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Shadow Representation in Central Perspective, a Descriptive Geometry Application

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Abstract: The issue of shadow representation is studied in various domains such as architecture, town-planning, design, painting, and so on, in order to highlight the shapes and proportions of the designed objects, which can subsequently be interpolated in complex compositions. It is a well-known fact that the expressiveness of a work of art undoubtedly increases by rendering the objects' own or carried shadows based on some descriptive geometry theories.

Keywords: shadow, central perspective, descriptive geometry, light sources, perspectiv plan, sun shadow.

1. INTRODUCTION

Shadow representation is an interest, study and use issue, present in a series of domains such as: architecture, town-planning, engineering, design, fine arts, etc.

The subject of descriptive geometry plays a major role in this study since it provides the proper fundamental shadow representation theories, in different situations imposed by the positioning of the light source to the object (body) or its type (a light source, which is at an infinite distance, such as the sun, the moon, or a fixed light source, such as a light bulb, a lamp, a candle, a headlight – used indoors).

When one needs the most faithful rendering of the general aspect of an object, it is recommended to represent it together with its shadow.

All light sources emit light beams which propagate in a straight line, the directions being parallel or convergent, depending on their type. The light beams pass through the object or they do not pass through it (they are absorbed by it), depending on its degree of transparency or opacity.

2. THE CENTRAL (CONICAL) PROJECTION USED TO REPRESENT SHADOWS

In order to explain shadow representation in central projection, (Fig. 1) was drawn, in which the following notations have been made: S – the light source, which may be also considered the centre of the conical projection; P – the screen on which the shadow is projected (it is analogous to a certain chosen projection plan); C – the opaque body, which is projected.

The light beams, emitted by the source S, which are tangent to the body C, may be understood as projections that cross both the body C and the projection plane P. They are organized in a conical light surface (K), circumscribed to the body, which becomes tangent to it after the curve (u), named shadow line, or separating line (separator). The shadow line separates the bright side (the body surface, which intercepts the light beams) from the shaded one. The conical surface K intersects plane P after a curve (**U**), which represents the border of the shaded surface or the body's shadow limit curve on the screen **P**.

Conventionally, in the literature of the genre, it is considered that:

- own shadow is the shaded part of the body;
- the carried or thrown shadow is the shadow area thrown by a body on another element (plane, screen, or on a body in space).

If the light source is very close to the body, the ray beams, which converge in point **S**, form a conical surface circumscribed to it. In this case, the body candle shadow is obtained.

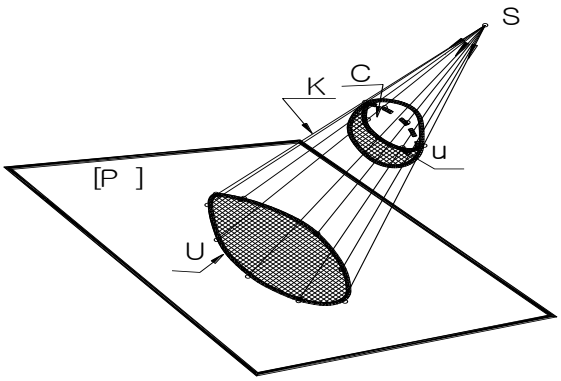

Fig.1 The own and carried shadow of a body C

If the light source is at great distance, the ray beams converge in the point **S**, situated at infinite distance, and in this case, the beams are parallel because they form a cylindrical light surface, circumscribed to the body, and the obtained shadow is called sun shadow.

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3. HORIZONTAL PLANE THROWN POINT SHADOW PERSPECTIVE REPRESENTATION

Horizontal projection plane thrown point shadow perspective representation is studied under various circumstances such as:

- 1. real - space sun;
- 2. virtual – space sun;
- 3. neutral – space sun;
- 4. the sun situated in a particular case.

3.1 Real-space sun

The real-space sun determines the existence of a perspective bi-point **Ss** on the screen, where **S** is situated above the horizon line **HH₁** and **s** is on the horizon line (Fig. 2). The elements represented in perspective are considered to be lit from behind, the shadows being directed towards the observer. (that is to say, in front of the elements).

