GALAXY INTERNATIONAL INTERDISCIPLINARY RESEARCH JOURNAL (GIIRJ)
ISSN (E): 2347-6915
Vol. 10, Issue 11, Nov. (2022)

OPTICAL THEORY OF AXONOMETRIES, USED IN THE HISTORY OF CENTRAL ASIAN PAINTING

Sh. Abdurahmanov
Pedagogue, Associate Professor, NamMQI

S. Rahmatullaev
Master's Student, QDPI

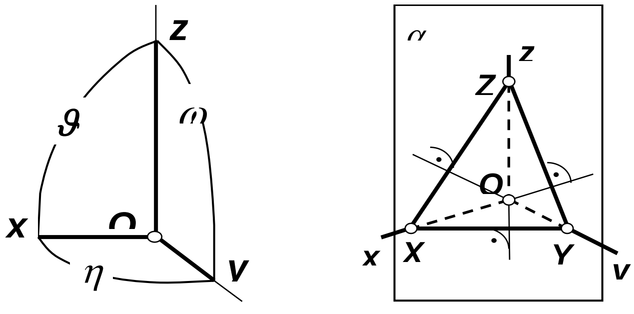
S. Yoldoshev
Master's Student of QDPI

ANNOTATION

The article, named as "The optical theory of axonometry applied in the history of drawing in Central Asia", comprehensively presents scientific information about axonometry, about their theory applied by artists in the history of Central Asia of the IX – XIX centuries.

Keywords: projection drawing, parallel projection, axonometry, rectangular axonometry, axonometric axes, distortion coefficients, oblique axonometry, trimetry, dimetry, isometry.

When we talk about the art of graphics belonging to the history of Central Asia, we can witness the presence of such thoughts as he is right below: "the distinctive features of the eastern miniature... Objects located at different distances in relation to the observer will simply be placed on their spines: those near them will be placed on the bottom, those far up, and those far away will not be reduced in proportional ra-Vish" [7, kn.2, 247-b.]. "...The art of oriental painting is characterized by Japanese character... In the East, the image is formed on the basis of axonometric constructions, light and shadow are not involved in the image" [13, 316-b.].
It is necessary to have a broader knowledge of what type of images is understood when it is called "axono-metria", about the process of constructing axono-metric images, and especially about the theory of axonometry, which is based in the history of Oriental graphic art, fully joining the given ideas of famous Orientalists and art critics. In this scientific article, we will try to clarify these issues.



а)　　б)

Figure 1: a - oblique axonometry - image of arrows at; b – image of right-angled axonometric axes.

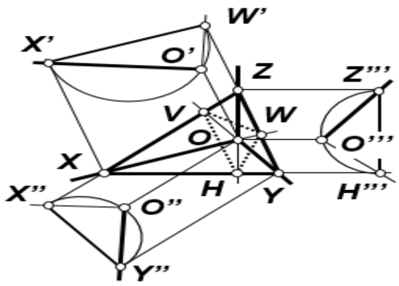


Figure 2. Axonometric change in axes expression of coefficients.

Axonometries are considered parallel projections, and all invariant properties related to parallel projections remain valid.

Figure 1 shows a three-dimensional rectangular Cartesian coordinate system. According to this picture, O is the coordinate head, x is the axis of recording distances related to the width (left and right) of the object under consideration, y is the axis of recording distances related to far and near, z is the record of distances related to high and low. axis of reach. The term "axonometry" is based on the word "axis". "Axonometry" is a combination of the Greek words axon and metroo, and in Uzbek it means "I measure the axis".

Since two intersecting straight lines represent a plane: the x and y axes η flatland, **x** and **z** axis ϑ flatland and y and z axes **ω** they appear flat. Drawing in geometry **η – plane of horizontal projections, ϑ – plane of frontal projections,ω – the profile is called the plane of projections.**

In the study of axonometrics, their form as in figure 1-b is used along with the figure in figure 1-a. Axonometric axes **Ax** and **Oz** in Fig. 1 are parallel to the drawing plane. Therefore ϑ Forms lying in the plane or parallel to it are depicted in their true size in axonometry.

