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PRINT MARCH 1971

SOUND ARCHITECTURE

1. Definition

A LINE IS AN INFINITE series of points.

A line of sound is produced when sound moves along a series of loudspeakers, from one loudspeaker to another.

Space can be defined by lines.

Lines of sound can also define space: space-through-moving-sound.

1.1 Space Through Moving Sound

In many examples a large number of loudspeakers have been used to distribute sources of sound and eventually to produce a movement of sound in space. The examples are almost exclusively works by musicians and composers, i.e., the message is a musical one, whatever the definition of music is. The movement of sound in three dimensions, therefore space itself, is the message. Sound in space. *Music*.

Architectural space, however, is not a total message in itself. It makes something possible, but it becomes fully meaningful only when it is used in an appropriate way. The architectural space can be an indication of the content. Space created through moving sound is the frame for different kinds of activities and functions, a spatial experience for certain uses. The building material is sound, the abstract line of sound. Space through sound. *Architecture*.

1.2 The Motion of Sound

One is tempted to associate a musical composition with the word “sound.” In the context of space-through-moving-sound, “sound” is an acoustical stimulus comparable to the visual stimulus which allows spatial perception. But the use of the word “space” needs rethinking and redefinition: the distinction between a two-dimensional plane and a three-dimensional space is—visually speaking—clear and easy to make, whereas moving sound along an abstract circle in a plane cannot be perceived as an experience of a plane in the optical sense. It is unclear to a person located in the center of this circle what he is experiencing: is it a plane bounded by the line of sound or is it already a cylinder-space defined by the acoustical expansion of the line of sound? On the other hand it seems to be evident that the same person is able to measure the height of this sound-circle in relation to his body. (The radius is obviously of crucial importance.) He can tell whether it is at the level of the knee, at head level, or above.

It has been demonstrated that a spatial sensation is experienced when sound travels along an abstract three-dimensional line. But it is not a space all the boundaries of which can be experienced at once (“static space”) nor is it a space the boundaries of which change within a certain pattern (“dynamic, fluid space”). It is a space which is created and which fades away at the same time, portion by portion, with the development of sound in time. A line of sound can never be static. Lines of sound are the result of a continuous movement of sound. This is a new, not yet evaluated, very complex way to create space.

2. The Building Material for Sound-Architecture

A number of loudspeakers are distributed according to a specific spatial program in such a way that sound traveling between the loudspeakers defines an abstract line. This line will delimit the planned space. Sound is the material for both defining space in its dimensions as well as determining its character: *architecture which has its possibilities and limitations in the laws and principles of the world of sound.*

2.1 Time

The fundamental phenomenon of sound is its development in time. Architecture is basically static; time is introduced through changes in daylight, periods of different intensity of noise

and, above all, through the movement of people. Sound-architecture is in its essence an event of temporal development. Space is developed gradually in time. But it is not a space, it is a constant sequence of spaces.

2.2 Determinants of Space

Space is determined by the characteristics of the world of sound:

Speed—How fast or how slow space is produced.

Changing the speed

Timbre—Timbre is not essential for defining the boundaries of sound-architecture but certainly it is one of the critical factors for creating a distinctive character.

Changing the timbre

Pitch—Changing the pitch means psychologically changing the scale, dimensions, the quality of space. This is similar to some other specifics of sound.

Intensity—Using a very inaccurate comparison with the optical-touch world: a low-intensity-line of sound might be a “transparent” boundary; a high-intensity-line of sound, a noisy volume of sound, might correspond to a heavy, massive wall.

Changing the intensity

Rhythm—Rhythm in the sequence of spaces which are themselves created through lines of sound.

Pause—The duration of an interruption in the development of space. Theoretically this interruption is a “spaceless” situation.

Repetition—The only way to experience the same space over a longer period of time is to repeat it. It is evident, however, that new criteria have to be taken into account for this experience. For example, recognizing the space or waiting for the space.

