THE ELLIPSOID IN ORTHOGONAL AXONOMETRIC: HOMOLOGY APPLLICATION

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Abstract.
You've long heard about ellipsoid, both from a mathematical analysis that under the geometric representative profile. However, so far no one has ever affronted the problem from the point of the application of descriptive geometry with homology. The use of homology, in fact, can make it extremely simplified and actual use of geometric tools giving the user a graphical mastery of the outcome that would otherwise be dismissed even with the use of innovative technologies of representation.
Through the analysis of the proposed methodology, you can use to identify the strengths, the corresponding approvals now required between reality and projection.
An ellipsoid is a closed type of quadric surface that is a higher dimensional analogue of an ellipse
If all three radii are equal, the solid body is a sphere; if two radii are equal, the ellipsoid is a spheroid: if $a = b = c$ we have a sphere; if $a = b > c$ we have a oblate spheroid (disk-shaped); if $a = b < c$ we have a prolate spheroid (like a rugby ball); if $a > b > c$ we have a scalene ellipsoid ("three unequal sides").
The points (a,0,0), (0,b,0) and (0,0,c) lie on the surface and the line segments from the origin to these points are called the semi-principal axes. These correspond to the semi-major axis and semi-minor axis of the appropriate ellipses.
Scalene ellipsoids are frequently called "triaxial ellipsoids", the implication being that all three axes need to be specified to define the shape.
We impose constant upstream points and keys belonging to the horizontal section, is ellipsoidal and the wing generates the following transformation to time in plumes ellipsoid.
I can repeat all of the assumptions made for the ball: cups, cupolas, domes, fused, areas, triangles, wedges, holes, aggregations, drums and domes above ellipsoid, lunettes, modulated compositions of elements, but also, cruises elliptical arc, etc...
This is coupled to the imagination, the ellipsoid can be round, if, for example, the main section, the ellipse in projection, but it is not an ellipse circumference, in which case it is a surface and a solid rotation , the director is circular and has a generating ellipse.

Keywords: ellipsoid, homology, orthogonal axonometric

INTRODUCTION

We can star with our study from the mathematical and analytical equation.
An ellipsoid is a closed type of quadric surface that is a higher dimensional analogue of an ellipse. The equation of a standard axis-aligned ellipsoid body in an xyz-Cartesian coordinate system is:

$$\frac{x^2}{a^2} + \frac{y^2}{b^2} + \frac{z^2}{c^2} = 1,$$

where a and b are the equatorial radii (along the x and y axes) and c is the polar radius (along the z-axis), all of which are fixed positive real numbers determining the shape of the ellipsoid.
More generally, an arbitrarily oriented ellipsoid, centered at v, is defined by the equation:

$$(x-v)^T A^{-1} (x-v) = 1$$

where A is a positive definite matri and x, v are vectors. In that case, the eigen vectors of A define the principal directions of the ellipsoid and the square root of the eigenvalues are the corresponding equatorial radii.
If all three radii are equal, the solid body is a sphere; if two radii are equal, the ellipsoid is a spheroid:

$a = b = c$ Sphere;
$a = b > c$ Oblate spheroid (disk-shaped);