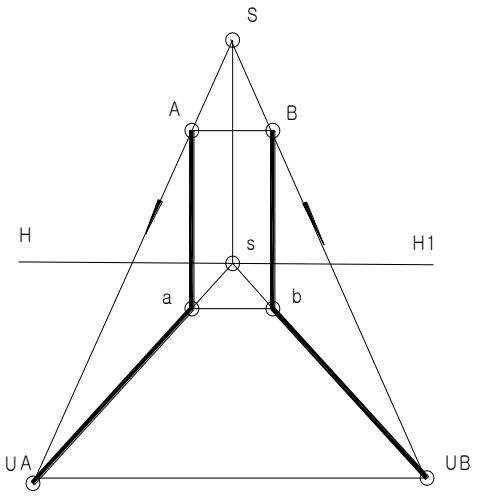

Fig. 2 Horizontal plane point shadow when the sun is in real space

A represents the screen perspective of point **A** in space, **a** is the screen perspective of point **A**'s projection on the horizontal plane.

SA is the space light beam perspective, **sa** is the light beam's horizontal projection perspective.

At the intersection of these lines point **UA** is obtained, the shadow thrown by point **A** on the horizontal plane.

UA is, by analogy with descriptive geometry theories, the horizontal shadow of the line **SA**.

It can be noticed that the shadow of the vertical line **Aa** is the segment **aUA**.

If the vertical line **Bb** is in the same front plane as the vertical line **Aa**, and if it has the same height, then **UB** is situated on the front horizontal line that contains the shadow **UA**.

3.2 The sun situated in virtual space

The sun, situated in virtual space, implies the existence of the perspective bi-point **Ss**, with **S** situated under the horizon line **HH₁**. In this case, the elements are lit from the part where the observer is, that is to say from the front, the shadows being formed behind the elements, fading convergently (towards point **s**) from the observer. The shadow of point **A** is noted with **UA** and is found at the light beam **SA** perspective and its projection **sa** perspective intersection. (Fig. 3)**.** The shadow of the vertical line **Aa** is the segment **aUA**; the shadow of the vertical line **Bb** is the segment **bUB**. The shadows **UA** and **UB** are situated on a common front horizontal line, because the vertical lines **Aa** and **Bb** belong to the same front plane, and the points **A** and **B** have equal shares.

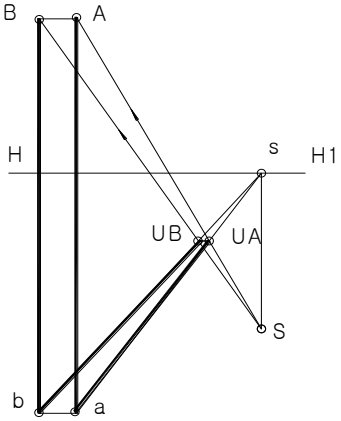

Fig. 3 Horizontal plane point shadow when the sun is in virtual space

3.3 The sun situated in neutral space

The sun situated in neutral space always implies the replacement of the perspective bi-point **Ss** with a light beam, which is parallel to front straight line **D1**.

In this case, the elements are lit from one side (either the left or the right side), and the shadows have front horizontal directions, parallel to the horizon line (Fig. 4).

3.4 The sun situated in a particular case

At dawn or at dusk, the perspective bi-point has the points **S** and s overlapped in the same place on the horizon line. In this case, the light beams are horizontal and infinitely long; also, the shadows are directed towards the observer. It is a known fact that any horizontal line has the vanishing point on the horizon line (Fig. 5).

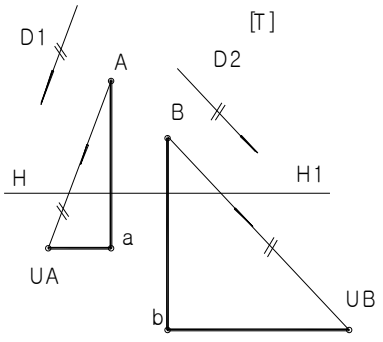

Fig. 4 Horizontal plane point shadow when the sun is in neutral space

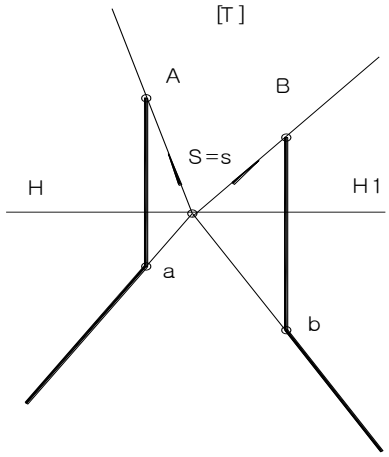

Fig. 5 Horizontal plane point shadow at dusk or at dawn

In all the above-mentioned cases, on the perspective screen [**T**], the point **S** is the vanishing point of the light beams from space, the source being at an infinite distance from the considered elements.

The point s represents the light beam horizontal projection vanishing point.