Figure 1b shows the axonometric plane parallel to the drawing paper. This plane crosses the **xOy** plane and forms the XY lin ϑ ≡ Crossing the **xOz** plane gives the line **XZ**, and intersecting the plane yOz gives the line YZ.as a result, the **XYZ** triangle formed by these lines is called the triangle of the traces of the axonometric plane (in the frontal, horizontal and profile projection planes, in short, it is called the triangle of traces.

Also, if we bring the point **O** located behind the plane a by projecting it in a vertical direction to this plane and connect it with the points **X, Y** and **Z**, then the axonometric axes **Ox**, **Oy** and **Oz** will appear lying on the plane a, and they are, respectively, heights to the corresponding sides of the trace triangleperforms its function.on this basis, one of the important theorems of right-angled axonometries is formed: in right-angled axonometries, the image of each of the axonometric axes is perpendicular to one side of the triangle of traces.

If the points H, V and W, which are the bases of the axonometric axes on the sides of the **XYZ** trace triangle, are joined together, a shape called the triangle of changes is formed (Fig. 2). This shape is also called the Weiesbach triangle. In right-angled axonometrics, the bisectors of the triangle of changes serve as axes of axonometry.

Another important concept of axonometrics is the concept of coefficients of change on axes. The change coefficient means the ratio of the length on one or another axis of axonometry to the length on the corresponding axis in space. In particular: kx = OX : O'X'; ky = OY : O"Y" and kz = OZ : O'"Z'" (Fig. 2). In right-angled axonometrics, the sum of the squares of the coefficients of change along the axes is equal to 2: kx2 + ky2 +kz2 =2. In oblique axonometrics, this expression looks like this: kx2 + ky2 + kz2 = 2 + Ctg2**φ.** There: **φ** – the angle between the direction of projection of the set (system) of volume measurement axes onto the axonometric plane and this plane.

Depending on the ratio of the coefficients of change along the axes, axonometrics are divided into the following types

– **isometries** (the coefficients of change on all three axes are the same): $\mathbf{k_x = k_y = k_z}$;

– **Dimetries** (the coefficients of change on two axes are the same, on the third axis are different): $\mathbf{k_x = k_z \neq k_y}$; or $\mathbf{k_x = k_y \neq k_z}$.

– **trimetries** (coefficients of change on all three axes are different) $\mathbf{k_x \neq k_y \neq k_z}$.

if there is no adjective in front of the name of the type of axonometry, then we are talking about right angle axonometry. if it is about oblique axonometries, their names are as follows: oblique angle isometry, oblique angle dimetry, oblique angle trimetry [8].

In the lexicon of axonometric theory, there are "exact axonometries", "standard axonometries", "inferred isometry", "secondary projections", "Cavalier projection", "zenith perspective", "military perspective", "cabinet projection", " Expressions like "other perspective" are also widely used [10, pp. 47-55]

The theory of axonometrics also interprets standard horizontal, frontal and profile projections as axonometric images. In a horizontal axonometric projection $\mathbf{k}_z$, in frontal axonometric projection $\mathbf{k}_y$, profile in axonometric projection $\mathbf{k}_x$ coefficients will be equal to "0". In architectural drawing, horizontal projections are called plans, and frontal projections are called facades. This category of images also includes terms such as horizontal cut, frontal cut, profile cut.

The given information allows to easily describe in detail hundreds of examples of the history of Central Asian painting in the 9th - 19th centuries. Let's turn to examples.

It was found in the so-called Oktom and Kuyimozor locations of Khorezm oasis and mil. avv. On fragments of objects belonging to the 1st - 1st millennia, a person is depicted as a profile and frontal projections [13, p. 149]. A bronze tray believed to belong to the 5th - 6th centuries of Sughd is depicted as the facade of this building [A.Sh., p. 81].

