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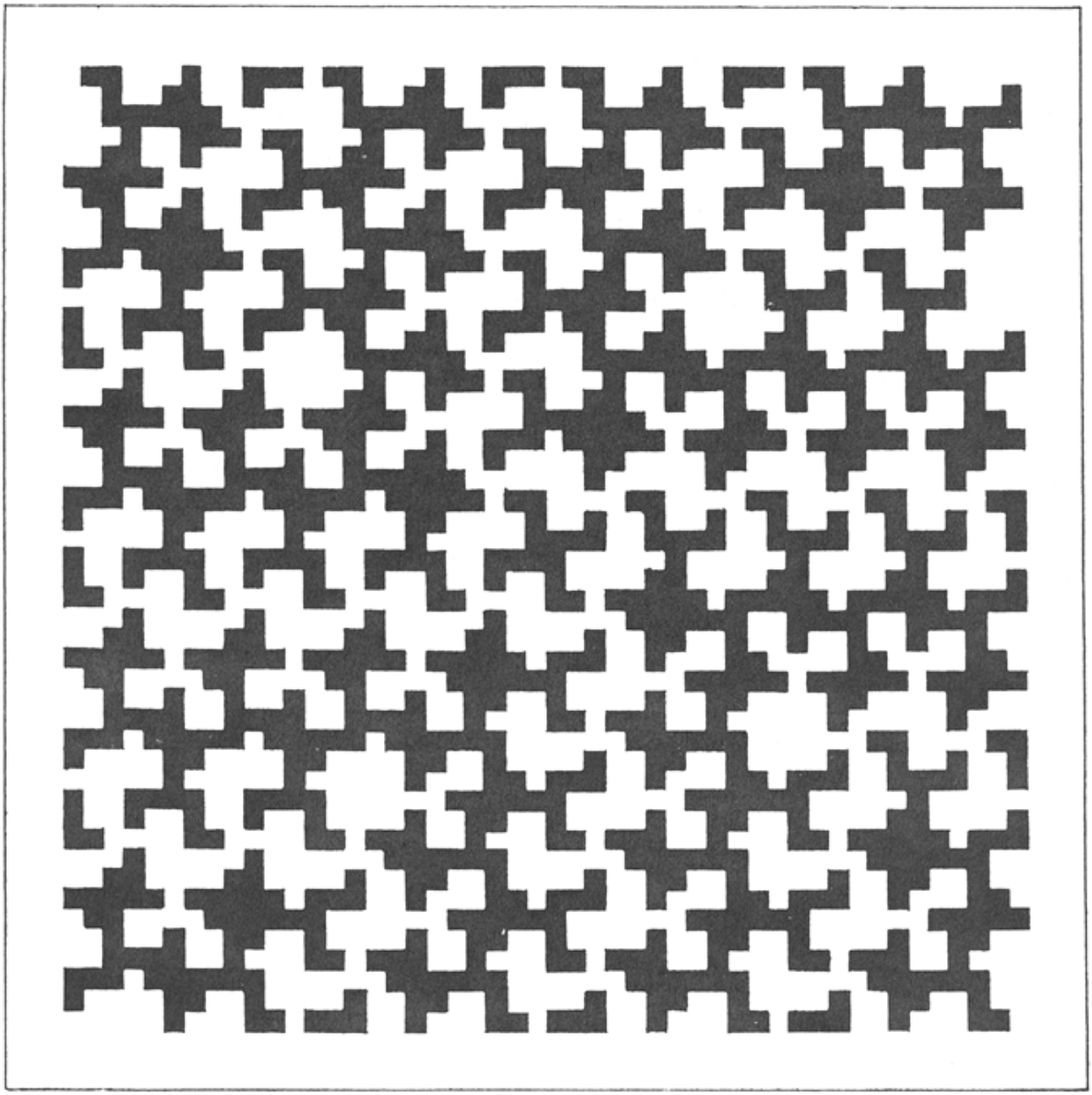