4. STRAIGHT LINE SHADOW PERSPECTIVE REPRESENTATION

4.1 Horizontal line shadow perspective on a horizontal plane

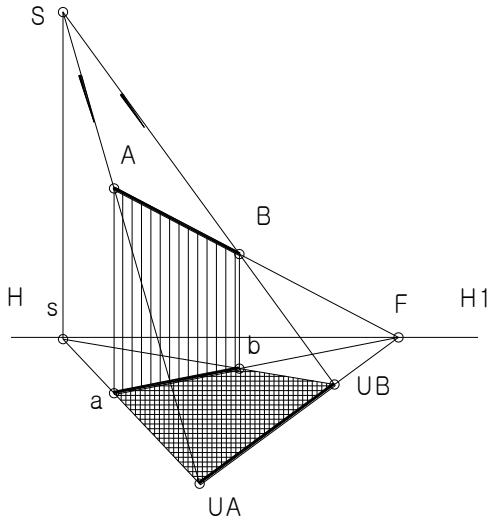

Fig. 6 The shadow of a horizontal segment and of the rectangle formed with its horizontal projection when the sun is in real space

Be the segment AB (a horizontal segment) represented in perspective on the screen [T].

In Figure 6 the sun is in real space. In reality, the segment **AB** is parallel to its projection on the horizontal plane, noted **ab**, and to the shadow emitted by the points **UA**, **UB**. The three-segment parallelism implies the existence of a common vanishing point – **F** – situated on the horizon line.

The rectangle **ABba**, which belongs to a certain vertical plane, has the perspective shadow included in the quadrilateral **a**, **b**, **UB**, **UA**.

In Figure 7, it was represented, on the one hand, the horizontal segment **AB** shadow (**UA**, **UB**) perspective, in the case of virtual space, and, on the other hand, the formed rectangle shadow horizontal projection.

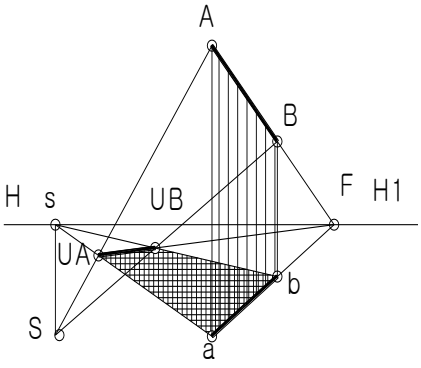

Fig. 7 Horizontal segment and its formed rectangle horizontal projection shadow when the sun is in virtual space

4.2 The perspective of the shadow thrown, on a vertical plan, by a horizontal line parallel to the vertical plane

The situation from paragraph 4.2 was represented, in Fig. 8 with the sun situated in virtual space, with the horizontal line **AB** represented in perspective on the screen [**T**], the horizontal line being parallel to the vertical plane, which has the perspective marks noted **QH** (horizontal mark perspective) and **QF** (plane vanishing point). The vanishing point **F** of the horizontal line **AB** is identical to **Qh** (the vanishing point of the mark **QH**). The straight line horizontal projection perspective is **ab**, which tends towards the same vanishing point **F**.

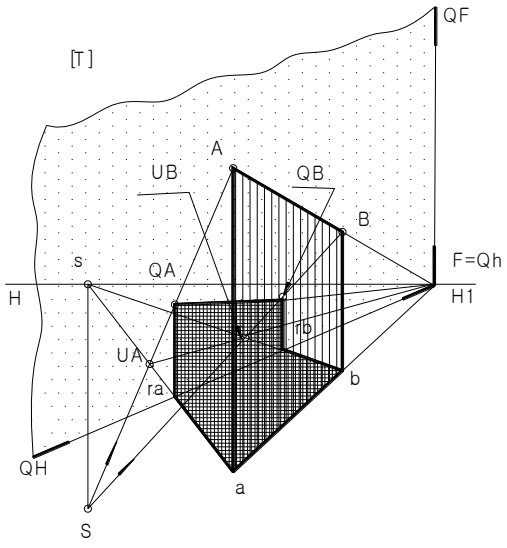

Fig. 8 The shadow of a horizontal segment thrown on a vertical plane and of the formed rectangle with its horizontal projection, when the sun is in virtual space

The shadow **UA**, **UB** raises on the plane **Q**, this constituting an obstacle for the light beams, thus one obtains the horizontal thrown shadow on this plane, noted **QA**, **QB**, which also tends towards the vanishing point **F**. There were noted on **QH** the points **ra** and **rb**, which change shadow direction, behind the vertical lines (**ra**, **QA**) and (**rb**, **QB**). The shadow of the vertical line **Aa** is composed of two segments: (**a**, **ra**) – the part of the horizontal plane shadow – and (**ra**, **QA**) – the part of the shadow on the plane **Q**. The shadow thrown by the vertical line **Bb** is divided in the same way.

