Sound Dome
Leo Küpper

Leo Küpper
The Sound Dome at Ars Electronica 84 in Linz [Austria]

Music and Technique Today

The parameter of the sound space in music

SHORT HISTORY OF SOUND SPACE PARAMETERS IN MUSIC

In the Egypt of the pharaohs there lived, about the year 2700 BC, HUFU-'AN, the first musician history knows of, and he was–incredible but true — passionated with the study of a musical parameter, of pitch, unknown then. Maybe we are in a similar situation as he must have been, when in front of the unknown parameter of musical space we ignore the maybe long way in front of us as Hufu-'an ignored the long way from the discovery of the pitch parameter to the music of J. S. Bach. Is the parameter of musical space as rich as in traditional music with its so well-explored parameter of pitch, or so widely varied as the parameter of sound colour, explored by today's music? The Linz Sound Dome shall explore the richness of this spatial parameter in music.

If the history of music has, above all, occupied itself with the parameters of pitch, of timbre, of instruments, we can nevertheless be sure that many composers–during this musical history–have already explored in their ways the spatial parameters with the technical means at their disposal. If today we are still where they were at their time (in fact, the aesthetical perception of music has not undergone great changes), one thing, anyhow, has emerged as completely new: electronical technology.

In this musical past, you will find, naturally, "experimental composers" where the experimental architects are to be found. The polyphony of stone has evoked a polyphony in music. Experiments of musical "spatialization" took place in Venice (St. Mark's) and Rome (St. Peter's). If in the churches the reverberation was too long for an elaborated experience of the sound space, the composers nevertheless tried to integrate it into their oeuvres. Monteverdi, Palestrina, Orlando di Lasso as well as Victoria composed music in space. Andrea and Giovanni Gabrieli had the choirs sing in tetraphony at St. Mark's in Venice (the geometry of the churches–their concert halls–calling for spatial musical shapes). Thomas Tallis had already acquired an extensive spatial experience with his motet a quaranta (for 40 voices!), "Spem in Alium", the choirs singing in spatial distribution, just like Andrea Gabrieli with his "Symphoniae Sacrae", with choirs and instrumental ensemble responding to each other. At St. Thomas in Leipzig, J. S. Bach experimented with the spatial parameter in his way in his Passion music (in his St. Matthew Passion, organ choirs and trumpets respond in dialogues within the space of the church in musical forms).

Now we have to jump to the romantic era, for the post-baroque composers did not practise the spatial experience. Ludwig van Beethoven did not compose very much for the opera, but it is exactly in his "Eleonora" that the choirs–in the backstage–realize spatial musical effects. W. A. Mozart, in his "Don Giovanni" composed also under consideration of the spatial parameters by having three orchestras responding on the stage. In his requiem "Tuba Mirum", Hector Berlioz encircles the public with four orchestras up to the point of scaring them with this mighty tetraphonical effect.

Today, K.-H. Stockhausen accomplishes a step forward in the exploration of this parameter with his oeuvre "Carré" for four orchestras and four conductors (once again a spatial tetraphony).

ACTUAL SPATIAL SPECIAL EVENTS

Our era has realized its events on spatial parameters in a much more methodical fashion (without forgetting the numerous scientific research programs) by abandoning the backstage effects in order to devote itself to the shape of halls and thus articulating space in a more elaborate manner:

THE PHILIPS PAVILION AT THE EXPO 1958 IN BRUSSELS

Architects:
Le Corbusier und I. Xenakis

Composer:
E. Varèse ("Poème Electronique")

Fig. 1: Der fertige "Philips Pavillon", Eingang

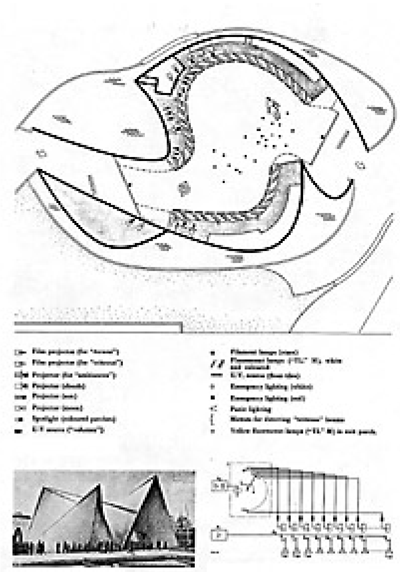


Fig. 2—4

(see fig. 1 through 4) Architects: Le Corbusier and 1. Xenakis Composer: E. Varèse ("Poème Electronique") The stone flowers from the gothic cathedrals have become metal figures in hyperbolic and parabolic shapes. About 450 individual loudspeakers (from 10 to 20 Watts) were distributed along the walls. The piece by Edgar Varèse was distributed in the hall starting from a 15-track tape recorder. The gain of the loudspeakers was automatically controlled and the music was accompanied by luminous and visual effects (architecture, light-and-sound show). The whole of this artistical diffusion was pre-programmed (pilot tensions on the recording controlled the amplifiers) and the program unrolled automatically from the beginning to the end.