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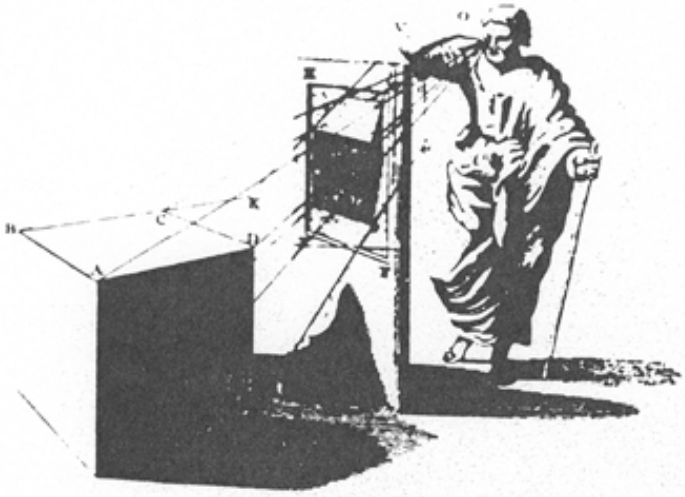
Contents:



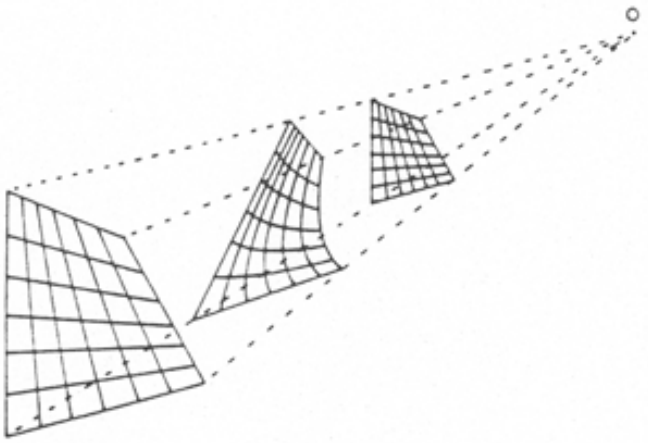
1. The pyramid of sight [1]

Mathematical Analysis of the Works of Hans Peter Reuter. **Ulrich Grevsmuhl.**

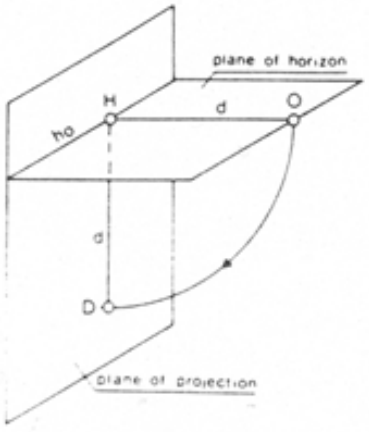
Abstract: Constructions of linear perspective in the paintings and drawings of Hans Peter Reuter are investigated and analysed over a period of nearly twenty years by determining the parameters of inner orientation and the circle of sight. The analysis reveals that the proportion of the distance d to the length L of the larger side of a picture, which is chosen implicitely in the construction and intuitively by the artist, is an important measure for distortions in the painting. When the principle point H is located near the centre of the picture, a value of 0.8 for this proportion is a lower limit where no distortions occur and where the works tend to be more harmonious. Reuter's latest works show a tendency to use values between 0.5 and 0.6 which produce moderate distortions inducing tension.

Hans Peter Reuter (born 1942 in Schwenningen, lives and works in Karlsruhe and Nurnberg, West Germany) explores in his works the themes light, space and structure for more than twenty years and is well known for his paintings and drawings of tiled rooms and public baths. His rooms are usually painted in shades of blue and are of strict order and clarity without a trace of persons or objects. Within concrete and constructive art he takes a special position as it is his achievement to rediscover linear perspective as a means of systematic construction in the modern sense of art and as a mathematical system to represent his spatial visions in two-dimensions.