Electronic sound, noise, human voice and language, as well as conventional instruments, are

the tools to express, define, and build sound-architecture.

3. The Material of the World of Sound

3.1 Laws, known

Generally speaking only the composer is expected to have control over the world of sound. Good composers know how to use the characteristics of the world of sound in a meaningful way. Somewhat simplified, the musical experience is described as an un-rational, emotional, almost magical phenomenon. “One is captivated.” This is an indication of the importance of the world of sound; at the same time it shows that the rationalization of the world of acoustics is far behind the exploration, the discovery already accomplished in the visual world. Our ears have not been educated yet.

Composers work with rules. They “know” the rules. The artist has control over both the perception of dimensions and the psychological dimensions of perception. Good compositions are “in tune.” The listener reacts as planned, not by chance. The strong design of a fugue by Bach is in no way more ordered or precise than the end of *Siegfried*. In both cases the measures, speed, changes of speed, pauses, etc., are not accidental. The material of the world of sound has been organized according to its own principles to convey a specific message.

3.2 Laws, unknown

To a large degree the psychological principles of the world of sound are still unknown today. The phenomenon of hearing is being investigated more as an isolated, anatomical question than as a comprehensive physical-intellectual experience. The importance of the acoustical environment is such that the ear should be able to measure it, to experience it consciously—but the ear itself is underdeveloped.

Among the already established facts the following seems to be of basic significance for sound-architecture: neurophysiological experiments have proven that acoustics are the critical lever for changing the level of brain activity. Specific musical elements produce specific unconscious nervous reactions.

Timbre and rhythm are already subjects of scientific experiments. At the University of Vienna,

for example, it has been demonstrated that a simple tone on an instrument has the same emotional impact upon most people. Further, it is known that only slight variations in the wave pattern of an electronically-produced sound significantly transform its expressive character.

Some subjects which have not been explored scientifically are speed, increase of intensity of sound, and pauses—not to mention the exploration and evaluation of various combinations of the different elements. This means that the importance of each of the elements comprising the world of sound has been recognized but has not yet been scientifically explored and evaluated. Even the composer's control over the sound-material is inadequate, if the elements have to be understood and redefined as building material for sound-architecture, for space rather than for music.

4. New Conditions—New Values

In the science of acoustics, dealing with consequences was and still is predominant: the message of a piece of music or of a speech is accepted as a fact and never questioned. The function of acoustics has been to create the best conditions for a desirable quality of reproduction for this message. Architectural space has had to fulfill these demands. The problem has been the distribution of sound in three dimensions from an accepted sound source. In sound-architecture the shape of space itself is defined by traveling sound. Defining space as a functional message has to be studied in acoustical terms. The separation between a message and the unrelated field of acoustic-technical reproduction is no longer possible. It would be absurd to ask acoustical engineers to take over the tasks of medical doctors or sociologists. But it will be essential that acoustical scientists and engineers participate in a creative way in defining the meaning and functional message of a specific space or spatial experience.

Sound-architecture is an overlapping of architecture and the world of sound. It creates new conditions for human behavior; new values in the fields of psychology, medicine, sociology and acoustics as well as for those we tend to consider specialists in sound or space, musicians and architects.

Some subjects for research:

How do acoustical changes influence space perception?—The influence of acoustics on balance and orientation.—The control of psychological variables (muscle stress, brain activity). Biopsychological experiments.—Fast transformation of a narrow space into a wide one and vice versa.—Simulation of street experience. Crowding versus openness.—Space created through traveling sound for medical purposes.—Acoustical space perception overlapped with visual space perception.—Sound-architecture as therapy.—Electrophysiological experiments.—Spaces for relaxation.

Both the proportions and the message of an existing space can be changed with lines of sound. To a long, neutral, exhausting corridor for a large number of people (in airports, for example) circling lines of sound are added transverse to the axis of the corridor at certain intervals: the corridor acquires an ornamentation, a new rhythm, is humanized and rescaled for the individual.