THE GERMAN PAVILION AT THE EXPO 1970 IN OSAKA (see fig. 5 and 6)

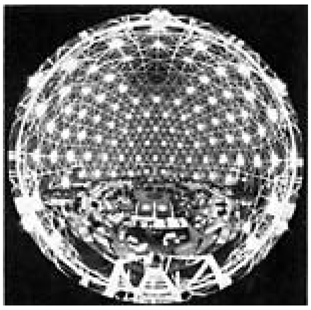


Fig. 5

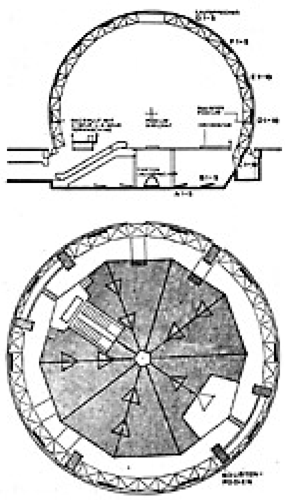


Fig. 6

The experience of the German pavilion at Osaka is another step in the development of the spatial parameter in music. The spheric hall with a diameter of 30 metres was plastered with about 50 loud-speakers. A grid as "floor" divided the sound dome and invited the visitors to take a seat. Through this grid the loudspeakers could penetrate the space from the bottom. The reverberation in the sphere was of approximately 1.4 seconds, the dynamics were either manually or automatically controlled. Those principally responsible, Prof. F. Winckel and K.-H. Stockhausen, thus were able to realize their old dream of a sound sphere.

GALLERIA NAZIONALE D'ARTE MODERNA, ROME, 1977 (see fig. 7 and 8)

Fig. 7

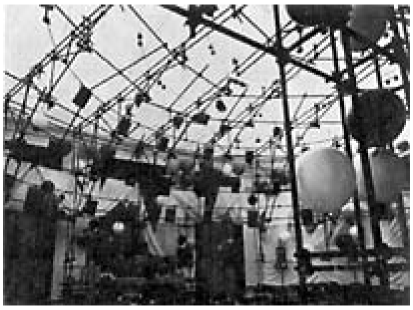


Fig. 8

Realized by L. Küpper, Nuova Consonanza and V. Consoli (engineer). Construction of 1/4 of a dome with 72 three- and four-way-speakers (making about 200 individual sound sources). The goal was the exact study of the space parameter in music by creating a new musical instrument and avoiding the domains of spatial effects or customary effects like stereo- or tetraphony.

In this dome, the following events were realized: PUBLIC COMPUTER MUSIC: Music commissioned by the public in the form of digital impulses (analogically captured by various microphones distributed in the hall).

These digital impulses controlled a complex variety of pre-programs (as structures), which appeared and disappeared automatically on the sound dome. As a default, the amplification of the microphones allowed an auto-stimulation of the machine and to go on at random with the enouncement of its musical structures.

SPATIAL DIFFUSION OF MUSIC on the basis of tape recordings. Four musicians became the interpretors of space according to a score or in free improvisation.

LIVE CONCERTS with the "Nuova Consonanza" ensemble of Rome. By the aid of microphones, four instrumentalists played in the dome, while four others played outside the dome itself (total of 8 musicians). It was a great surprise to the public, very numerous every day, to hear the instruments no longer fixed to one place on the ground, but travelling through the sound space (the piano was literally flowing in the air, the viola stood still in the air and the cello was voyaging around the dome, touring the audience…). These experiences could fortunately go on for one month, allowing the participants to acquire an advanced knowledge in the art of handling the space parameter.

CHAPPELLE DES PÉNITENTS BLANCS IN AVIGNON, FRANCE 1981

A second experience of this kind was tried in Avignon, again under the direction of Leo Küpper and V. Consoli. Again 1/4 of a dome was established in this church, favorable in the beginning by offering a scaffolding in place. Nevertheless, the experiment did not work out so well as in Rome. For one the reverberation was too long and besides, it could be noticed that the electro-acoustical composers who are their own interpreters, have acquired such a stereo-oriented experience, that they could or would not alter it, even on a sound dome.

On the other hand, the articulation of the space parameter must be realized maybe not by virtuosi, but at least by well-trained interpreters, which is seldom the case. As there are no halls, no sound domes, no diffusion systems (complex and of quality) nor instruments for spatial playing, it is self evident that there are not as yet any interpreters.