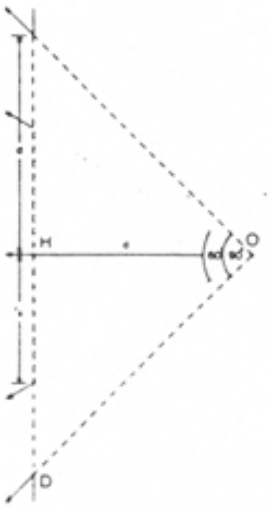
The principle of linear perspective is based on the physical law that light propogates rectilinearly in a homogeneous medium, and that consequently our view is normally confined to staight lines. The mathematical construction is defined by the central projection of the objects to be represented upon the plane of the picture. The centre of the projection O is the point in the spectator's eye which is the apex of the visual angles. The two dimensional representation of the object is the cross-section of the visual cone or pyramid of sight. (fig.1, [1])



2. Equivalent configurations as seen from a fixed eye-point O.



3. The inner orientation of a picture is determined by the horizon ho, the principle point H, the orthogonal distance d and the distance point D.



4. Side view of the circle of sight with the radius $r_s = d * \tan 30$ and the circle with radius d.

It is important to note that although the central projection is a one-to-one transformation, linear perspective is not reversible. This fact is illustrated in fig.2 by a number of grids. When all corresponding points of the grids are situated on the same light ray or line of sight, the grids cannot be distinguished from the centre of projection by the viewer and the perspective pictures are the same. For the central projection in fig.1 this implies that there are an infinite number of objects and equivalent configurations which may be fitted within the pyramid of sight in such a way that they produce the same image in the plane of projection and in the spectator's eye. [2]

When an object is drawn in linear perspective, certain mathematical parameters by which the central projection and the construction of the perspective representation is defined can be determined. The 'inner orientation' is defined by four parameters (fig.3): the horizon ho, the principle point H, the orthogonal distance d and the distance point D. Once these are set, the plan elevation of an object can be constructed. If the length of the side of an object is known, the scale of the picture can be determined. This is called 'outer orientation'.

For the analysis it is essential that a fixed eye at rest can only see that part of the room without distortions that lies within a visual cone with an angle of approximately 60° (fig.4). When the spectator's eye coincides with the centre of projection D, the visual cone intersects the plane of projections in the circle of sight and determines the zone where no distortions occur. If the viewer's direction of sight is orthogonal to the plane of projection, the circle of sight has as its centre the principle point H and a radius r_s which is approximately 0.58 times the distance d.

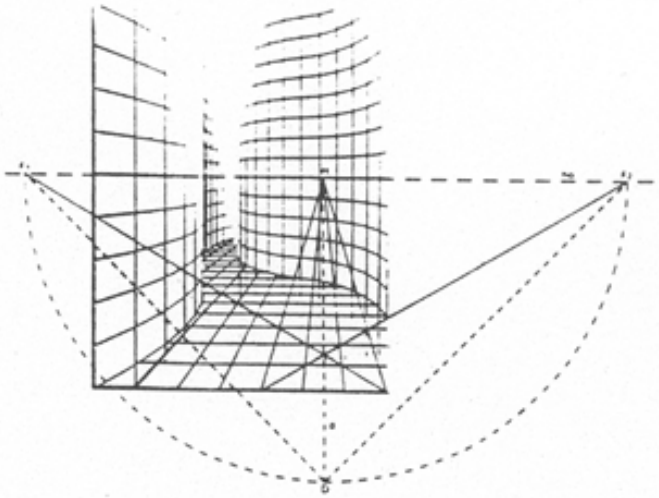
If one takes into account that an eye can rotate in its orbit, the visual cone, assuming a fixed position of the head, is enlarged to an angle of 90° and now intersects the plane of projection in a circle with radius d (fig.4). This means that with a single eye only those parts of a picture can be viewed from the centre of projection D which are within the circle with radius d. Parts of a picture which are outside the circle of sight but within the circle with radius d are only seen without distortion when the spectator's eye is in the centre of projection D. Outside the circle with radius d all parts of a perspective representation are always seen strongly distorted.