Sound traveling along an abstract line, between loudspeakers which are placed underneath an existing passageway, leads blind people, while at the same time it personalizes the passage.

The building material for sound-architecture must be evaluated scientifically and artistically, and the space created with this material must be analyzed as well. The properties of both building material and spaces are analyzed and quantified through empirical experiments. The results will either be inserted into existing systems or they will lead to new ones.

5. The Soundcube

5.1 Description

The Soundcube has a grid of loudspeakers on each of its six walls. The dimensions of the cube depend upon the particular situation. It is ideally “neutral” visually speaking, i.e. without any specific spatial message. The sound is programmed to travel from loudspeaker to loudspeaker. An infinite number of spaces or spatial sensations can be created.

5.2 Function

The Soundcube is not a space for producing music.

The Soundcube is an instrument for producing space (with sound). It is a laboratory for experiments and studies in environmental research, definition and character of space. At the same time it is a place for demonstrations and presentations of results to the public.

5.3 Spaces Created within the Soundcube

+Timbre of sound has not been considered in the following examples. The main purpose here is to describe the principle of spaces created by traveling sound.

++The notation of pitch follows classical notation. It should not be interpreted as a musical statement. It is an illustration of the simple but crucial relationship between pitch and definition of space.

5.31 SC-K # 3

Definition of space I (RK I): the tone starts to circle from loudspeaker #21 in the center of field “a” counter-clockwise. During the second half of the cycle it travels along the loudspeakers at the bottom of the walls. The duration of the cycle is determined by the speed of sound; half a cycle is sixteen and a half seconds long plus three seconds for changing the height of the line of sound plus a pause of half a second (total, twenty seconds). The full duration of RK I is forty seconds. Both pitch and intensity of sound vary during the development of RK I, thereby emphasizing the circular line of sound, the circling, the circle-shaped definition of space. Definition of space II (RK I) is equal to RK I, but mirror-like: the sound travels clockwise.

Each loudspeaker has a number and a letter indicating the field it is in. This allows an exact notation of the line of sound, i.e. the traveling sound between the loudspeakers. The distance between two loudspeakers is, in this case, two meters (6’8”). Definition of space (RK), speed of traveling sound (TG), pitch (TH) and intensity of sound (TL) are listed in a table.

A second table shows the sequence of spaces, the sequence and combinations of RK I and RK II. The determination of the sequence of spaces is the real architectural challenge—the creation and invention of space. A complex architectural statement can be made without changing RK I or RK II, only through repeating and combining RK I and RK II, or parts of them, in many different ways.

The sequence of spaces of SC-K # 3 can be subdivided in five sections: (a) In the beginning RK I and RK II are experienced together, then separately, but always as a full circle. (b) First overlapping: RK I starts, RK II starts half a cycle or 20 seconds later. Second overlapping: second half of RK II is overlapped with new beginning and first half of RK I. Another combination: second half of RK II overlapped with first half of RK II. (c) RK I + II are overlapped after 20 seconds by RK I + II. (d) Similar to (b). (e) This part is section (a), mirrored.

Each variation (definition of space RK being constant)—for instance, change of speed—effects a decisive change in the character of the space. By varying speed, pitch and intensity the number of possibilities for the sequence of spaces is infinite. Which of the countless possibilities will best correspond to the function and meaning of a particular space created through traveling sound, becomes the area of study.

5.32 Corridor

It is likely that the lines of sound as visualized graphically in the diagram will not define planes, which could be experienced, could be heard, as planes. But it is obvious on the other hand that the corridor's different borders will be experienced in significantly different ways. The bordering "planes" change the character of the corridor from path-in-the-plain experience to valley-like space.

The sequence of A - B - C - B - A - B - C - B - A, etc. is an up and down, waving, wing-like bordering of the corridor. This is shown at the beginning and the end of the sequence of spaces notation. In between, A, B, C are combined in different ways, including shifts in time: i.e. the corridor can have a very steep border on one side and a flat one on the other. The walls of a space can be changed continuously. A new dimension for architecture.