Music in space

The parameter of height has developed rather slowly in music. Primitive music did not use more than two or three intervals. From the Orient and from Greece musical scales came to Europe:

the pentatonic scale from the Far East, the Indian and Persian scales (mostly in heptades), from Greece the Grecian scales and those of the Middle Ages.

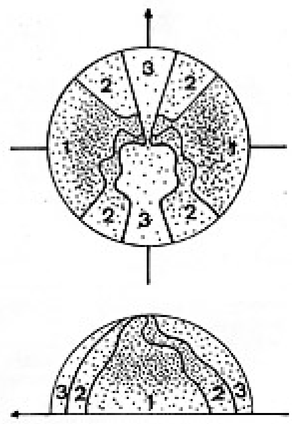
The 7-tone system soon developed into a 12-tone scale, which was tempered by and by. Finally this temperation was dodecaphonized. If today the pitch scales continue their development although being overtaken in importance by the timbre research, the intervals seem to be insufficient for the development of the actual technical music.

In comparison, we can ask ourselves if the space parameter will know the same slow historical development or if science will force it into an accelerated development. As we have previously stated, many a spatial experiment has been made, but not until now could this parameter appear as autonomous as pitch. Maybe its development remained impossible due to technical limitations. It is difficult to play an instrument or to sing while moving through the acoustical space (in one dimension only, in any case). This musical immobilism in connection with a static conception of the world caused the spatial parameter never to become an expressive necessity. The development of orchestras (group of instrumentalists under the common direction of a conductor) could not bring any changes to these spatial needs (on the contrary, the conductor causes a further immobilization of this sound space parameter). Maybe it is the technical advance making the sound space parameter grow in importance. The technology of loud-speakers, automatization, the development of variable gain amplifiers (automatically controlled), the diffusion of sound from multi-track recorders… today it is possible to create an automatic loop between the sound space and the pitch or the intensity, so as to have the sound move in space as it increases or goes up the scale.

SOUND DOME

Also the intensity of every channel can be played with by the aid of manual faders or by controlling the intensity of channels by computer (digital gates). In the technical area, thus, spatialization has become an easy game and above all very precise. What lacked was the appropriate hall: the Sound Dome: But if on the technical side everything seems ready for a fast development, the compositional side and the interpretation area still leave a lot to be invented. In any case, a fast development of the sound space parameter within the next few decades may safely be predicted.

Physical parameters of spatial perception



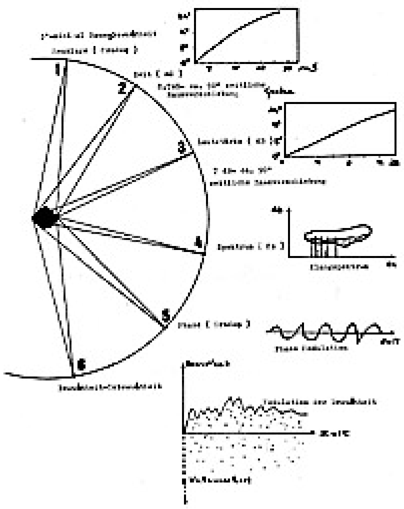


Fig. 9—10

As the majority of our perception is complex and refined, so is the spatial perception of Man (acoustics and psycho-acoustics are not sufficient for explaining these sensations in their function). Also the pitch-based music could not be expressed in theories but had to be practically experienced. The points in fig. 9 symbolize the number of different spatial perceptions we distinguish in a hemisphere. For better comprehension we have divided the spherical area into three distinct sectors. The most astonishing fact is that in the horizontal-frontal area, where we believe to have an extra good perception, perception in reality is extremely poor. Maybe this depends on the fact that the eyes scrutinize the same area, giving us an impression of audio-visual richness. On the other hand, we are most aware of things in front of us and generally in upward directions (from 30 to 60 degrees). We can distinguish three areas of perception:

I. the area of maximum spatial sensitivity

II. the area of medium sensitivity

III. the area of restricted spatial sensitivity

Our limited sensitivity to things in front of us can be explained by the fact that the eyes offer a remedy for this (and for the back, the head itself shading off perception). On the other hand, for the sides the physical parameters (of intensity and of time) are most different, thus accounting for spatial perception. But what with the area between 30 and 60 degrees upwards? Could this be a remainder of the prehistorical man living in the wood and thus searching his nourishment in the trees?

In the daily sound perception the spatial perception is fundamental (it is rather more important to know, from where the car comes than analyzing the grumble of its engine for timbre or, worse, for pitch!). So we may conclude that directional perception is fundamental for avoiding and escaping dangers.