For the analysis of perpective representations in works of art additional mathematical parameters are required as measures for the distorions which may occur in a picture. These are the proportions of distance d and radius r_s of the circle of sight to the length L of the larger side of a picture. To make sure that the total picture is within the circle of sight and does not show any distortions, painters in previous centuries often located the principle point H near the centre of the picture and chose the distance d one-and-a-half times larger than the largest side of the frame, ie d:L=1.5.

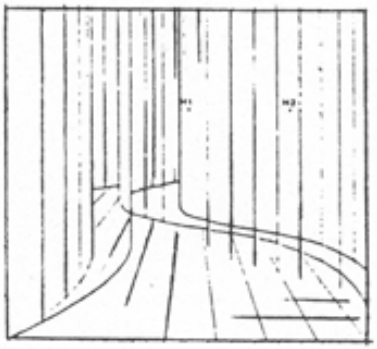
An example of a simple reconstruction is shown in fig.5 for Reuter's 'Licht-Raum(318)' which reveals the dynamics of this picture. The spectator attempts to look towards the end of the room and around the corner but is distracted at the same time by the orthogonal lines of the tiles leading to the principle point H. As this point is located in the right-hand side of the picture and as the parameter r_s :L is relatively small, the circle of sight does not cover the whole picture such that distortion is visible in the left and bottom rows of the tiles. The principle point H acts here as an invisible anti-pole to the centre of the picture. It is interesting how Reuter develops the interplay of pole and anti-pole in his working drawing (fig.6) by shifting and replacing the initial principle point H1 in the centre of the picture.

In carrying out the mathematical analysis of Reuter's works, reproductions of 49 paintings and drawings between 1969 and 1986 were chosen and methods of reconstruction were carried out to determine the parameters discussed above. The works show two lines of development which may be illustrated by the series 'public baths' ('Stadtbader', until 1976) and 'rooms with pillars' (from 1977 onwards). Further themes like 'mirror rooms' or 'curved rooms' may be fitted into the development of these two main themes.

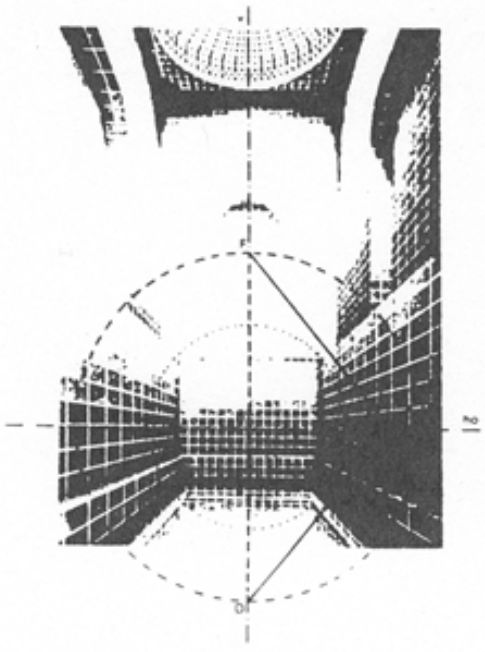
The construction of linear perspective leads to an ideal room which does not exist in reality. Reuter employs the central projection as a mathematical system to express his spatial visions. As was shown in fig.2 the representation of the third-dimension implies an ambiguity. Pyschological experiments on perception have shown that our perceptions do not reveal the reality but pick out , ie "see" these things that appear to us most likely or most simple or that we already know. Reuter achieves the illusion of spatial depth as Renaissance artists did by painting tiled floors and using the expectations of the spectator who assumes that the floor is flat and that all tiles have the same size and shape and who interprets their progressive reduction and foreshortening as spatial depth [3].