If the reasoning goes further, the shadow of the rectangle **Abba** is composed of two areas: one on the horizontal plane – the perspective rectangle [**a**, **ra**, **rb**, **b**] – and one on the plane **Q** – the perspective rectangle [**ra**, **QA**, **QB**, **rb**].

5. THE PERSPECTIVE OF THE SHADOWS THROWN ON THE UMBRELOR ARUNCATE PE PLANUL ORIZONTAL DE VOLUME

Volumes must be considered as a set of points organized under a structured form. In perspective, on the screen, there must be obtained a bi-dimensional image.

In Figure 9 there have been chosen a set of reference points, situated on the apparent contour line of a certain body, for example points **A, B, C, D, E, F, G, I, J, K, L**. The perspective of their horizontal projections is built (**a, b, c,...k, l**), then all the shadows of these points are represented according to the previously described methods, in the case of real space. In virtual space, the volume representation volume is made according to the previous representation, but relying on the graphics from **Fig. 7** and for each peak of the considered volumes.

In Figure 10, it was represented, in neutral space, the shadow thrown (of some adjacent volumes) both on the horizontal plane and on the lateral vertical or horizontal sides, which deflect the projection direction. **D** is the natural light beam direction, **F1**, **F2**, the vanishing points situated on the horizon line **HH1**.

6. CONCLUSION

- The purpose of the present paper was to briefly present the issues that concern shadow representation in perspective on a flat screen, based on some original graphical representations, drawn by the author in Auto-CAD. There have been drawn 10 figures with exemplifying red.
- The paper explained the fact that, in approaching these issues, descriptive geometry knowledge is indispensable, this knowledge being the fundamental theoretical background which was applied.
- It is important to underline that: the expressiveness of a work of art increases indisputably by rendering the own or carried shadows of the represented objects; for this, one has to rely heavily on rigorous descriptive geometry theories that must be assimilated in a responsible manner.

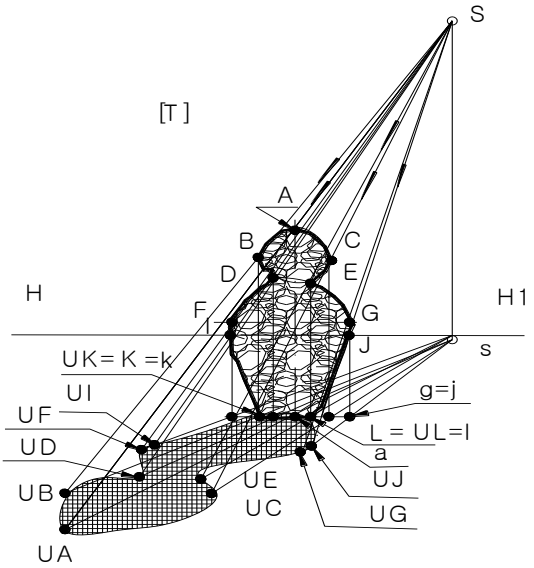

Fig. 9 Certain volume horizontal plane thrown shadow (in perspective), in real space

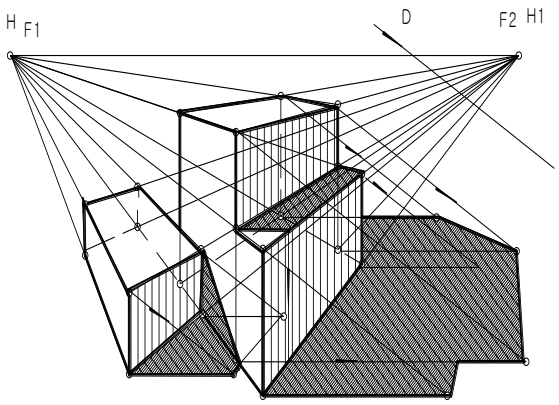

Fig. 10 The shadow (in perspective), of volumes, thrown on the horizontal plane, in neutral plane

REFERENCES

[11 *A., Tănasescu,* Geometrie descriptivă, perspectivă, axonometrie, Editura Didactică şi Pedagogică,..Bucureşti, 1975.
[2] *L., Tocariu,* Estetică industrială – teorie şi aplicaţii, Editura Evrika, Brăila, 2001.
[3] *L., Tocariu,* Elemente de geometrie descriptivă utilizate în desenul tehnic, Editura Evrika, Brăila, 2001.