We can further state that the parameter of pitch (and the scales acquired in the course of each civilization's history) has been ordered by intuition, as none of the composers could have a knowledge of the laws of psycho-acoustics. They heard, but did not know HOW. They tempered the scales as linear functions on logarithmical physical bases (we hear far more pitch levels between 2 and 4 kHz than between 200 and 400 Hz). Will the spatial scales be tempered scientifically or according to intuition?

Psycho-acoustical limitations of spatial perception

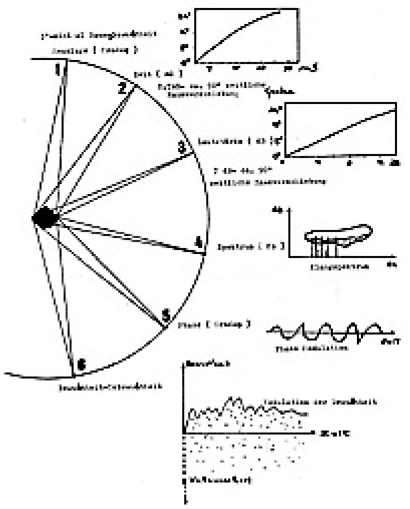


Fig. 11: Parameters of spatial perception

Our spatial perception depends on several factors: the position of the sound source in relation to the listener's head (in degrees), the temporal difference in reception (in milliseconds), the perception of intensity differences (in dB), the spectral entity (the total of the components of the sound spectrum), the phase (in degrees or temporal intervals) and the general attention paid to the message.

Generally, the **microscopic information** goes up a scale of perception, becoming the **mesoscopic information**, this, in its turn, becomes the **macroscopic information** and this again can be integrated in the general information system, thus closing the circle. We perceive the phase for the low and especially infra-frequences (in the shape of temporal rhythms). Spatial perception is very precise for sharp frequences and diminishes according to the decrease of frequences in the auditive sector. For instance, we much better perceive the sound impulses in spatial variation than in sinusoidal tones (spectral richness increasing the space perception capability). Surely this perception is strongly connected with our visual habits.

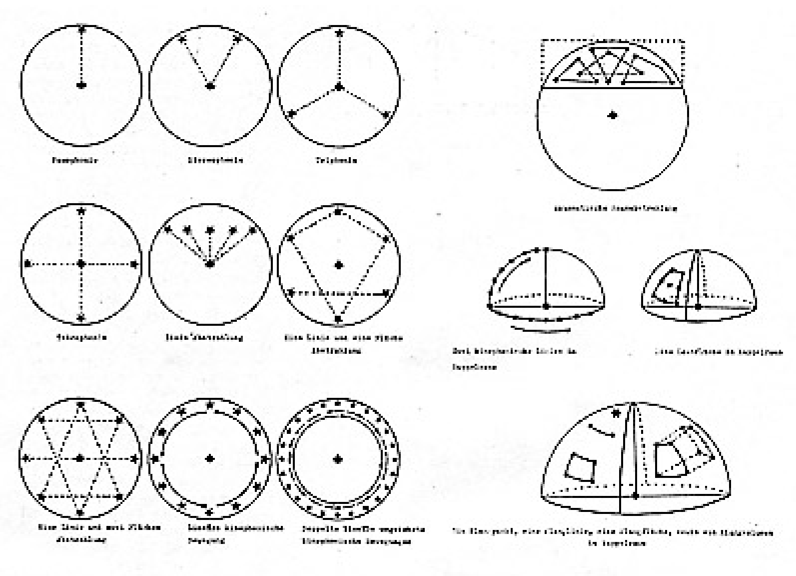
Saint Bernard and his theoretician Achard did not want windows in their architecture, for they thought auditive perception sufficient to generate internal joy. They cultivated rather the ear than the eye and for them silence was fundamental for hearing (for music comes from silence and falls back into this silence). Reverberation, nevertheless, was important, for it spatialized the spirit and slowed down life (they had up to four seconds of reverberation in their architecture). Auditing was the way to "vision".

We have realized our own experiences of sound space: listening a whole night long, to one and the same sinus-tone, experiences with the white rustle, with looped information tapes… In this different informational world, the limits of our perceptive world are crossed and it is completely changed (with the sinus-tone, for instance, the notion of space is purely mental and no volition can track the signal back to its original source, the loud-speaker). Everybody can experiment in this unusual world.

THE INTERPRETERS/COMPOSERS AND SPATIAL DIFFUSION

The new technical music (or electronical, cybernetical, computer music, etc.) has been strongly connected to the development of the spatial parameter–and that for some thirty years now.

See fig. 12 and 13.