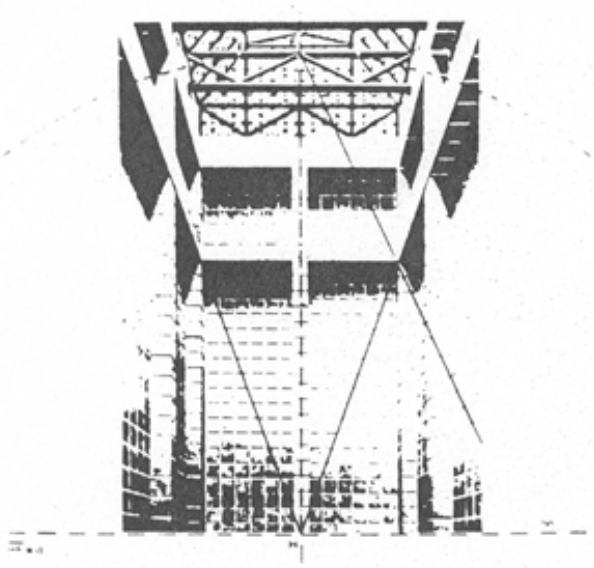
5. Licht-Raum(318) 1984 screen print 45*35cms.
d=36cms, r_s =21cms, d:L=0.80, r_s :L=0.47



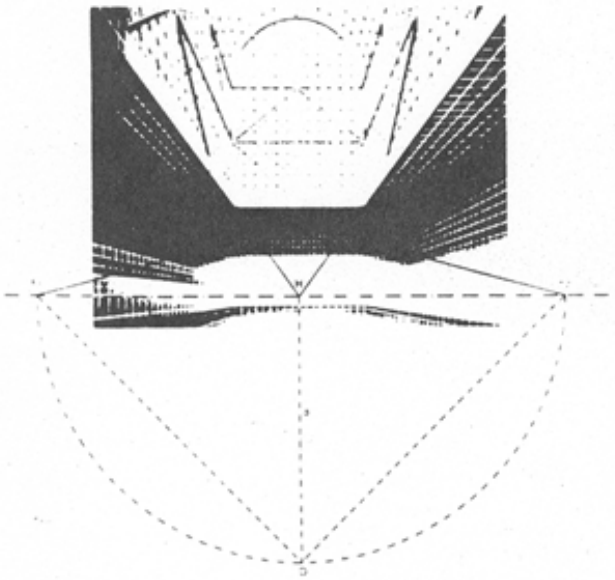
6. Working drawing to Licht-Raum(318) 1984, 52.8*38.9cms. The principle points H1 and H2 are indicated.



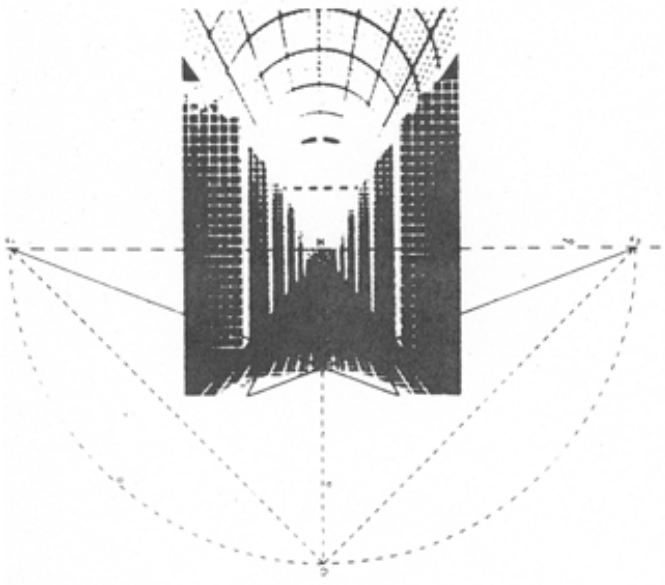
7. Stadbad ohne Ding Nr.47+48 1971, oil on canvas, 200*150cms. d=68cms, r_s =39cms, d:L=0.34, r_s :=0.20



