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Axonometry and New Design of Bauhaus

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Abstract. In this paper we analyze and clarify the relationship between the use of axonometry and the new design tendency of Bauhaus. First we analyze the three characteristics of axonometry: 1) an image of appearance and an image of objects themselves — their ambivalence, 2) a tendency from a limited world with a human center to one already fixed infinite world of objects, 3) engineer's language.
Then we analyze the new design of Bauhaus, we point out the following three characteristics corresponding to axonometry: 1) from an image of appearance to an image of objects themselves, 2) co-existence of a limited world with a human center and one already fixed infinite world of objects, 3) a tendency toward seeing a building as a 'machine'.
In short, the main characteristic of axonometry as a visualization tool is the objectification of vision. This tendency is less explicit in isometric projection, which is one of orthogonal projections having characteristics similar to perspective, than in military projection which does not simulate individual's view, as this paper clarifies. Bauhaus in the early years maintained an individual's subjective, individual vision by using isometric projection. On the contrary, other contemporary modernists such as De Stijl used only military projection. The use of military projection implies that in its extreme pole there is no need of individuals' existence. For military projection does not simulate individual's view. The tendency of later Bauhaus design toward 'Neue Sachlichkeit' corresponds to this implicit characteristic of military projection. We could find this tendency most explicitly in a drawing of H. Meyer, second director of Bauhaus, who followed Gropius.

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1. Introduction

Axonometry and perspective are useful tools to represent 3-D objects. But an architect as a designer had not used axonometry, but used perspective almost exclusively in the field of

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architecture until 19th century. The conscious use of axonometry started in early 1920's [2]. Leopold surveyed the uses and effects of axonometries from a historical view point [9].

For example, Gropius declared in 1923 that Bauhaus avoided old academic perspective and developed a new spatial representation tool known as *'axonometry'* [4]. His referring axonometric drawings were those of isometry which was one of orthogonal projection [5]. In the same year De Stijl's exhibition was held and their axonometric drawings influenced the other modern architects such as Le Corbusier. But their axonometry is of military projection where the top view is undistorted. In its early years, Bauhaus used isometry, but later used military projection.

In this paper we will analyze and clarify the relationship between the use of axonometry and the new design tendency in Bauhaus, comparing this with other contemporary modern designs such as those of De Stijl.

2. Characteristics of axonometry

We would like to discus first the two following views:

1) the form image without distortion should be important as shown in an elevation,
2) the apparent image with distortion should be important as shown in a perspective.

The argument about the difference between those two images can be traced back to Plato. According to M. Sekimura, Plato called the image which expresses the object's size correctly *'eikon'*, and distinguished it from the image called *'fantasma'* where sizes are altered considering the change of dimensions in the appearance [11].

There is a following argument also in the Renaissance era when the modern perspective method was devised: which should be used as a method of expressing architecture, geometrical drawings (a plan or elevation) or perspective drawings? Raphael says in *'a letter addressed to Pope Leo X'*.

"Because the manner of drawing employed by an architect is different from that of a painter, I shall describe the way that seems to me appropriate for the communication of the measurements and the location of all the elements of a building without error. ... In these drawings (elevation), there should be no foreshortening at the extremities (even if buildings are round or square) to show both sides, because the architect cannot obtain measurements from perspective drawings; it is essential in his art that the measurements are absolutely exact and all the lines parallel, conveying the reality and not semblance" [6].

Raphael says that an architect should adopt a means of expression that treats the true form instead of the apparent image.

2.1. An image of appearance and an image of the object itself — their ambivalence

According to projection theory, axonometry is a parallel projection as those used in an elevation drawing. In order to express the upper surface and the side simultaneously, in addition to the front, objects are projected in an oblique direction or set on the oblique in axonometry. Parallel lines in axonometry are projected onto parallels like in an elevation drawing. But an angle generally changes. Although length also changes according to a scale, length (size) can be known easily if the scale is taken into consideration.