It is possible to see the drawing of the series of pishangs drawn by Ibn Sina for the book "Miyorul Uqul" [4, p. 51] as a profile projection of this device. The fact that the drawing is completely black indicates that it is a silhouette image. In Ibn Sina's drawing of hanging scales in the book "Miyorul Uqul" [1, p. 126], some of the details (e.g., scale scales) are frontal projection, some (e.g., scales circuit) are horizontal projections, and some (e.g. , posang, ends) described as profile projections. In Ibn Sina's drawing of the drill and ratchet combination device drawn for the book "Miyorul Uqul" [4, p. 53], some gear wheels are interpreted as their frontal projections, others as profile projections

The drawing of Beruni's device (alot) for measuring the specific gravity of substances, which is given in the book "Mezon ul-hikmat" by Umar Khayyam's student Abulfath al-Khazini [3, p. 253], is described as a profile cut of this device.

4 plans drawn by the master of Bukhara in the 16th century [pp. 1, 132-133] each represented a horizontal section of the corresponding building created by means of a planar drawn at a certain height.

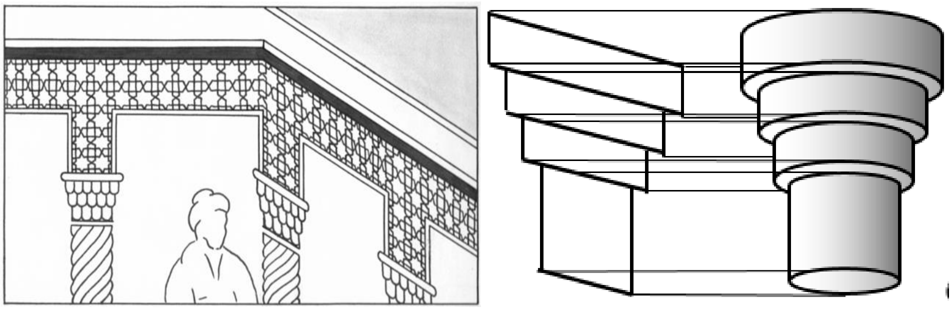
The plan of the observatory made by abul Munim Omili for "Kitobi oloti zij" ("Book of Astronomical Instruments") written in 1700 [12, p. 126] consists of a cut-out image of the structure created by means of two horizontal planes made at different heights.

The plan drawn in the second half of the 19th century [A.Sh., p. 134] shows the two-story house of the brothers Ahad Khan and Muzaffar Khan.

drawings of such devices as polyspast, ratchet, screw, strong ratchet, ratchet and screw combination, polyspast and ratchet combination, ratchet, screw and pishang combination drawn for Ibn Sina's book "Miyorul Aqul" [4] are based on the rules of building frontal dimeters with angular angles - gone.

The 15th-century miniature khavontakht image for the book "Tarihi Abdulkhairkhan" and the

16th-century miniature koshk image for the book "Tuhfat-ul-Ahrar" by Abdurrahman Jami [A.Sh., p. 76] were also made based on the rules of building diagonal dimetries.



а) б)

Figure 3. A miniature of Kamoliddin Behzod (16th century)
In fragment (a) "secondary axonometric projection» (б).

Ibn Sina's drawing for the book "Miyorul Aqul" [4, p. 48], Alisher Navoi's 16th-century miniature image of a part of the building for the book "Khamsa" [1, p. 82], Abulqasim Firdavsi's "Shahnama" The image of the king's throne made in 1556 [1, p. 82], academician of building partsShirin Muradov's drawings [11, 16, and 82] were created based on the rules of construction of oblique frontal isometry.

The image of the king's throne in a miniature made in the 40s of the 15th century for the book "History of Abdulkhairkhan" [1, p. 83] was made based on the rules of construction of trimeters.

Another interesting evidence: in a fragment of a miniature of Kamoliddin Behzod (XVI century) (a) "secondary axonometric projection" (b) is depicted (Fig. 3) [1, p. 111].

Although it is anecdotal, the information discussed above shows that in the 9th - 19th centuries in Central Asia, axonometrics were a rather developed type of images. but it should be noted that we analyzed those examples based on the knowledge of the theory of axonometric images developed in Europe in the 19th century. Here a legitimate question arises: were the authors of the examples we considered aware of the above knowledge of axonometry? Answer: yes. in a certain sense, they were definitely aware. Otherwise, we would not have such a skillfully executed gallery of axonomic images.