8. Stadbad ohe Ding Nr.54 1973, crayon on paper, 70*50cms. d=66cms, r_s =38cms, d:L=0.94, r_s :L=0.54



9. Stadbad ohne Ding Nr.56+57 1973, oil on canvas, 150*200cms. d=127cms, r_s =74cms, d:L=0.64, r_s :L=0.37



10. Stadbad ohne Ding Nr.89-91 1975, oil on canvas, 250*150cms. d=203cms, r_s =118cms, d:L=0.81, r_s :L=0.47

But linear perspective is not only a means of depiction, for Reuter. The exploration of the mathematical system of central projection is at the core of his systematic study. However, it is important to realise that Reuter does not calculate the size of the mathematical parameters but when carrying out his constructions, he chooses them intuitively in order to create distortions or hidden focal-points by which the architecture of the picture is being dramatized. The spectator realises that these rooms do not exist in reality and only come into existence in the realm of two-dimensional space. He sees the illusion of reality or the reality of illusion or even the illusion of an illusion and becomes aware of his own perceptions.

The following examples illustrate the development of the theme 'public baths'. 'Stadtbad ohne Ding Nr. 47+48 (fig.7) is one of the earliest works of this series and as with all works of this period, it is characterized by an imperfect construction which has been only partially carried out. The value for the distance d can be determined only approximately as the foreshortening of the tiles has not been chosen correctly and consequently the diagonals of the tiles do not lead to the same focal point. Assuming that the tiles are squares, one finds an extremely small circle of sight covering only the lower part of the picture as well as strong distortions outside of the circle with radius d.

In his later works Reuter makes use of better constructional procedures although smaller faults in the construction occur frequently. In the public baths Nr.54 (fig.8) and Nr.56+57 (fig.9) the horizon runs at or near the bottom of the picture. In both cases the parameters are chosen in such a way that the circle with the radius d covers most of the picture. A peak in this development is achieved in 'Stadtbad Nr.89-91' (fig.10). Here the spectator's view is drawn along the focal lines into the wide interior with its symmetric architecture. The whole picture is very harmonious as no distortions are visible and the horizon divides the height of the picture according to the proportions of the golden section. When the principle point is, as in this case, located near the centre of the picture and the proportions d:L and r_s :L take values of 0.8 and 0.5, respectively, the circle of sight covers nearly the whole picture. These values may therefore be taken as lower limits where no distortions occur.

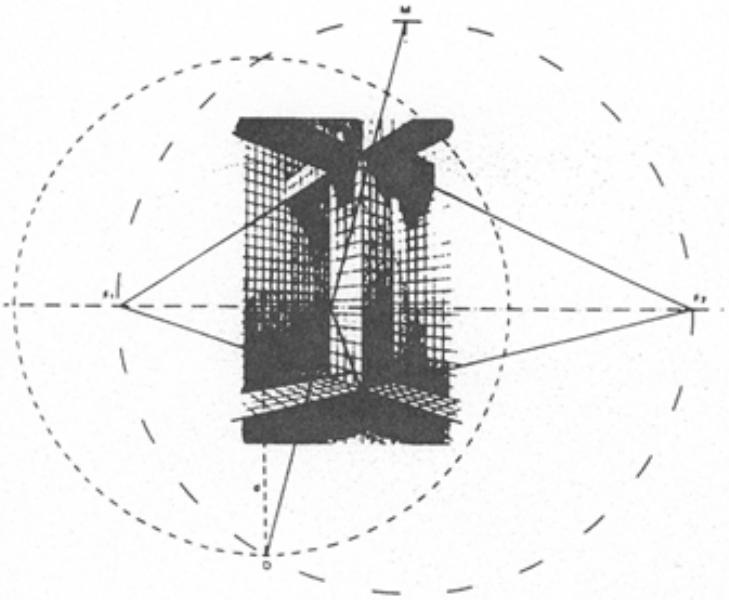
The works on the theme 'rooms with pillars' reveal various forms of representation of pillars with orthogonal sides and supporting beams. 'Raumkreuz (135)' and Raum (137)' both show principle points which, as a result of the asymmetrical representation, are dislocated from the middle line to the left. In fig.9 the construction leads to a value