5.33 Swinging Space

Seven "circles" (I to VII), gradually changing their angle of inclination with the floor, are the elements for RK, i.e. for defining space. Circle IV is horizontal and parallel with the floor of the Soundcube. Different TG and TL of the elements **I to VII underline the different degrees** of the angle of inclination. I, II, III, mirror V, VI, VII. The sequence of spaces is a sequence of

RK and its inversion. The circling line of sound oscillates around an imaginary axis. The space swings.

The examples of space created within the Soundcube through traveling sound (5.31 and 5.33) are independent of and unrelated to the movement of people within these spaces. There is no substantial interdependence between the movement of the line of sound and the movement of a person.

6. Primary Space and Secondary Space Overlaid

Primary space is visually clearly determined.

Secondary space, created through traveling sound, defined by lines of sound, is continuously changeable.

6.1 Description

An architectural statement (gate, corridor, plaza) is overlaid by movements of sound which result in a qualitative transformation: the statement is either emphasized or deemphasized. Two of the following examples show an overlay of two movements, the movement of people and the movement of sound. Movement of people in a specific direction is provoked and underlined by sound developing in the same direction. Accompanying, guiding sound. Movement of people in a specific direction becomes more difficult if sound develops in the counter-direction. The primary space is defined by visual lines. Loudspeakers are mounted along those lines (for instance: in a tube). The secondary space is defined by lines of sound. Sound travels along the loudspeakers. The new quality is a consequence of overlaying these two spaces. This means both psychologically new dimensions of the space and a new character, a new message.

6.2 Examples

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++The notation of pitch follows the classical notation. It should not be interpreted as a

musical statement. It is an illustration of the simple but crucial relationship between pitch and definition of space.

6.21 Entrance

An endless tube circumscribes the funnel-shaped entranceway, leading to the entrance through gradually smaller gates and the narrowing of the way. Loudspeakers are placed inside the tube. Sound travels along this tube towards the entrance. The characteristics of the tone are described and fixed in the notation: the intensity of sound increases gradually towards the entrance, but it is taken back nine times during one development. Swelling maelstrom effect. Nine times the same half tone interval corresponds to the nine parts of increasing intensity. The speed of sound slows down towards the entrance proportionally to the size of the gates.

The acoustical drawing-in effect of the secondary space created by traveling sound emphasizes and enhances the already well-defined meaning of the funnel-shaped primary space.

Simply by reversing the sound program of this example one can change the drawing-in entrance to a throwing-out, pushing-out exit. On the other hand, it is conceivable to overlay the tube funnel with a theoretical opposite funnel of sound. Sound continuously moving away from the entrance makes it psychologically difficult for people to reach and penetrate the entrance.

6.22 Lane of Sound

An endless tube circumscribes an arcade-like lane. The lane is meant to be directional; people wander from one end to the other. Loudspeakers inside the tube allow the overlay of the desired direction of movement with movement of sound. The tone changes its pitch during one run along the entire tube (glissando up two octaves from the beginning to midpoint, glissando down two octaves from midpoint to the end), and it also changes its intensity (crescendo to midpoint and then decrescendo to the end). The second tone, A2, starts when the first tone, A1, has traveled one quarter of the lane's length. When A1 reaches midpoint and A2 has traveled a quarter then A3 commences, etc. It is a canon-like development of spaces created by traveling sound, like waves helping and leading people to move in the desired direction.

6.23 Soundplaza

Columns are located in the circumference of a circular plane creating a special place, a plaza. Loudspeakers are inside of each column and underneath the floor along a line from the bottom of each column to the center of the plaza. A new psychological quality or dimension is added to the plaza through movement of tones—similar to the phenomenon of a fountain on a plaza.

