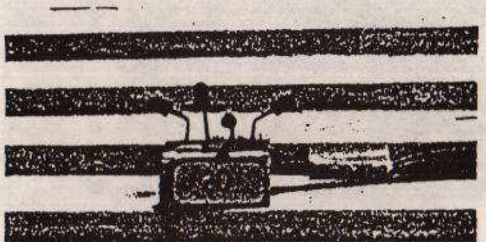

Fig. 4 Directional photodiodes

Fig. 5 Optical detection system

The arrival of fast and relatively cheap computers made the development of a computer programme very atractive and after a year it made our photodiode technique, look somehow prehistorical. The use of a CAD programm together with our own raytracing programm REFLEXSON allowed us to study in more detail than before and certainly much faster, not only first reflection delays, but the whole impulse response of the room, the influence of small variations on reflector orientation etc.

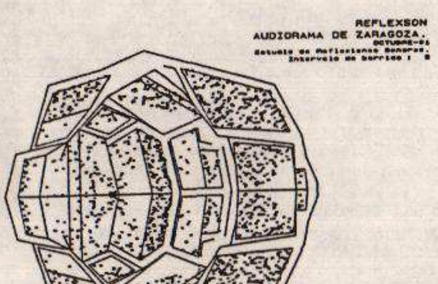

Fig. 6 Delays in a hall using a computer

SPAIN GOES CLASSICAL

6. BUILDING HALLS

To put the theory into practice requires a long battle with all the teams involved in the building process. Some of the most important parameters in the final acoustic results could still be modified throughout that process and unless the acoustic consultant is present at the sight and at every meeting, experience shows that his efforts could be waisted.

No other member of the team will understand or care about warmth, orchestra blend, coherence or difussion. Floating floors, double doors, absorbent ceilings etc. will be questioned by structural engineers, building conntractors and ownership in that order. Cost increases in these projects are always balanced against acoustics requirements since it is something "very subjective". But every person involved in the project looks towards the acoustic consultant the night before openning as if he was "Medicine man", that could turn mistakes into successes, shaking a few beans.

In Fig 7 there is a clear example of what a wrong decission on the chairs could mean on the acoustics of a hall; the same persons were seated over three different types of chairs.

Acoustic success in a hall is therefore difficult to obtain because it depends on so many factors beyond the control of the acoustic consultant; only when there is a conspiracy between the four partners: Architect, Builder, Consultant and Owner, to go for the best in acoustic conndition, can that success be obtained.

In the Table are some of the characteristics of most of the halls with more than 800 seats opened or under construction in Spain, where my colleagues at GARCIA-BBM S.A. and I have been (or still are) working.

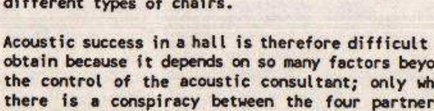

Fig. 7 Absorption for occupied chairs

7. TWO EXAMPLES

Of those halls mentioned in the Table, two could be chosen for some detailed comments. The PALAU de la MUSICA in Valencia was the first of the series to be opened, in 1987, and it was the public's first audition in a modern, reverberant hall. With a ratio of 8.5 m3/seat, the high reverberation was achieved with very low absorption chairs, particularly at low frequencies. A very low background noise (< NC20) with the air conditioning system, allows good conditions for listening to weak musical sounds and even commercial recordings.

Opinions about its acoustics from the public, musicians and particularly conductors are unanimously enthusiastic. With a similar volume, capacity and T60 (occupied and empty) than Musikverein, it is, when full an excellent hall for those who like to be surrounded by music.

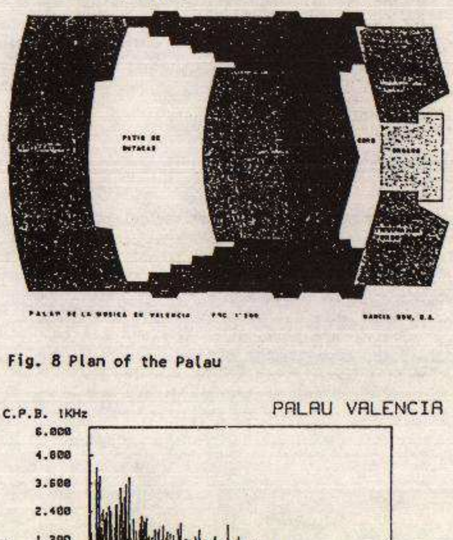

Fig. 8 Plan of the Palau

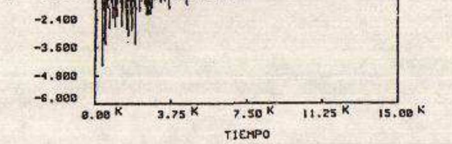

Fig. 9 Echogram for a seat in the balcony (1 Khz)

SPAIN GOES CLASSICAL

The Teatro de la Maestranza in Sevilla was our first truly multipurpose hall since it was going to be used extensively for concerts and operas. The cylindrical shape of the hall was modified where it could be acoustically dangerous, but it was left in its original shape in the upper part, above a technical gallery. With the requirement for both uses, the hall was designed as a concert hall, hoping to find an effective and economic way to reduce the long reverberation for symphonic music, to shorter values in case of opera.