for the distance d which is smaller than the distance of 25 to 30cms below which the eyes cannot accomodate without seeing distortions. Fig.12 is one of the few examples where the principle point is positioned outside the picture. The circle with radius d does not cover the right pillar. As in fig.10 distortions here are avoided by taking large values for the distance d and the radius r_s and showing the tiles in frontal view.

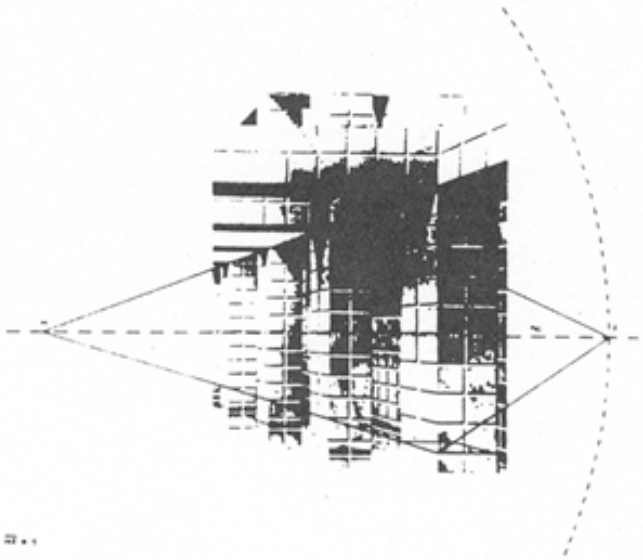
In the light-rooms (330) and (399) (fig.13 and 14) the spectator's eye is caught by the massive pillar and the supporting beams. In both works the analysis reveals a small circle of sight which covers approximately only half the area of the picture. Although the circle with radius d covers nearly the whole picture, the small value for the proportion of distance d to the larger side L of the picture has the effect more than in other works that the central projection O is relatively close to the picture. This is particularly noticeable in 'Licht-Raum (399)' where as a result of the large side of the painting (200 x 150cms), the spectator will automatically step back in order to view the whole of the picture. But then his/her eye is no longer in the position of the centre of projection O. The cross-beam with its strong distortion appears heavy and threatening.

'Licht-Raum (399)' forms in a similar way to 'Stadtbad ohne Ding Nr.89-91' a peak in the development of this theme. In this work Reuter achieves spatial depth leading to infinity by showing a series of exits which are arranged one after another. Assuming that the building is made out of cubic stones or quadratic tiles with edges of 20cms length, one finds by simply counting the number of visible tiles that the height of the ceilings increases rapidly. While the visible part of the pillar below the cross-beams has a length of at least 1.80m, the other exits have heights of at least 2.80m, 5.00m, 6.10m, 10.00m and 22.00m respectively. The construction of linear perspective leads here, as in many other of his works, to a very questionable reality. The spectator sees a room where the threatening appearance of the cross-beam, the depth of the missing floor and the maze of the exits induces a field of strong tension confronting her/him with a state which can not be resolved.