It can be said that:

1) in that the angle is distorted as it is in perspective, axonometry is a representation of an apparent image,

2) axonometry is far from an *'eikon'* and close to a *'fantasma'*,

3) because of expressing the size of the object correctly instead of an apparent image, it would be geometrical like an elevation drawing.

In short, an axonometric drawing is an image ambivalently equipped with the two characteristics: an image of appearance and an image of the object itself.

2.2. A tendency from a limited world with a human center to one already fixed infinite world of objects

El Lissitzky has stated in *'A. and Pangeometry'* that,

"perspective limits space; it has made it finite, closed. ... Suprematism has extended the apex of the finite visual cone of perspective into infinity" [3].

It does not need to be said that he had axonometry in mind as opposed to perspective. As he says, perspective limits space within the visual field, and the man has a fixed perspective. So we can say that perspective is a means expressing 'the limited world where the human center is fixed'.

As opposed to perspective, axonometry has the following characteristic as a result of moving the apex of a visual cone to an infinite point: a solid image does not change even if the viewpoint moves, for a solid image is an intersection of a projection plane and the parallel visual lines which pass an object. In other words, axonometry has the fixed image already prepared on a projection plane which spreads infinitely. We are only looking at the image. That is, irrespective of a viewpoint, the world of objects can be expressed beyond a visual field and we look at 'the infinite world of objects prepared beforehand'.

In fact, this characteristic of axonometry had not been taken into consideration so intentionally until El Lissitzky first recognized it. Axonometry had been considered a kind of perspective that was easy in manual drawing construction. And it had been restricted to the two methods understandable easily:

1) axonometric top view (military), which is constructed by elevating a plan,

2) axonometric front view (cavalier), which is constructed by giving depth to an elevation.

The completed projection theory of axonometry was first described by W. Farish in the 19th century. It is in 19th century that a noun 'axonometry' was coined and it was completely separated from perspective. Axonometry has been independent both theoretically and practically as an expressive medium from perspective since then.

2.3. Engineer's language

Another characteristic of axonometry is that the diffusion of axonometry was delayed in the field of architecture, especially among architects as designers, and the diffusion is most noticeable in the field of engineers' education.

We can see here the third characteristic: axonometry as an engineer's language vs. perspective as a designer's language.

3. Characteristics of Bauhaus design

Bauhaus design had the following tendency:

1) that of 'expressionism' in the early years,

2) that of 'Neue Sachlichkeit' in the later years.

We will see the shift in this chapter.

If we take the use of axonometry into consideration, we can point out the following three characteristics in new design of Bauhaus, corresponding to the three characteristics of axonometry.

1) From an image of appearance to an image of objects themselves.
2) Co-existence of a limited world with a human center and one already fixed infinite world of objects.
3) A tendency toward seeing a building as 'a machine'

3.1. From an image of appearance to an image of objects themselves

The image of objects changes in perspective; the image of objects is distorted and their size changes according to the position of the viewer. Because perspective depends on the position of the viewer, we can see serious appreciation of the appearance (vision) in the background of perspective.

In contrast to perspective, axonometry does not have changes of the image according to the movement of a viewpoint. So we can say that the objects themselves are more important than the vision.

Bauhaus adopted isometric projection from the beginning (Fig. 1: left). But De Stijl exclusively adopted military projection (Fig. 1: right). The left is a drawing of the director's office in the Weimar Bauhaus, which is designed by Gropius and drawn by H. Bayer. The right is a drawing of the case study house (Versuchshaus) am Horn, which is designed by G. Muche and drawn by B. Otte. We would like to call attention to this difference. In order to understand the meaning of this difference, we have to look at axonometry still more carefully.