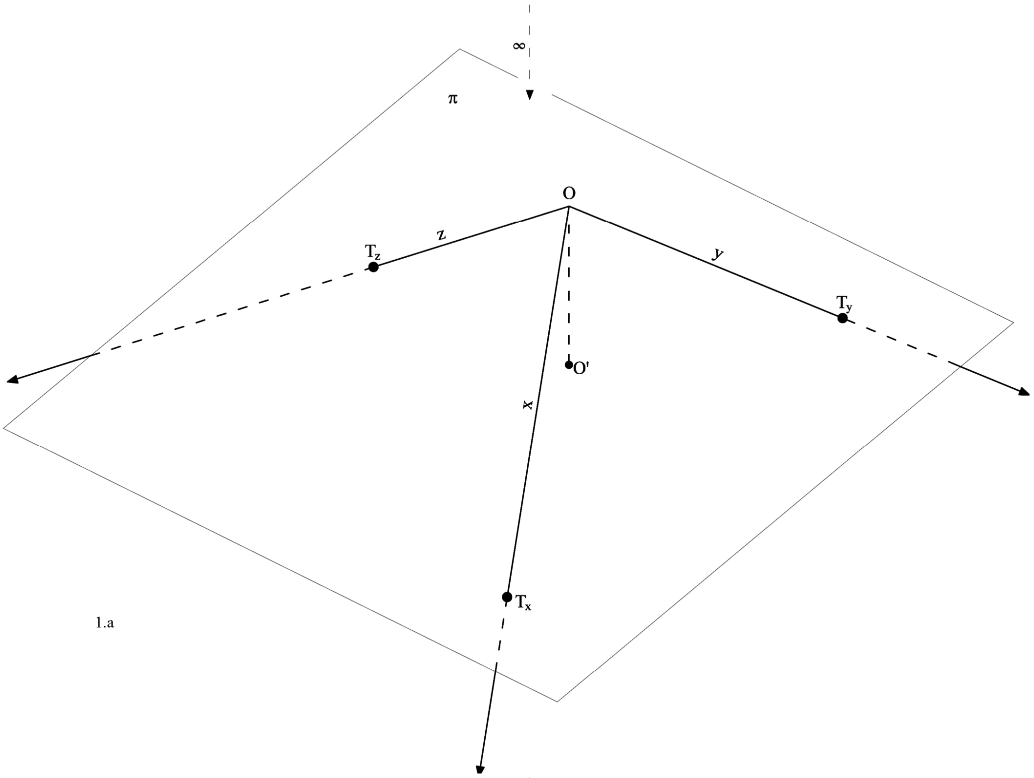
$a = b < c$ Prolate spheroid (like a rugby ball);
$a > b > c$ Scalene ellipsoid ("three unequal sides").

The points (a,0,0), (0,b,0) and (0,0,c) lie on the surface and the line segments from the origin to these points are called the semi-principal axes. These correspond to the semi-major axis and semi-minor axis of the appropriate ellipses.
Scalene ellipsoids are frequently called "triaxial ellipsoids", the implication being that all three axes need to be specified to define the shape.
Any planar cross section passing through the center of an ellipsoid forms an ellipse on its surface, with the possible special case of a circle if the three radii are the same (i.e., the ellipsoid is a sphere) or if the plane is parallel to two radii that are equal.

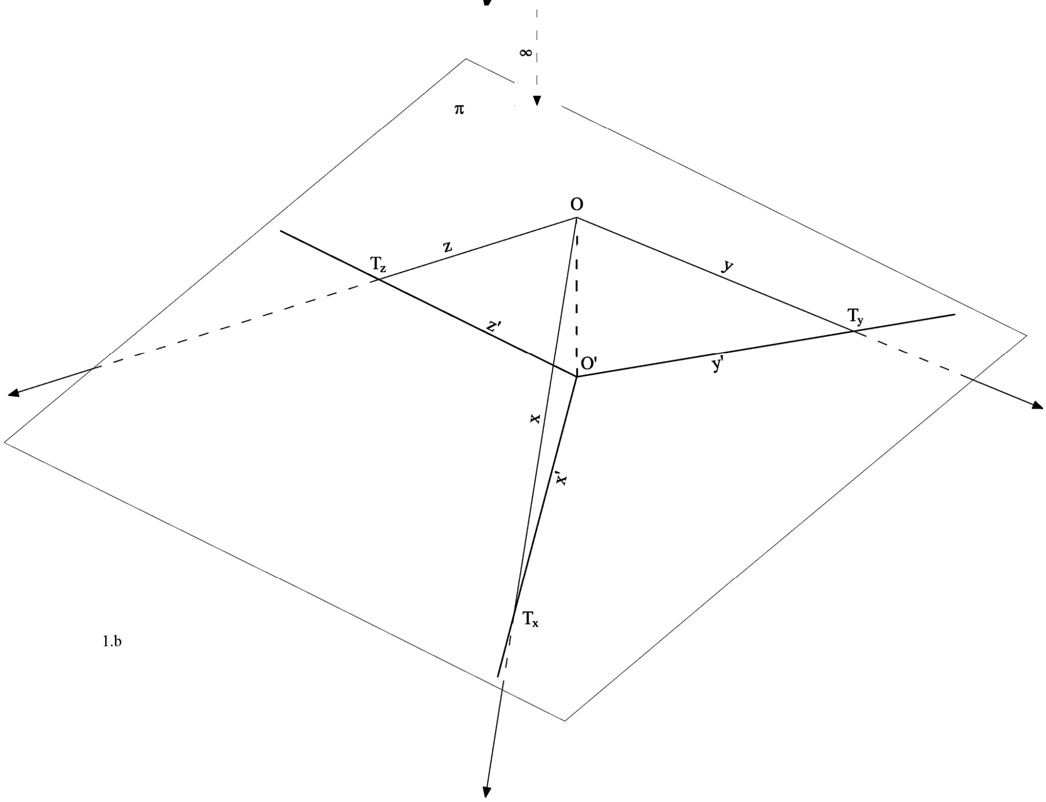
ELEMENTAR CONCEPTS ABOUT OTHOGONAL AXONOMETRIC: HOMOLOGY APPLICATION.