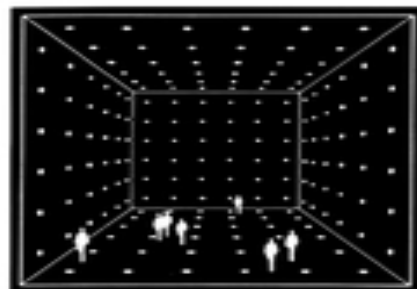
Five motions of sound are demonstrated: sound travels from all sides starting at the upper end of the columns towards the plaza's center (3). Or it performs the opposite (bowl creating) movement (1). Sound circles along the edge of the plaza, like a fence (2). The lines of sound form an ornament on the floor (4) or sound bounces up and down along the columns (5). The soundplaza can be overlapped with different activities like exhibition, market, assembly, according to the dimensions of the plaza.

Provided with a well-elaborated sound program, the soundplaza can take up a social-urbanistic function. The quality of the soundplaza can be constantly changed by varying the motions of sound, the motions of acoustical stimuli; therefore the programming of the plaza is of great importance. For two hours the soundplaza may have the audio-psychological value x, for another hour the value z; the following day it may have to react to different needs and new conditions.

A relaxing plaza, a plaza for meditation, a pulsating plaza, an amusing, a cheerful; a tragic, an exciting plaza.

The soundplaza. . . . a plaza as an instrument.

—Bernhard Leitner



SOUND ARCHITECTURE

Space created through traveling sound

1. Definition

A line is an infinite series of points.
A line of sound is produced when sound moves along a series of loudspeakers, from one loudspeaker to another.

Space can be defined by lines.
Lines of sound can also define space: space-through-moving-sound.

1.1 Space Through Moving Sound

In many examples, a large number of loudspeakers have been used to distribute sources of sound and eventually to produce a movement of sound in space. The examples are almost exclusively works by musicians and composers, i.e., the message is a musical one, whatever the definition of music is. The movement of sound in three dimensions, therefore space itself, is the message. Sound in space, Music.

Architectural space, however, is not a total message in itself. It makes something possible, but it becomes fully meaningful only when it is used in an appropriate way. The architectural space created through moving sound is the frame for different kinds of activities and functions, a spatial experience for certain uses. The building material is sound, the abstract line of sound. Space through sound, Architecture.

1.2 The Motion of Sound

One is tempted to associate a musical composition with the word "sound." In the context of space-through-moving-sound, "sound" is an acoustical stimulus comparable to the visual stimulus which allows spatial perception. But the use of the word "space" needs rethinking and redefinition: the distinction between a two-dimensional plane and a three-dimensional space is — visually speaking — clear and easy to make, whereas moving sound along an abstract circle in a plane cannot be perceived as an experience of a plane in the optical sense. It is unclear to a person located in the center of this circle what he is experiencing: is it a plane bounded by the line of sound or is it already a cylinder-space defined by the acoustical expansion of

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The fundamental phenomenon of sound is its development in time. Architecture is basically static; time is introduced through changes in daylight, periods of different intensity of noise and, above all, through the movement of people. Sound-architecture is in its essence an event of temporal development. Space is developed gradually in time. But it is not a space, it is a constant sequence of spaces.

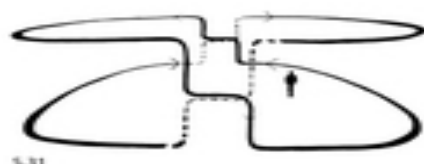
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BERNHARD LEITNER