There are two kinds of axonometry which differ in their projection method: oblique axonometry and orthogonal axonometry. The former consists of two subdivisions: military

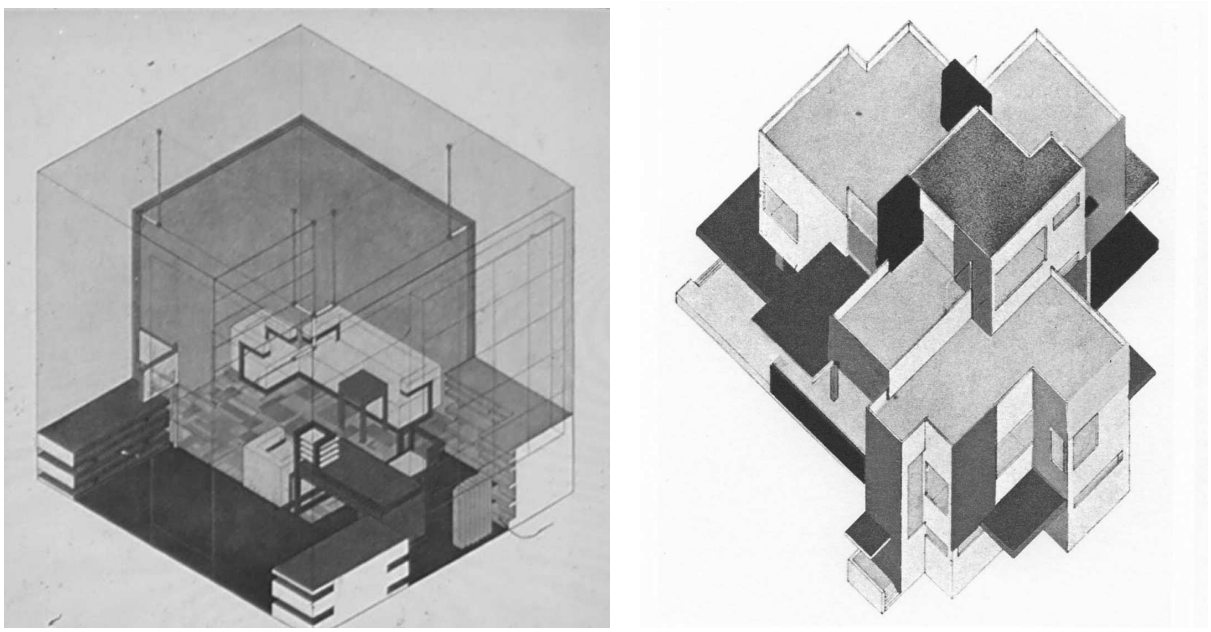

Figure 1: Difference of axonometry between Bauhaus and De Stijl
the left is shown in [5, pl. XI], the right is shown in [1, pl. 5]

projection (axonometric top view) where a top view is undistorted and cavalier projection (axonometric front view) where the front view is undistorted.

However, the image of oblique axonometry differs from the copy of man's retinal image. We can check this with model photographs which are those of the model in order that Eisenman might show the fictional nature of oblique axonometry (Fig. 2).

The left photo is similar to an axonometric top view. But when the model is photographed from a different position, the photo is at right. In the left photograph the model is seen to be a cube, but the right photo shows that the model differs completely from a cube. This suggests that oblique axonometry (such as axonometric top view) cannot been got by looking at objects directly. So strictly speaking, oblique axonometry is not an image produced by the direct result of seeing an object.

We do not see but read a solid from oblique axonometry. In other words, the true shape of object has been given beforehand in oblique axonometry and we recognize it through seeing. Axonometry has not an apparent image of object but both the form and the size of object. This should be called 'a recognized form' as opposed to the image in perspective. That is, oblique axonometry is a means of expression that treats the recognized form directly.