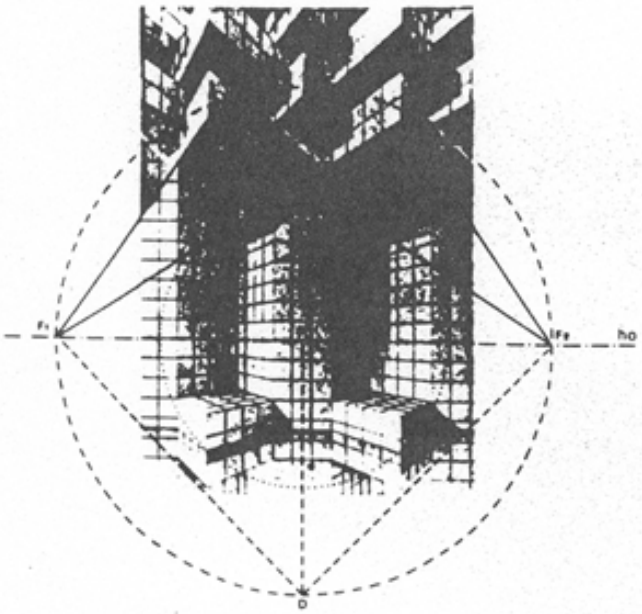
The mathematical analysis of Reuter's works from 1969 to 1986 shows for the proportion d:L a range of values from 0.3 to 1.5 revealing the artist's joy of investigation and experiment. Whereas his first paintings employ for the perspective construction very small values between 0.3 and 0.4 and as a consequence of this show strong distortions of the architecture, the values for this proportion increase until 1979. In 1975 an



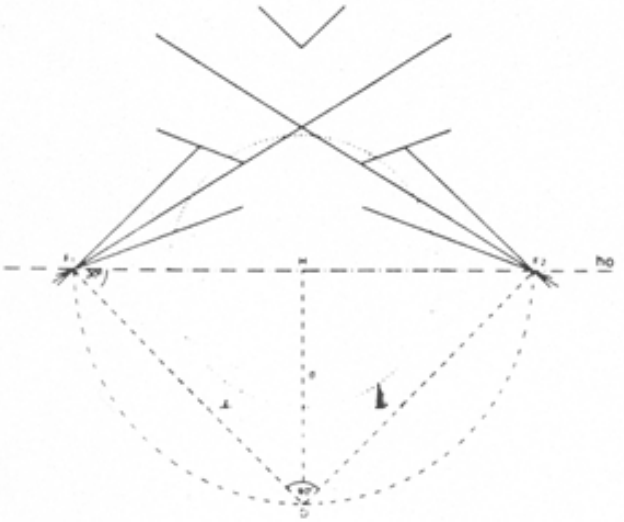
11. Raumkreuz (135) 1978, crayon on paper, 27*17cms.
d=21cms, r_s=12cms, d:L=0.78, r_s:L=0.44



12. Raum (173) 1979, water colour/gouache, 64*50cms.
d=96cms, r_s=56cms, d:L=1.50, r_s:L=0.88



13. Licht-Raum(330) 1984, water colour, 50*35cms.
d=26cms, r_s=15cms, d:L=0.52, r_s:L=0.30



14. Licht-Raum(399) 1986, oil on canvas, 200*150cms.
d=117cms, r_s=68cms, d:L=0.59, r_s:L=0.34

intermediate peak in the development is reached by creating public baths with values near 0.8 which show no distortions and are more harmonious (fig.10). After 1979 the tendency is to use smaller values again. In recent years his works employ values of 0.5 to 0.6 and show more sophisticated constructions than previously, coupled with more subtle tension.

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[1] B.Taylor, **New Principles of Linear Perspective**, London, 1715; 2nd Edition, 1719; 4th Edition, 1811.

[2] B.R.Carter, 'Perspective' in: H.Osborne (Ed.), **The Oxford Companion to Art**, Oxford, 1970, pp.840-861.

[3] E.H.Gombrich, **Art and Illusion**, Phaidon Press, 1977.

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