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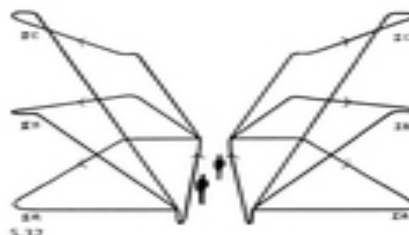
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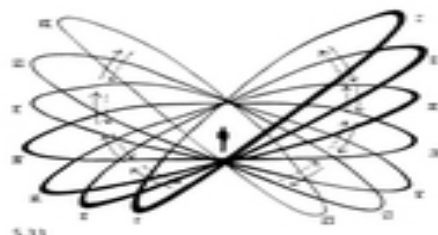
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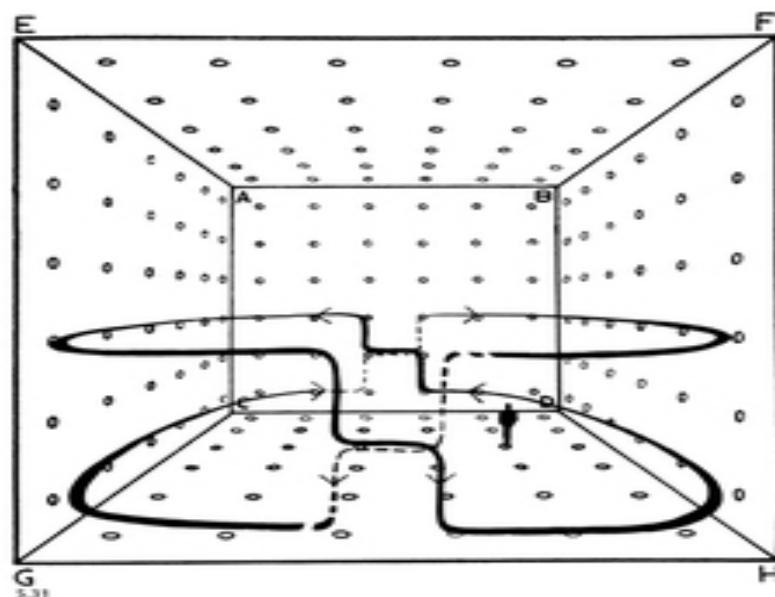
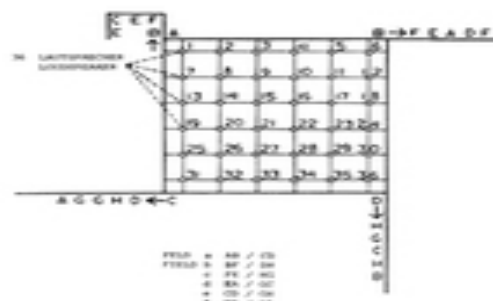
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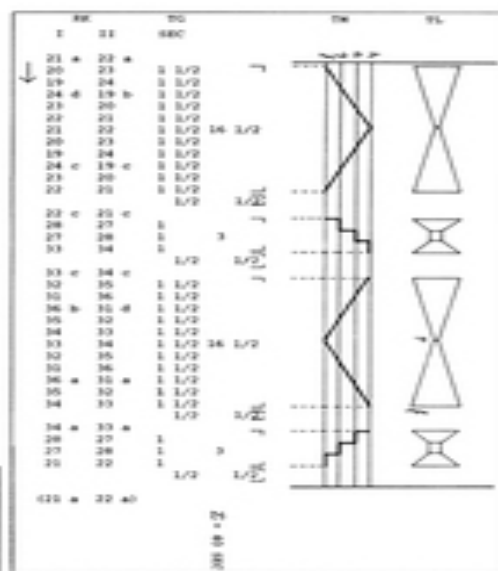
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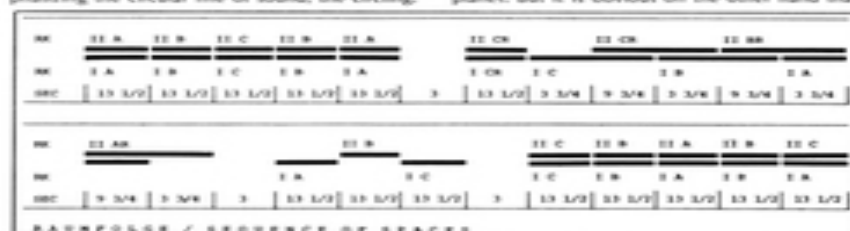
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5.3.1 SC-K # 3

Definition of space I (RK I): the tone starts to circle from loudspeaker #21 in the center of

field "a" counter-clockwise. During the second half of the cycle it travels along the loudspeakers at the bottom of the walls. The duration of the cycle is determined by the speed of sound; half a cycle is sixteen and a half seconds long plus three seconds for changing the height of the line of sound plus a pause of half a second (total, twenty seconds). The full duration of RK I is forty seconds. Both pitch and intensity of sound vary during the development of RK I, thereby emphasizing the circular line of sound, the circling.