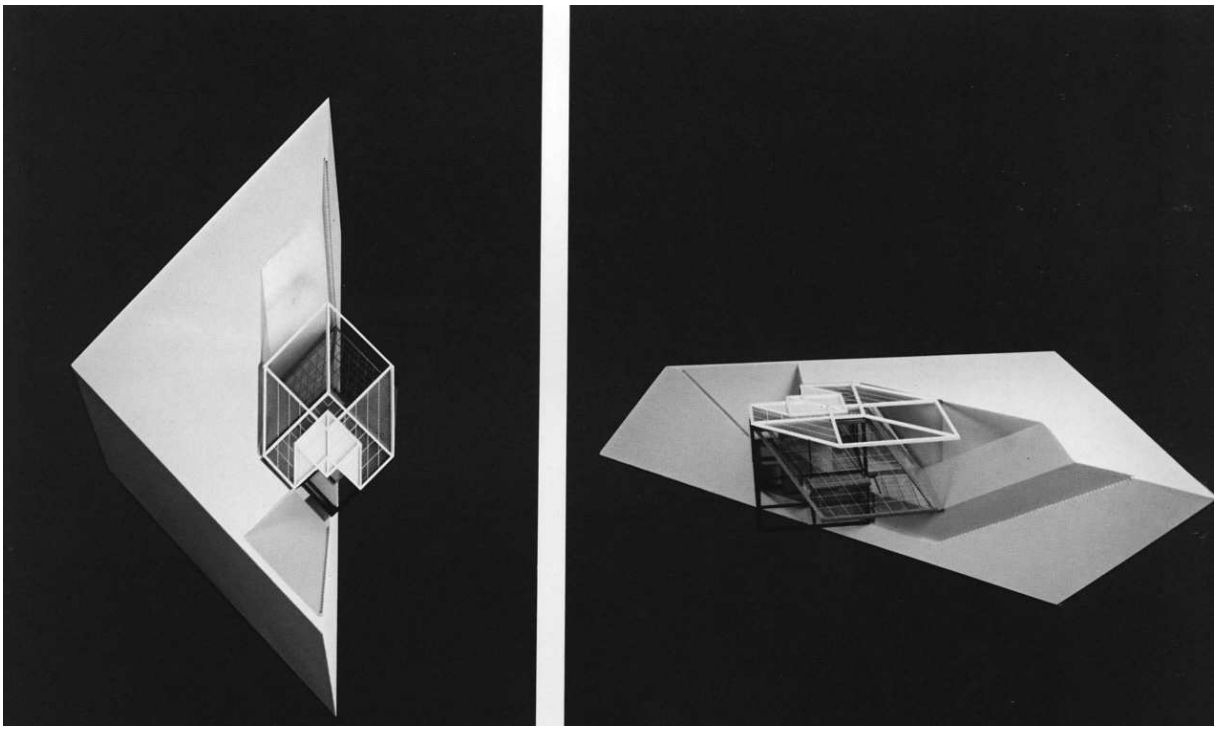

Figure 2: Eisenman's model, as shown in [10, pl. 12–13]

As opposed to oblique axonometry, an object aslant is placed and projected orthogonally to a projection plane in orthogonal axonometry. Among them isometric projection has been diffused because of the most easiness in manual drawing construction.

Since isometric projection is a parallel projection, it is different from perspective in a strict sense. However, this kind of projection would be the perspective seen from an infinitely distant point. Therefore, isometric images would be seen as if they were the perspective from an infinitely distant point, or the photograph taken from a distant point with a super-tele lens. The image near the center of the retina is almost undistorted because its range is very small. So an isometric image has little difference from an image near the center of the retina.

In other words it will be closer to the apparent image (perspective).

Bauhaus adopted axonometry instead of perspective. Here can be seen the ambivalence of the concern on the image of the appearance and on the form of the object itself. But the evasion of the apparent image in Bauhaus was less clear than that of De Stijl, for the former adopted isometry in an early stage but the latter adopted exclusively the oblique axonometric projection.

If we recognize both the change of use of axonometry and the above mentioned differences between oblique axonometry and isometric (orthogonal) axonometry, we can explain a shift of design of Bauhaus: from expressionism to Neue Sachlichkeit tendency. The reason for this is that there is the following similarity:

1) in the former human feeling is important but in the latter objects themselves are important,
2) in perspective human appearance is important but in axonometry objects themselves are important.