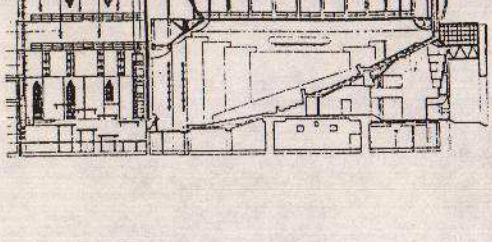

Fig. 10 Cross section of the theatre

The upper part of the cylinder, over the gallery was an ideal place to locate some sort of absorbent material. The existance of an internal gallery around the perimeter of the hall, could be used to hide absorbent elements when not required. Custom designed mineral wool cylinders 30 cm. in diametre and 3.2 m. long are vertically hung and can be pulled into the room through a rail system at the discretion of the conductor. To increase the absorbent surface they are separated 35 cm. between themselves and 20 cm. from the wall.

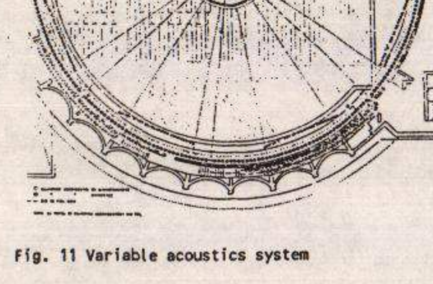

Fig. 11 Variable acoustics system

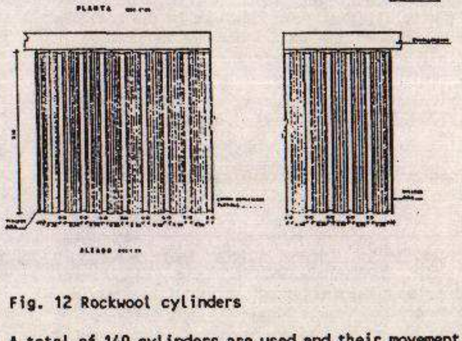

Fig. 12 Rockwool cylinders

A total of 140 cylinders are used and their movement through remote control make them very practical. Their effectiveness is shown on Figure 13.

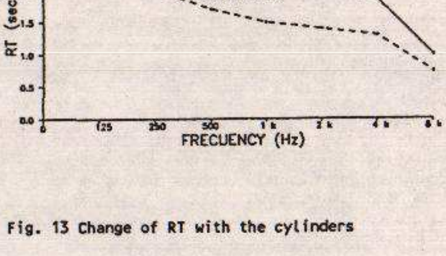

Fig. 13 Change of RT with the cylinders

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NAME	CYTY	USE	SHAPE	V (m3)	AUD.	L (max)	W (max)	H (av)	T60 empty	T60 occu
C. ACTIVIDADES MUSICALES	VITORIA	CO	RECT.	6500	800	36	16.5	11.5	2.10	1.65
PALAU DE LA MUSICA	VALENCIA	CO,CF	RECT.	15400	1780	45	26.0	16.0	3.15	2.10
AUDITORIO	CORUÑA	CO,SO	FAN.	14500	1800	39	63.0	11.0	2.35	1.85
AUDITORIO DE GALICIA	SANTIAGO	CO,SO,CF	SQUARED	6950	1000	30	30.0	9.0	1.91	1.65
T. MAESTRANZA	SEVILLA	CO,O	CIRC.	18500	1860	42	40.0	16.0	2.80	2.20
									(2.20)	(1.65)
AUDITORIO CANTABRIA	SANTANDER	CO,O	RECT.	15000	1600	40	34.0	15.0	2.10	1.70
PAB.AMERICA	SEVILLA	CO,CF	SQUARED	5000	800	25	24.0	6.0	1.93	1.65
				VAR.	UP TO					
TEATRO CENTRAL	SEVILLA	T,CO,SO	RECT.	14000	1200	36	18.0	15.0	1.95	1.70
				7000	"	"	"	"	"	1.40
AUD. NACIONAL(*)	MADRID	CO	RECT	20000	2200	50	25.0	16.0	2.10	1.75
			UNDER CONSTRUCTION						EST.	
AUDITORIO	MURCIA	CO,O	FAN	15000	1650	36	57.0	14.0	2.20	1.90
P.CONGRESOS Y AUDITORIO	SALAMANCA	CO,CF	SQUAR.	14000	1200	28	27.0	12.0	2.00	1.70
AUDITORIO	ZARAGOZA	CO,CF	ROMBOID.	21000	1800	56	44.0	10.0	2.30	2.10
AUDITORIO	PUERTOLLANO	CO	SQUAR.	8600	1200	25	26.0	14.0	2.00	1.70
CASA COLON	HUELVA	CO,CF	"	7200	850	30	30.0	8.0	2.00	1.70
TEATRO HUECAR	CUENCA	T,CO,SO	"	5000	800	24	27.0	9.0	1.90	1.60
AUDIORAMA	ZARAGOZA	CF,CO	RECT.	27000	VAR.	66	26.0	16.0	3.50	1.50
			PROJECT						2.20	
AUDITORIO	LAS PALMAS	CO	ROMBOID	18000	1700	45	35.0	13.0	2.20	2.00
"	LA PALMA	CO,SO	SQUAR.	12000	1200	36	39.0	18.0	2.00	1.80
"	ELCHE	CO,CF	RECT.	7000	850	26	22.0	12.0	1.90	1.70
"	MASPALOMAS	CO,CF	RECT.	11000	1000	35	25.0	14.0	1.90	1.70
C.TABACALERA	CADIZ	CO	RECT.	7000	800	36	22.0	12.0	1.90	1.70

* With L. Cremer

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