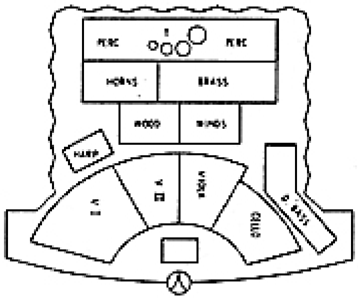
DEVELOPMENT OF SPATIAL SHAPES FROM MONOPHONY TO KINEPHONY

The origin of spatial diffusion was as monophonic as TV is still today. Stereo uses two channels of diffusion (left and right at 60 degrees) and numerous scientific writings describe it–due to the fact that both radio and record industry use it. Triphony needs three channels (triangular information creating a horizontal plane). Tetraphony, with its four channels, is the diffusion method for electronic four-track recording. It is possible to compose for four channels, also in the studio. Thus the notion of space composition takes only a small place in compositional thoughts. Hexaphony, with its six channels, can be divided into a tetraphony and a stereophonic line. Octophony can be divided into two tetraphonies and into a stereophonical line (depending on the hall and the works to be diffused). Musical forms and the shape of the hall have also to include the participation of the public.

With four channels we can already move the sound in circles (even if the sound is still considered "jumping" from one channel to the other, with 12 channels the movement becomes really rather linear). This movement can be realized by manual control of the balance as well as automatically by analog gates.

We call this sound movement "Kinephony" (kine: Greek for movement, phone: voice). Kinephony is thus music moving in space. Fig. 12 shows also a 24-channel unit with the sound moving in two kinephonic lines in contrary motion. Until here we still stay within one plane of diffusion: on a horizontal plane (where–see above–we are not very sensitive to spatial perception). Fig. 13 presents a frontal diffusion, called Acousmatic by the Paris school (INA/GRM), a term applying to any sound the origin of which cannot be determined. The speakers are in front of the public (like an orchestra). The sound space is divided into sound sectors and spectral areas in geometrical sense, and the composers interpret their oeuvres by assigning a specific timbre to each sound source. The tendency goes towards assigning a loudspeaker to each instrument (loudspeaker orchestra). Let us consider once again that, situated in the horizontal plane, this diffusion chooses the zone of minimal spatial perception. A completely different conception is diffusion within a sound dome (cf. fig. 13). For a long time man has been dreaming of the music of "spheres", intimately linked to astral music. The dome, however, is not a privileged place for sound diffusion as the shape tends to entrain many a problem. In this figure we see two kinephonic lines in two different planes. Within a dome we may distribute both sound lines and sound surface (and if the quality of the loudspeakers is good enough, this surface tends to become acoustic, which means that the speakers are no longer perceptible, a viola might be considered a microscopic discontinued line of small loudspeakers specialized in an area of sound vibration). Finally we now can develop a complete vocabulary of spatial articulation, from punctual diffusion to the kinephonic line via fixed or moving sound surfaces. Point, line, surface, sound bodies are the new concepts in contemporary music, especially because these movements are projected into space. For working well the hall must be "dry", which means that the reverberations should be limited to a minimum.

We can synthesize any desired reverberation according to our needs and desires and thus create any shape of hall we like. What is new, is the kinephonic reverberation (completely anti-natural), but technically quite easy to produce. By integrating all of those new aspects in the sound dome, we have created a new musical instrument.



The composer in the sound space

The hall, the orchestra, the musicians and the public, all of them are in a correlation: they form an entity. As long as the orchestra plays in front of the public, the spatial parameter will not become effective (the orchestra will play acoustically, so that the public sees both conductor and musicians in action). But the ensemble of the orchestra is delivered to him by a huge complex group of loudspeakers. Maybe the message is a little bit spatially distorted, but as only the play of pitches and timbre are considered important, there is no aesthetical contradiction.

Today the architects are very active in the construction of new halls, especially in the USA. But none of them has ever been constructed according to other than the traditional principles of sound diffusion by an orchestra.

Fig. 15: Brucknerhaus, Linz: Disposition of the orchestra in the Great Hall.

Fig. 16: Here the orchestra is seated in the bottom center. Whether the musical perception is better has not yet been determined by psychoacoustics. The orchestra appears as a vibrating monophonic solid.

DREAMERS OF SPACE

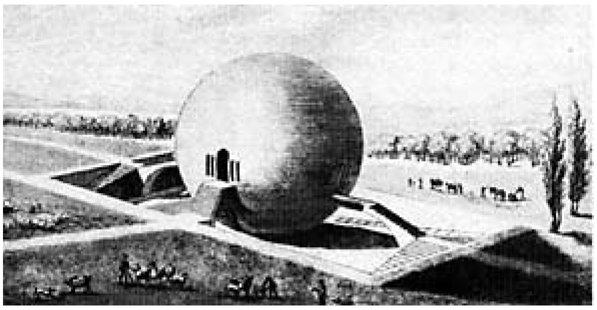


Fig 17: The French architect C. N. Ledoux imagined spherical houses (an idea picked up for the expositions in Paris, 1900, Brussels, 1958, and Montreal, 1967). The dome as a dream came to us from the Far East (intimately linked to astrology).