Now, let's give a brief information about the knowledge of axonometrics relied on by craftsmen, engineers, architects, painters, painters and other professions similar to them in the history of Central Asia in the 9th-19th centuries.

According to the scientific literature on the theory of images, the theoretical foundations of creating various images used in various fields were formulated, accumulated, generalized and developed mainly in the sciences of "**geometric constructions**" and "**optics**" [2, p. 13].

Knowledge of "geometric constructions" has been the main part of geometry books since ancient times. in the middle ages, books on geometric constructions created by Farobi and Abul Wafa, written on the basis of the works of ancient Greek and Byzantine scientists, and books similar to theirs were used to learn how to make accurate images.

«The first book called "optics" was published in Alexandria. av. It was created by the Lebanese

Euclid (365-300 BC) in the III century. Similarly, the book "Optics" was created by Ptolemy in the city of Alexandria in the II century. Scientists such as al-Kindi (801-873) and al-Nasrani (died in 910) wrote works on optics in the Near and Middle East in the 10th - 10th centuries. The most comprehensive works on optics were created by the Arab scholar al-Haytham (965-1039) in the 11th century. Under the influence of the Latin translation of the "Kitab al-Manozir" created by al-Haysam, the science of "Perspective" ("Depicting the View") was born in Europe. The integration of knowledge of geometric constructions and optical sciences has shown its positive effect on the improvement of images performed by various craftsmen

First of all, about the three-dimensional rectangular Cartesian coordinate apparatus: in the Middle Ages in the East, the edges of the rectangular parallelepiped bounding the body were used to measure the size of the body. Abu Rayhan Beruni (973 - 1048) wrote about it as follows: "The scale of bodies is oriented along three sides in space: the first is far-near, the second is width, and the third is direction along depth or height. It is not the abstract length of the body (the size it appears to the eye - A.Sh.), but its "**existing length**" (real size - A.Sh.) is determined by these three lines" [5, p. 222].

Similar descriptions prevailed in the same context before and after Beruni. for example: ... in the kindergarten, "a large porch was built, a large stone throne was placed inside the porch, the height was approximately fourteen to fifteen years old, the width was seven to eight years old, and the depth was one year old (emphasis is ours - A.Sh) » [6, p. 45]. here '**tul** '- continuation, distance; '**arz**' - width, width; '**umq** '- depth, profundity; "old" is a unit of measurement of length.

After thinking that the scale of objects extends along three sides in space: distance-nearness, width and depth or height, spatial distances are defined as the length of lines parallel to these three directions, Beruni also expressed the following idea: having, and with so many sides, it is bounded in space.If we imagine that an animal is standing in the center of this hexagon (parallelepiped (A.Sh.) and its face is facing one of these legs, then these legs are its front, back, right, left, top and bottom (emphasis is ours (A.Sh.) serve as sides" [Beruniy, p. 222] (Fig. 3.13). A little development of such an idea allows one to enumerate 26 different views of the enclosing parallelepiped one by one.

When looking directly at one side of the enclosing parallelepiped, the most prominent views are: a) front, b) left, c) top, g) right, d) bottom and e) back views.

Visible views when two adjacent sides of the enclosing parallelepiped are visible: a) front and top, b) front and left, c) front and right, g) front and bottom, d) top and right, e) top and left, j) bottom and right, z) bottom and left, i) back and top, k) back and right, l) back and left, m)back and bottom views.Prominent views of the enclosing parallelepiped with three adjacent sides visible: a) top, front and right; b) top, front and left; c) below, before and right; g) below, before and left; d) below, behind and left; e) bottom, back and right; j) top, back and left; z) top, back and rightviews.The presence of such a rich understanding and imagination about the types of appearances served as a solid ideological base in the creation of drawings of objects belonging to various fields.

When it comes to choosing impressive types of objects, masters preferred axonometries with coefficients of change equal to 1 on all three axes. as such types of axonometrics, the following can be specified: right-angled axonometry, oblique frontal isometry.

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