5.32

the circle-shaped definition of space. Definition of space II (RK II) is equal to RK I, but mirror-like; the sound travels clockwise.

Each loudspeaker has a number and a letter indicating the field it is in. This allows an exact notation of the line of sound, i.e., the traveling sound between the loudspeakers. The distance between two loudspeakers is, in this case, two meters (6'6"). Definition of space (RK), speed of traveling sound (TG), pitch (TH) and intensity of sound (TI) are listed in a table.

A second table shows the sequence of spaces, the sequence and combinations of RK I and RK II. The determination of the sequence of spaces is the real architectural challenge — the creation and invention of space. A complex architectural statement can be made without changing RK I or RK II, only through repeating and combining RK I and RK II, or parts of them, in many different ways.

The sequence of spaces of SC-K # 3 can be subdivided in five sections: (a) In the beginning RK I and RK II are experienced together, then separately, but always in a full circle, (b) first overlapping: RK I starts, RK II starts half a cycle or 20 seconds later. Second overlapping: second half of RK II is overlapped with new beginning and first half of RK I. Another combination: second half of RK II overlapped with first half of RK I, (c) RK I + II are overlapped after 20 seconds by RK I + II. (d) Similar to (b). (e) This part is section (a), mirrored.

Each variation (definition of space RK being constant) — for instance, change of speed — effects a decisive change in the character of the space. By varying speed, pitch and intensity the

number of possibilities for the sequence of spaces is infinite. Which of the countless possibilities will best correspond to the function and meaning of a particular space created through traveling sound, becomes the area of study.

5.3.2 Corridor

It is likely that the lines of sound as visualized graphically in the diagram will not define planes, which could be experienced, could be heard, as planes. But it is obvious on the other hand that

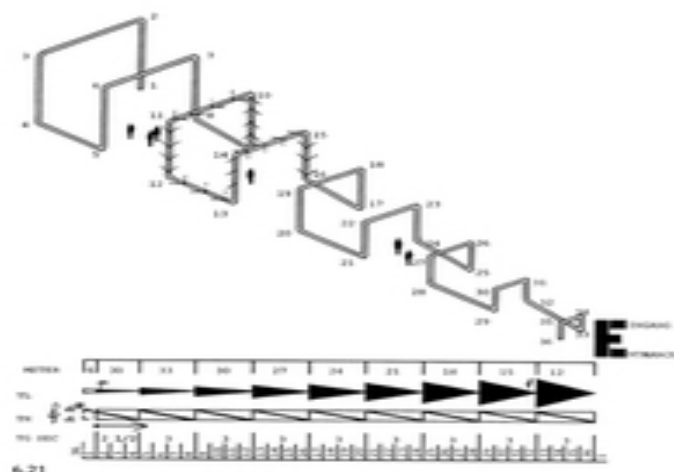
the corridor's different borders will be experienced in significantly different ways. The bordering "planes" change the character of the corridor from path-in-the-plain experience to valley-like space.

The sequence of A - B - C - B - A - B - C - B - A, etc. is an up and down, waving, wing-like bordering of the corridor. This is shown at the beginning and the end of the sequence of spaces notation. In between, A, B, C are combined in different ways, including shifts in time; i.e., the corridor can have a very steep border on one side and a flat one on the other. The walls of a space can be changed continuously. A new dimension for architecture.