In fact Bauhaus adopted oblique axonometry more often after the national Weimar Bauhaus exhibition.

The change of axonometry corresponds to the compositional method of Bauhaus design with the combination of simple geometric forms too. In orthogonal axonometry a circle or a square, which is a simple geometrical shape, turns into an ellipse or a parallelogram. They are distorted. However, in an oblique axonometric projection, it is possible to express these shapes undistorted.

One of axonometric drawings of H. Beyer showed the transient state of this shift (Fig. 3). In the upper part, circles are expressed in ellipses according to isometric projection rules. However, in the lower part, a square is expressed by a square by adoption of military projection.

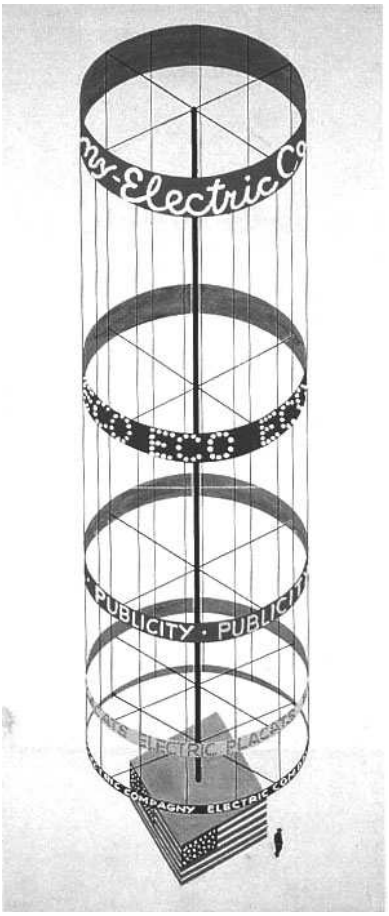

Figure 3: H. Bayer, *'project: Pavilion'* as shown in [7, 83-pl. b]

3.2. Co-existence of a limited world with a human center and one already fixed infinite world of objects

We would like to point out another characteristic by looking at the buildings of Bauhaus. In Bauhaus, the original axonometric drawing had been, as having already said, that of isometry (orthogonal projection) whose image was similar to a perspective.

As a result, buildings were also considered to have both the characteristics that were 'a limited world with a human center' peculiar to a perspective and 'a fixed infinite world of ob-

jects prepared beforehand' peculiar to axonometry. We can see the corresponding ambivalence in Bauhaus buildings.

We will explain it with examples. A building representing the 'limited world with a human center' can be seen in Kornhaus — a clubhouse at the riverside of the Elbe (Fig. 4 left). This building was designed from 1929–1930 by C. Fieger who took charge of architectural education in the Dessau Bauhaus from 1927–1934. It has a projected shape of a semi-circle with consciousness of the view to the Elbe. A man standing inside of the building can enjoy an external view. So the building embodies the 'world of perspective', for it was conscious of the external view from a human-centered point.

As an example representing the 'already fixed infinite world of objects', we can show 'the collective housing in Toerten' designed by Gropius (Fig. 4 right). There are the same housing units repeated almost infinitely along a passage. We can grasp the form of mass production and repetition beyond a humane scale in this plan. We feel a world where the dwelling unit itself carries out self-multiplication. It could be said that 'the infinite world of extensible objects is seen in the building as in axonometry.

Figure 4: left: Kornhaus, right: Collective housing in Toerten

It is of interest that the Bauhaus school building at Dessau is said to have realized Gropius' architectural view best. Its characteristics are separation of a building from the ground, creation of the transparency with glass curtain walls, functional articulation of a building and asymmetrical composition (Fig. 5).

We would like to point out another characteristic of this building: we cannot grasp the whole of the building in one point view. Axonometry has the similar characteristic because it does not premise a limited view from a fixed viewpoint as shown in perspective. Therefore we can say that this building has the similar characteristic to axonometry.