Imagine to have a plan π and an orthonormal triple axis x, y, z, with source in O, however obliquely disposed with respect to π; axes and planes xy, yz, zx, defined by them, intersect π in trace points Tx, Ty, Tz, and the straight lines traces t_{xy}, t_{xz}, t_{yz}.
In axonometric the projection is infinite in the direction orthogonal to π (in the case of the orthogonal axonometric) or in a generic direction respect π (in the case of the oblique axonometric).
Since, therefore, we are talking about orthogonal axonometric, we consider the projection of the triad in the direction orthogonal to π; the origin O and axes x, y, z, (fig.1.a) give rise to O' and to the triple x', y', z' (fig.1.b); the planes xy, yz and zx intersect the reference plane π according to a straight line intersection that is called trace of the plane. It turns out that the trace of each plan is orthogonal to the projection of the opposite axes, so for example, the trace of the xy plane, t_{xy}, will be orthogonal to the projection of z, z' (fig.1.c). The motivation that determines the geometrical relationship between the entities represented is to be found from a consideration regarding the straight line of maximum slope of the respective plans. Consider, for example, the straight line of maximum slope of xy, mp_{xy}, given the segment OH of xy respect to π, whose projection, mp'_{xy} on π, is given by O'H.
The plane defined by T_zOH, containing OO 'orthogonal to π, and containing z, orthogonal to the xy, is orthogonal to xy; this plane is perpendicular to π and to xy, and that’s why it is orthogonal at their intersection, the t_{xy} trace; accordingly, the t_{xy} is orthogonal to the plane zz 'and to all its straight lines, even to z'; the t_{xy} must be, therefore, orthogonal to z' (fig.1.d).
Looking at the figure with so much attention, we can make several observations; the three angles at O are right angles, but do not appear right angles; the sum of their projections is equal to 360 ° and each is greater than the rectum.
If the spatial triad has a different position respect π, O' moves inside the triangle $T_xT_yT_z$; if O' moves and approaches to H, T_z goes away; if O' coincides with H, T_z is at infinity, and xy is orthogonal to π.
The angle x'O'y' becomes flat; the projection of the figures placed on the xy vanish, π, resulting indiscriminately projected on the track t_{xy}, this is an inappropriate location, unacceptable.
Suppose that, by moving O', the angle $T_xO'T_y$ appears rectum; the rectum angle T_xOT_y is projected in a rectum angle only if the xy plane and π are parallel or coincide; thus z is orthogonal to π, and z' is a point; cancel the shares of the points in space. Once again, the choice of this location is inappropriate and unacceptable.
It can be concluded that there are infinite possibilities to position the triad respect to π, as long as you avoid that each of the three angles at O' is straight or flat.

We realize that a particular position: to $OT_x = OT_y = OT_z$, which occurs T_x, T_y, T_z, are vertices of an equilateral triangle, with O' orthocentre and x'O'y', y'O'z', z'O'x', equally among them; the shortening of the projections mp'_{xy}, mp'_{yz}, mp'_{zx}, maximum slope of the straight lines mp_{xy}, mp_{yz}, mp_{zx}, is equals; that's a simplification.