With the term of "space" we usually connect ideas of plains, of mountains, or even of outer space, but few could imagine that we could have space as an instrument, that space could become a way of musical expression, an intellectual and spiritual game like playing with the pitch. The Philips pavilion was an interesting essay in this direction, but deviated into audio-visual area (with a successful comparison to automatization and a practicable sound diffusion system). The projection hall of the IRCAM has been designed and realized to a clearly defined goal: The diffusion of actual music, above all instrumental. The instrumentalists occupy the center of the hall in contact with the close-by audience. But the spatial duality still exists and kinephony is difficult to realize. Surely a new need has come up and been met here.

Fig. 18

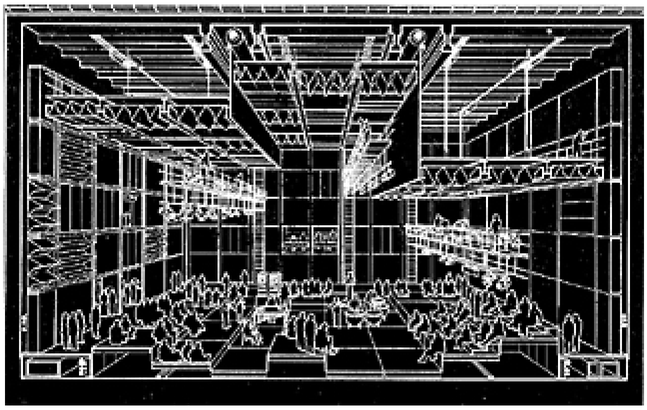


Fig. 19

The Linz Sound Dome

It is seldom and lucky that an important cultural institution takes the venture of realizing a new experience in the field of sound space. Thanks to Ars Electronica 84, this experiment will be carried out in practice. The Linz Brucknerhaus includes three halls: a large, a medium and a small one in a setting of great beauty.

THE MEDIUM HALL OF THE BRUCKNERHAUS

Abb. 20

This hall offers seats to an audience of 352 persons and is decorated with light wooden panels, the reverberation being quite suppressed. For the construction of the scaffolding, the seats will be removed, allowing a seating position more suitable to the sound dome. The scaffolding will sustain the ensemble of 104 loudspeakers, distributed according to the well-calculated plans by the project designers. As the loudspeakers are three- and four-way constructions, the total amount of speakers will be about 350.

Within a sound dome the best listening places are theoretically rare: they are at the focus of the dome. To avoid limiting the project to an elite of listeners, we have designed the dome's center as large as possible. A distance of at least 10 meters must separate the listener from the loudspeakers, in order to make the sound sources change in permanent movement (in the case of kinephonic music) without tiring the listener fixed in one place. The real center of the dome is a little below the horizontal line of the floor, allowing an enlargement of the sound dome and allowing more listeners the benefit of the ideal listening zone. Considering the trapezoidal shape of the hall, we decided to make an egg-shaped dome, well adapted to the proportions of the hall (see fig. 22).

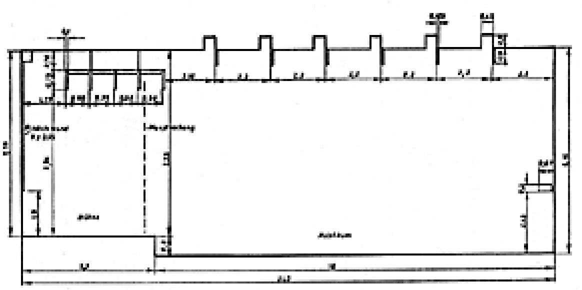


Fig . 22

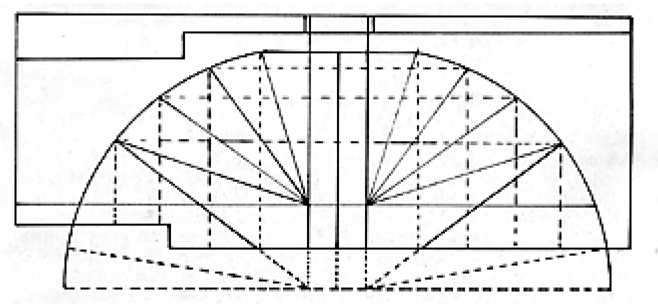


Fig. 21

Fig. 21: Longitudinal section showing the integration of the dome into the hall.