There is one more common characteristic. As opposed to perspective, axonometry does not have a target point. This building does not have a target point or a center. It could be said that its characteristic is closely related to the higher concept of modern architecture; 'Verlust der Mitte (Loss of center)' of H. Sedlmayr.

3.3. A tendency toward seeing a building as a 'machine'

The 3rd characteristic of axonometry is connected to an education system in Bauhaus. Bauhaus has two type of education aiming at the synthesis of design and manufacture: *form education*

by designers and *manufacture education* by craftsmen. Craftsmen require accuracy, so it can be said that they are close to engineers.

Craftsmen require the capability to repeat the same product. The capability probably distinguishes the craftsman from the designer who makes a single article work. Here was room for the 'mechanical' concept as opposed to the 'handwork' which Bauhaus aimed at in early years. That is, the productive capability for repetition of 'craftsmen' could include the tendency from handwork to mechanization.

Besides, the intention toward a 'machine' might be connected closely to a 'model' to which modern architecture referred. H. Suzuki said,

"Modern architecture was materialized when the social stratum of modern society caught an image of 'machine' as the greatest model which supports modernization" [12].

Furthermore, he mentioned 'invisibility of functions' in the electric-device of the present age. It was produced as a result of change of model, when modern architecture changed to contemporary architecture.

If it were true, I could understand a certain 'freshness' felt when I looked at the Dessau Bauhaus school building for the first time. The 'freshness' grows out from the visualized image of a 'machine' of those days which has become old now (Fig. 5).

Figure 5: Bauhaus building in Dessau

For example, this building visualizes the function of the constructional elements and the closing mechanism of a window like mechanical parts of a machine. There is no excessive thing. Therefore the Dessau Bauhaus school building was most faithful to the 'machine' model of modern architecture because of 'visualization of 'functions'.

If we see the collective housing in Toerten with this kind of 'machine' model, it can be said that the housing is the visualization of a machine production model. In fact the rail for cranes was first installed in a road, and its assembly was performed by the crane. The technique of the industrial production was introduced.

4. Conclusion

We looked back upon the relationship between the use of axonometry and Bauhaus design especially in architecture.

Bauhaus had a high regard to an individual's subjective vision in the early years. It corresponded to both 'expressionism' as a design style and isometric projection as a repre-