1.a



1.b

Fig.1.a. Imagine to have a plan π and an orthonormal triple axis x, y, z, with source in O, however obliquely disposed with respect to π; axes and planes xy, yz, zx, defined by them, intersect π in trace points Tx, Ty, Tz, and the straight lines traces t_{xy}, t_{xz}, t_{yz}.
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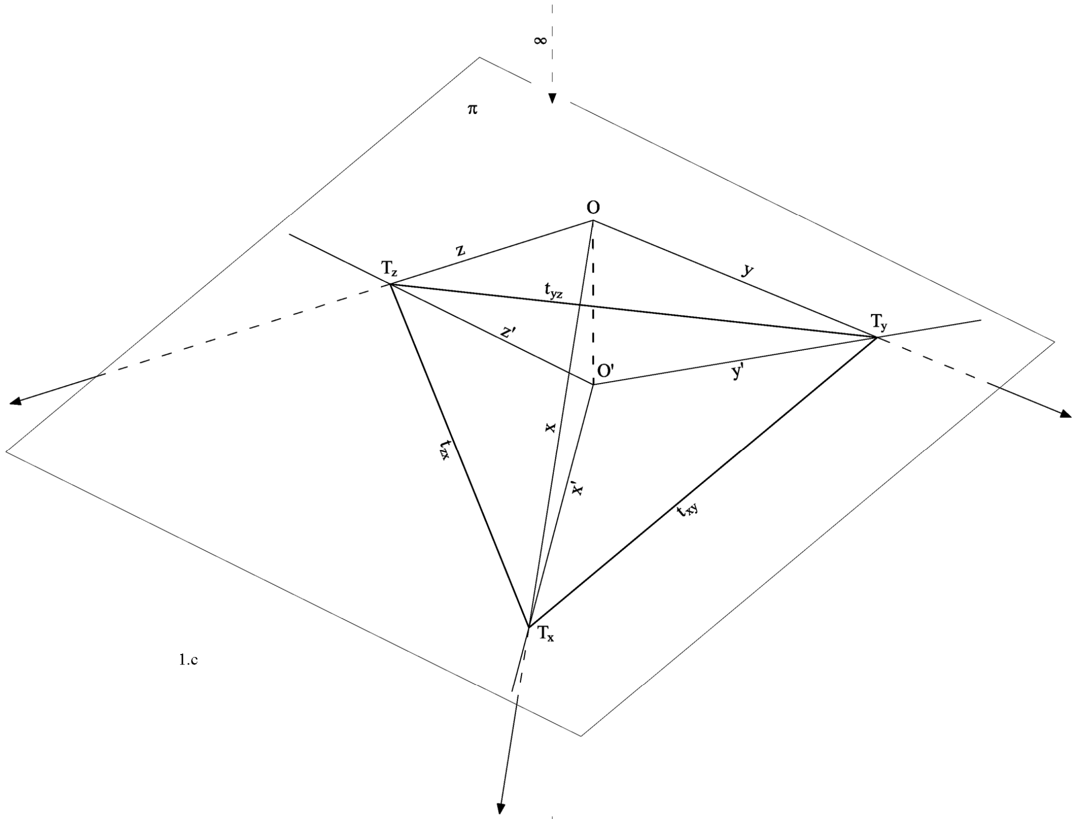
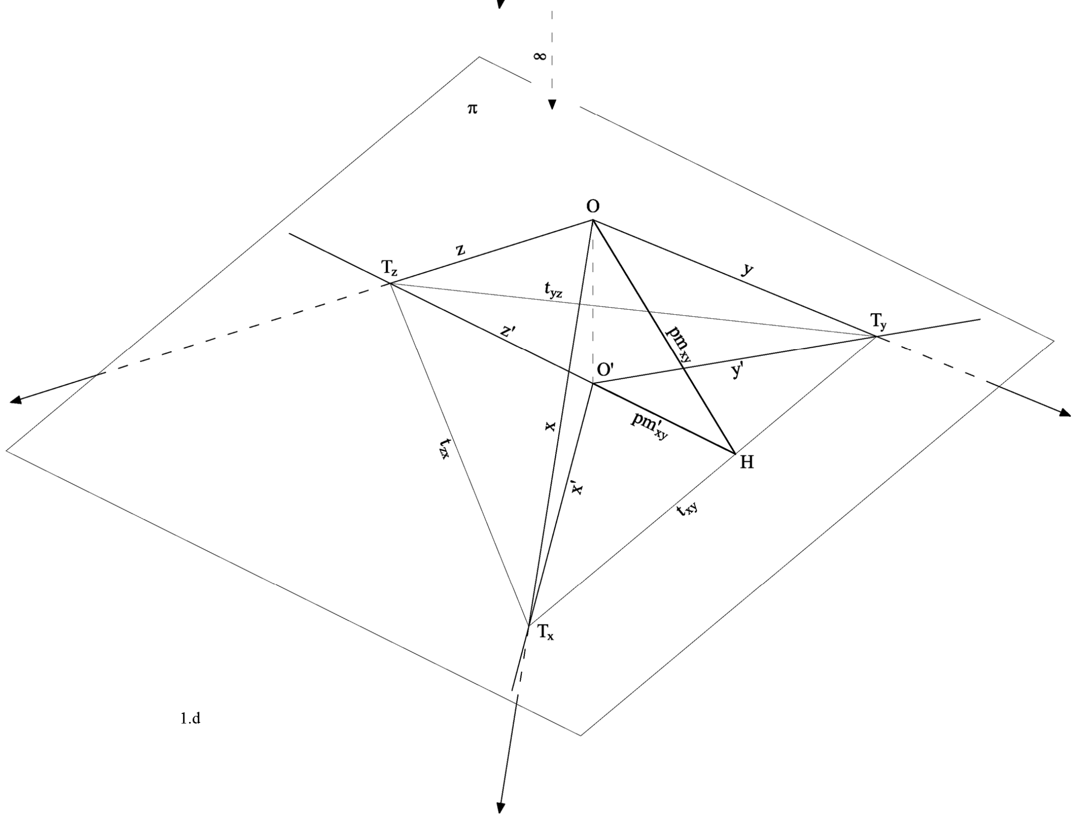
Fig.1.b. The origin O and axes x, y, z, give rise to O' and to the triple x', y', z'.