5.3.3 Swinging Space

Seven "circles" I to VII, gradually changing their angle of inclination with the floor, are the elements for RK, i.e., for defining space. Circle IV is horizontal and parallel with the floor of the Soundcube. Different TG and TI of the elements I to VII underline the different degrees of the angle of inclination, I, II, III, mirror V, VI, VII. The sequence of spaces is a sequence of RK and its inversion. The circling line of sound oscillates around an imaginary axis. The space swings.

The examples of space created within the Soundcube through traveling sound (5.31 and 5.32) are independent of and unrelated to the movement of people within these spaces. There is no substantial interdependence between the movement of the line of sound and the movement of a person.



6.21

6. Primary Space and Secondary Space Overlaid

Primary space is visually clearly determined. Secondary space, created through traveling sound, is continuously changeable.

6.1 Description

An architectural statement (gate, corridor, plaza) is overlaid by movements of sound which result in a qualitative transformation; the statement is either emphasized or deemphasized. Two of the following examples show an overlay of two movements, the movement of people and the movement of sound. Movement of people in a specific direction is provoked and underlined by sound developing in the same direction. Accompanying, guiding sound. Movement of people in a specific direction becomes more difficult if sound develops in the counter-direction. The primary space is defined by visual lines. Loudspeakers are mounted along those lines (for instance: in a tube). The secondary space is defined by lines of sound. Sound travels along the loudspeakers. The new quality is a consequence of overlaying these two spaces. This means both psychologically new dimensions of the space and a new character, a new message.

6.2 Examples

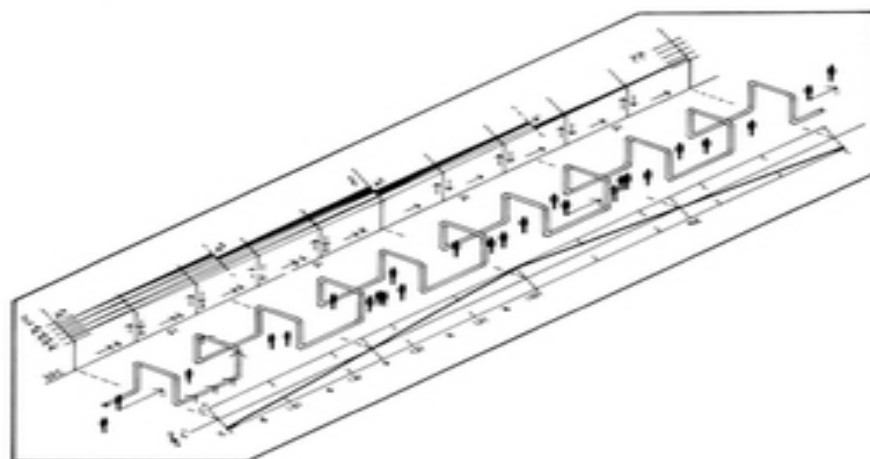
- Timbre of sound has not been considered in the following examples. The main purpose here is to describe the principle of spaces created by traveling sound.
- The notation of pitch follows the classical notation. It should not be interpreted as a musical statement. It is an illustration of the simple but crucial relationship between pitch and definition of space.

6.21 Entrance

An endless tube circumscribes the funnel-shaped entranceway, leading to the entrance through gradually smaller gates and the narrowing of the way. Loudspeakers are placed inside the tube. Sound travels along this tube towards the entrance. The characteristics of the tone are described and fixed in the notation: the intensity of sound increases gradually towards the entrance, but it is taken back nine times during one development. Swelling maelstrom effect. Nine times the same half tone interval corresponds to the nine parts of increasing intensity. The speed of sound slows down towards the entrance proportionally to the size of the gates.

The acoustical drawing-in effect of the secondary space created by traveling sound emphasizes and enhances the already well-defined meaning of the funnel-shaped primary space.

Simply by reversing the sound program of this example one can change the drawing-in entrance to a throwing-out, pushing-out exit. On the



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