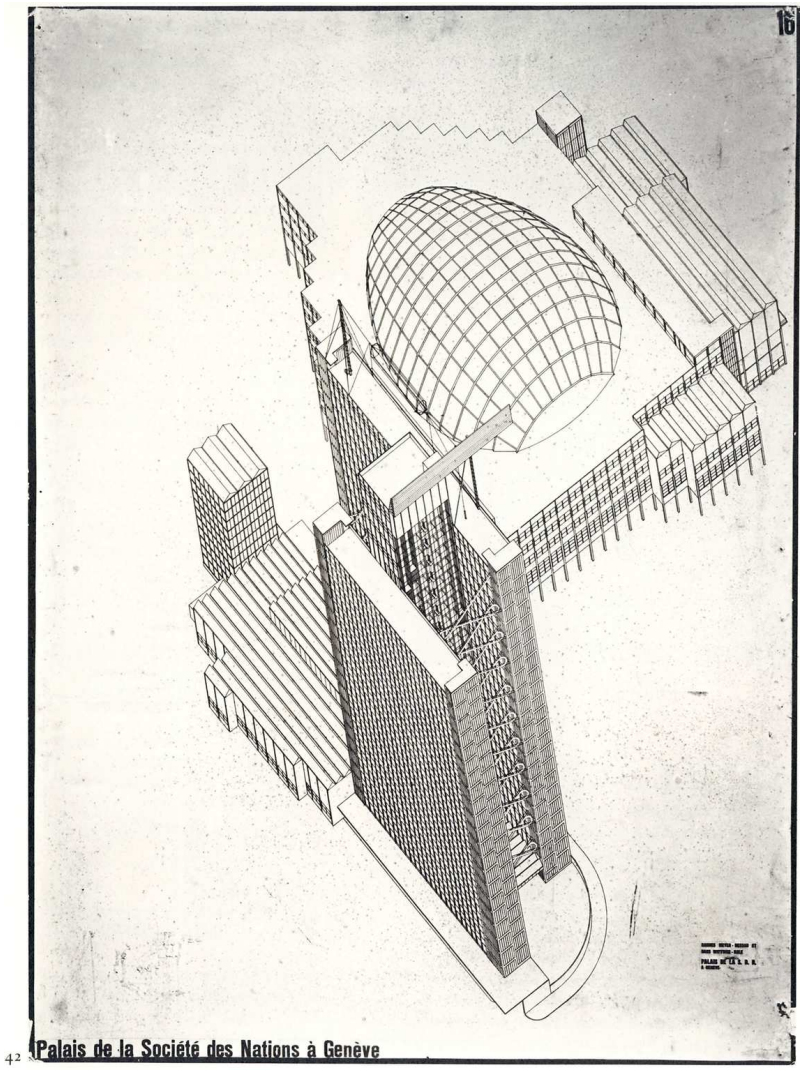

Figure 6: League of Nations, as shown in [8, p. 45]

sentation method. On the contrary, other contemporary modernists such as De Stijl used only military projection. The use of military projection implies that there is no need of individuals' existence in its extreme pole. The reason for this is that military projection does not simulate an individual's view. The tendency toward *'Neue Sachlichkeit'* in later Bauhaus design corresponds to this implicit characteristic of military projection.

We would call it 'objectification of vision', if the characteristic as a visualization tool is expressed in a few words. It was shown most explicitly in a drawing of the League of Nations produced by the 2nd director H. Mayer (Fig. 6).

This drawing has only lines, neither shades nor colors, to express the building shape. There is no room for individualities of draftsmen. The human influences such as man's viewpoints were kept away, and we could grasp the desire for exactness and objectiveness like a 'machine' drawing. As a result, we could easily understand the following design tendency: the design is going toward a simple functional composition without uselessness, which has no relation to the difference of individuals or the difference of the time.

References

[1] J. Badvici: *L'Architecture Vivantes*. Automne et hiver, 1923, Editions Albert Morance (Reprint da Carpo Press, 1975).

[2] Y.-A. Bois: *Metamorphosis of Axonometry*. Daidalos **1**, 41-58 (1981).

[3] El Lissitzky, R. Blomfield: *A. and Pangeometry*. Revolution and Construction, Shokokusha Publishing 1983, pp, 149–161.

[4] W. Gropius: *Idee und Aufbau des Staatlichen Bauhauses*. In: Staatliches Bauhaus Weimar 1919–1923, Kraus Reprint 1980, pp. 14–15.

[5] W. Gropius (ed.): *Staatliches Bauhaus Weimar 1919-1923*. Kraus Reprint 1980.

[6] B. Jestaz: *Architecture of the Renaissance*. Harry N. Abrams, 1995.

[7] Kawasaki Citizen Museum (ed.): *Revolution of Bauhaus Art Education and Experiment*. Kawasaki Citizen Museum, 1994.

[8] League of Nations: *Architectural Competition*. Rotogravure S. A., 1927.

[9] C. Leopold: *The Use and Effects of Axonometry and Perspective*. Proc. 7th ICECGDG, Cracow/Poland 1996, pp. 42–46.

[10] B. Schneider: *Perspective Refers to the Viewer, Axonometry Refers to the Object*. Daidalos **1**, 81–95 (1981).

[11] M. Sekimura: *Image and Mimesis*. Keiso-Shobo, 1997.

[12] H. Suzuki: *Modernization and Present Age of Europe and United States*. New Architecture SYSTEM 5 History of Modern and Contemporary Architecture, Shokokusha Publishing 1993, pp. 185–205.

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