A minor simplification is achieved if only two of the three angles x'O'y', y'O'z', z'O'x' are chosen equal; the traces triangle is isosceles, the shortening of its slope lines are the same.



1.c



1.d

Fig.1.c. It turns out that the trace of each plan is orthogonal to the projection of the opposite axes, so for example, the trace of the xy plane, t_{xy}, will be orthogonal to the projection of z, z'. The motivation that determines the geometrical relationship between the entities represented is to be found from a consideration regarding the straight line of maximum slope of the respective plans.

Fig.1.d. Consider, for example, the straight line of maximum slope of xy, mp_{xy}, given the segment OH of xy respect to π, whose projection, mp'_{xy} on π, is given by O'H.

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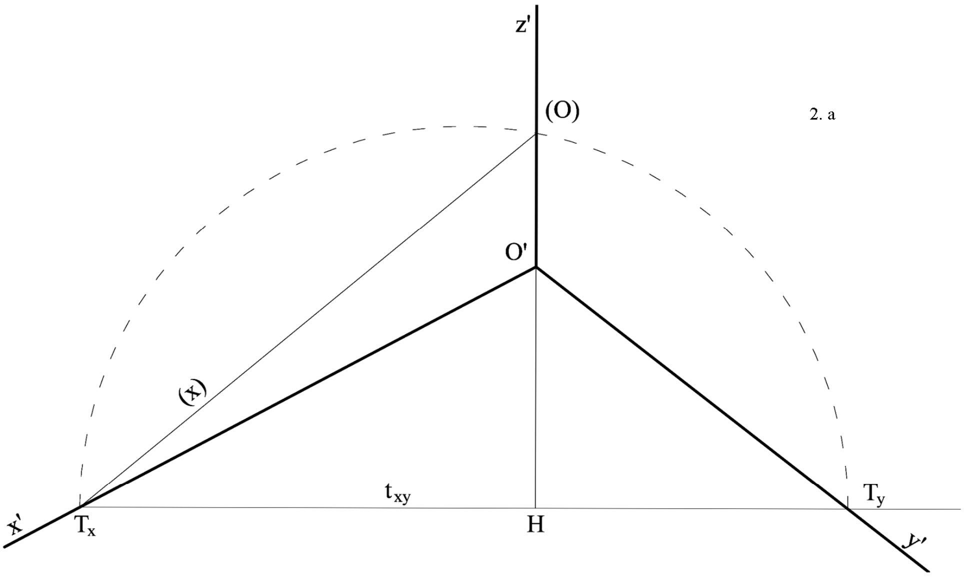
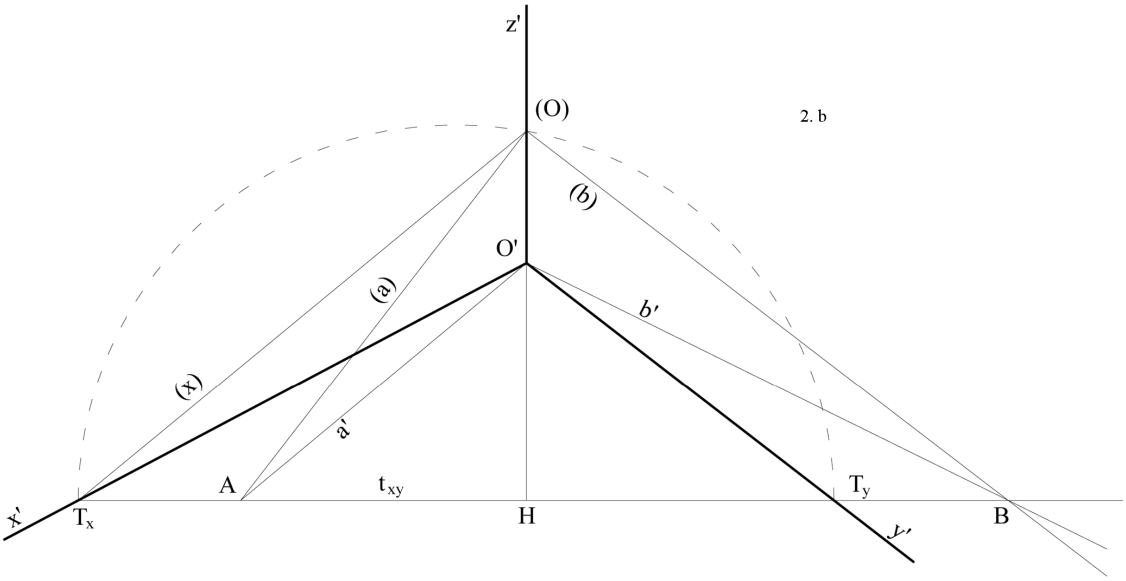
I think that teaching projection system through the image is an aid to understand, perhaps more expressive and persuasive words, spoken or written, and gestures, normal means of communication, intended to stimulate thinking, the reflecting, the motivation, the sharing. Enhance learning, involving the vision implies, however, that the image is correct, constructed according to the rules known to those addresses new knowledge.
Who pays to know, think and draw; the user apprentice, however, you see, clings to circumstantial impressions, gradually suggested by the observation in difficulty. He reads and thinks, reconstructs the visual communication and reflective, going beyond, seizing the new, to increase its availability theoretical and executive support for drawing in freedom and awareness.
If we reflect, we can conclude that the teacher transmits, without losing, an invaluable asset in its possession and the learner acquires, without removing, the intake, which in the end, it is multiplied, renewed, restored in the endless cycle of give and take.
Having said all this was to clarify how we should interpret the figures shown above.
In Figure 2.a we must clarify and confirm that the corners of fig.1.d, apparently not rectum, listed below, are actually rectum angles:

- the angles of the parallelogram π;
- the angle between OO' and π, or between z' and O'O;
- the angle between T_zO and OH;
- the angle between $t_{xy} = T_x$- H-T_y and z ', and OH = mp_{xy}, and O'H = mp'_{xy};
- the angle T_xOT_y.