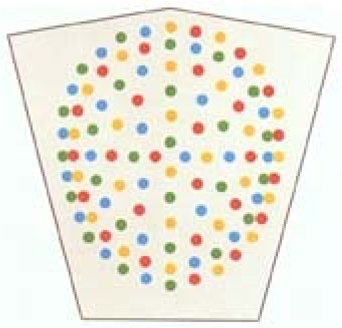


Fig. 24

Fig. 24: Spatial shapes determined by the position of the loudspeakers in the sound dome of Linz (seen from the top, which explains the shortening of distances towards the edges of the dome).

EXPERIMENTAL MODELS

For the study of the problems of the Linz Sound Dome, an experimental dome has been constructed. We studied problems of loudspeaker installation on the supporting structure, shapes and number of channels in relation to the dimensions of the hall as well as the general aesthetical aspects.

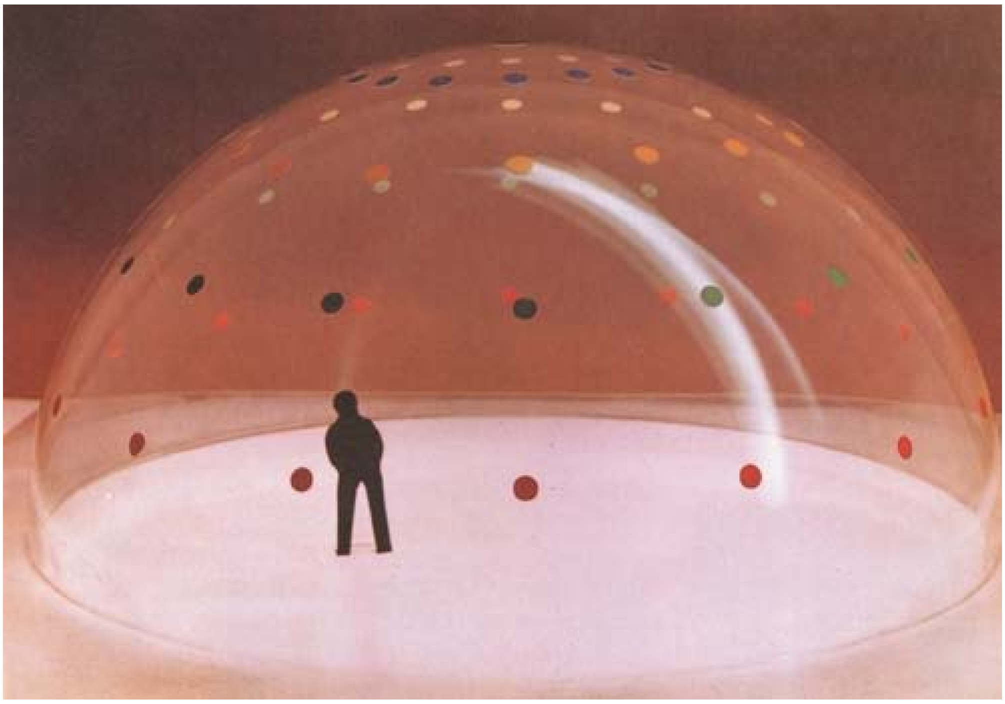


Fig. 23

Fig. 23: Experimental plexiglass dome for the study of suspension and diffusion problems of the Linz Sound Dome.

Starting from this model, we could ask ourselves the question about the necessary number of sound sources, about their density and the shapes of the spatial sound trajectories.

Knowing the areas of spatial perception we are able to design our dome as a function of this differential perception, not at all minimal (otherwise the dome would be overburdened with sound sources). We know that on the scale of pitch we can perceive up to 4000 different pitches. In the well-tempered system this number is considerably reduced (chromatical progression in half-tone steps). To be effective, the Linz Sound Dome had to undergo a spatial temperation process. Therefore we have realized experiments at the Studio de Recherches and we have found out for instance, that the interval c–d flat corresponds in spatial terms to an angle of 12 to 15 degrees. For different spatial perceptions of this kind in a dome of 20 meters in diameter we need from 100 to 120 sources. A hemisphere cannot be tempered in an equal fashion (even numbers). The divisions turn out to result in irrational numbers. Thus we have used 104 sources for a dome of approximately 20 meters. If we want to invent a new spatial instrument we will have to order this space: we must temper it. The anarchy of musical scales has never given birth to an articulated music and spatial anarchy will not bring forth an interesting spatial articulation. Thus we determined special scales allowing a logical-combinatory articulation. The colour indications represent the four channels: blue, red, green and yellow for channels one through four. We can diffuse one single signal or two to four different signals in the dome. See fig. 24.

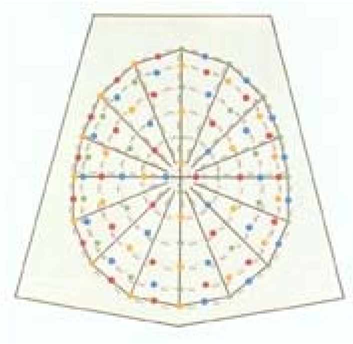


Fig. 25

Fig. 25 shows the general plan of the dome including the dimensions. By observing the colours you will notice that the sources are installed in spirals. Four spirals, symmetrical by pairs and opposed to each other, run through the dome from bottom to top. They are to allow a more reasonable playing by the interpreters. After our previous spatial experiences (Rome, Avignon) we wanted to avoid the total liberty of improvisation then available by prescribing pre-determined ways through the space (the spirals ascending and descending). Liberty to invent individual spatial ways is nevertheless preserved. The spatial musician is a rare bird still, and far from virtuosity. A pianist plays on 82 keys and spatial playing includes 104 faders–the combinations possible being thus quite numerous. Playing in the space needs a particular knowledge as well as good training. Fig. 26 shows the Italian composer F. Evangelisti playing one of this works on the manual "spatializer" at the sound dome in 1977 in Rome.

FUNCTIONS OF THE LINZ SOUND DOME

This is above all an instrument allowing the study of the problems of spatial diffusion. Then it is a new musical instrument with scales, forms, symmetries and an "articulation keyboard" allowing a new expression within the dimensions of sound space.

Music will be mostly electronic and computer music from pre-composed tapes. Some of the oeuvres were composed specially for this first performance in the sound dome (four track recordings); the spatial expansion of the dome will add a new dimension to these magnetic works (by the spatial shapes and the dialogue of the tracks, but also by the excellent quality of 104 high-fidelity channels).

Through the fact that the sound dome encircles the audience, the intensity and the value of listening are multiplied. The levels may remain quite low as the dynamics are also amplified (as the music becomes louder, more speakers are turned on) through the accumulation of speakers in function. Music distributed by a sound dome generally profits from the shape, the forms being rendered more clearly and the range of dynamics becoming larger and thus more expressive. The spectral presence (from the highest to the lowest frequencies) gives well-done works an almost tangible physical force. Melodical lines and phraseology are underscored, the counterpoint of the tracks is rendered audible through spatial dislocation, making the messages clearly distinguishable. With the spatial parameter an additional dimension accompanies the other parameters of music. Besides, spatial articulation exists also by itself: As one timbre (e.g. a viola) can reach different pitches, it is possible to divert the space for one single timbre, the importance being no longer the colour of sound but its placement in space. In this way, kinephony gives life to pre-recorded music.

By and by composers will produce space compositions just as they used to compose pitch music and the sound dome will be their instrument of composition and diffusion as organ and piano were for pitch. By that time the function of space will have reached a first stage of maturity giving an additional dimension to music, which was until now impossible for technical reasons.

THE SOUND DOME AND THE AUDIENCE

In the Philips Pavilion as well as in the Roman Dome the public was always very enthusiastic. Apparently this spatial function corresponds to a large social need. The perception of the sound space is in fact important for everybody and in daily life. The sound origin of objects, more that timbre or pitch, is fundamental for surviving. This parameter of perception concerns every human being. Besides, our actual world seems to develop the necessity of spatial comprehension since the sound objects have become more numerous and faster (automobiles, airplanes) and if we add that the conquest of outer space is an age-old dream, the interest of the public is easy to understand.

THE SOUND DOME AS MUSICAL INSTRUMENT

We must insist on the fact that the sound dome should not be considered a place of cheap sound effects, but a musical instrument, that it is important that the instrument be easy to play with (and to compose with) and thus it must be highly ordered (tempered) so that the musical spirit might easily find an inspiration in it. The geometrical idea, strongly present in the pitch scales already, acquires a superior dimension in the sound space–larger and more diversified. This geometrical space, with its possible symmetries, its controlled kinephonic movements, must allow the future composers to find a new way of expression (invention, imagination of sound shapes). It is self-evident that the instrument must be well-"tuned" and of technical quality (all the sources must be equal in terms of rendition, i.e. the pitch and the timbre of every channel must be identical as to allow the sound to glide from one channel to the next without affecting the geometrical position by its individual materiality). The spaces separating the sources must be as equal as possible to avoid spatial "holes" in the kinephonic movement or linear tracks of reinforcement by over-density of sources.

Those are the intentions and the technical requirements that will make space enter the music as a new real parameter, giving a new dimension to music, characteristic for our era and the future: space as a noticeable articulation of humanity equal to pitch and timbre. And it is in this way that the Linz Sound Dome will have marked a milestone in the development of the parameter of space–a dimension actually opening the way to the skies.

Leo Küpper, Studio de Recherches, Brussels 1984