This section is dedicated only to those who have full knowledge of orthogonal axonometric.
The spreadsheet of Figure 2.a, on which we are exposed to construction and testing above, is π, the one that in fig.1.d is the parallelogram π; here the eye, highlights, helped by the imagination, the establishment and operation of the system that relates the structure of space and the operations of projection of points, straight lines, lines, planes, surfaces, all the space in the direction perpendicular to the parallelogram π.
In the spreadsheet π of fig.2.b the geometric reasoning prevails, without which, relying on sight, one has the sense of loss; a threatening cloud of points, straight lines, lines, arcs, inevitably turns into a container where the elements of knowledge are all essential and deeply meaningful for those who, knowing, can catch the reality represented, overcoming the lack of appearance and pitfalls.
We examine the fig.2.a; on π are given the projections of x', y', z', a set of three spatial axes x, y, z, which are not seen, but you know about it; on x' is chosen at will a point T_x; follows that the triad is hooked to π through the trace of axes x on π; trace of xy on π is t_{xy}, orthogonal to z'; y' and t_{xy} have in common T_y; the points that are on π have no “ ' ” symbol, because they are not in projection, but they are both of the real system and of the plane of projection π.
Turning xy on π, around the t_{xy}; the point O, of the space, tilts in (O) and HO, maximum slope of xy respect of π, appears in H-(O) to true greatness and it is overlaps to z' and to its projection HO'.
This rollover allows you to obtain reversals of O_x, which projection is O'_x, in $(H)T_x$, not marked in the figure; in the rollover is established, between the points of xy turned and the corresponding projections, an affinities orthogonal homology defined by the axis t_{xy}, straight line of connected points, and the pair of homologous points (O), O', or T_x(O), T_xO'.
We choose the orthogonal directions (a), (b) outgoing from (O); they affect the t_{xy} in A, B; their projection on π is given by homologous directions AO', BO'; the rectum angle, AÔB, becomes AÔ'B no longer upright; these, in fig.1.d, are the directions of the sides of the parallelogram π, of any size, that home to the projective system (fig.2.b).
At this point in fig.1.d we choose the position of O'; the projection z' z is parallel to b', is chosen at will the inclination of the image of z intercepted by OT_z compared to its projection z' on by $O'T_z$, parallel to the b' side of the parallelogram.

The image OO' of the eight of O than the the parallelogram is shortened; it is an orthogonal direction to the plane of the parallelogram; in Figure 2.d is the segment hO' = 1-2, parallel to z '. Recall that the shortening of the parallel segments to z, is obtained by considering the overturning around HO' of the projecting plane z in z'; we derive O*, HO* which is the reversal of the maximum slope straight line HO, and orthogonal to HO* we get z* (fig.2.c).





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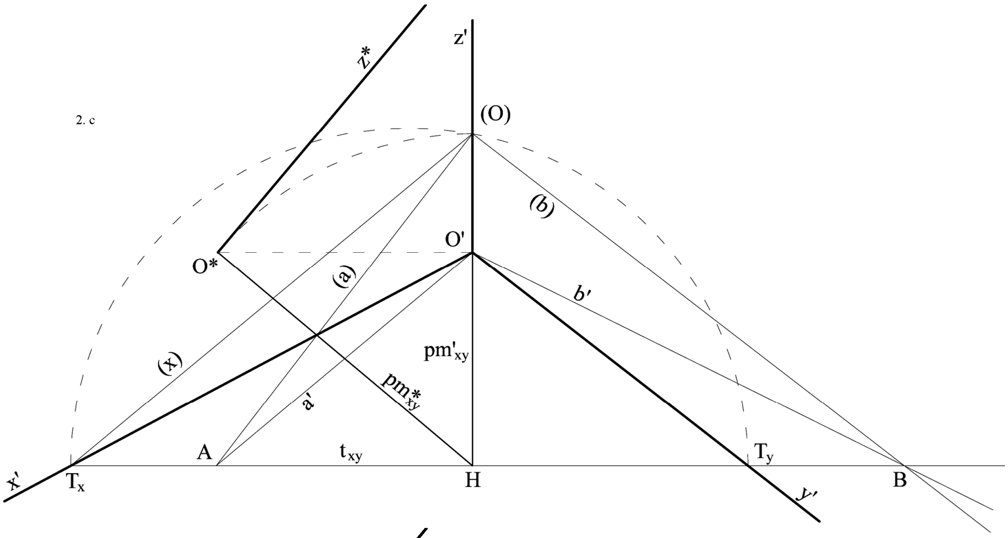
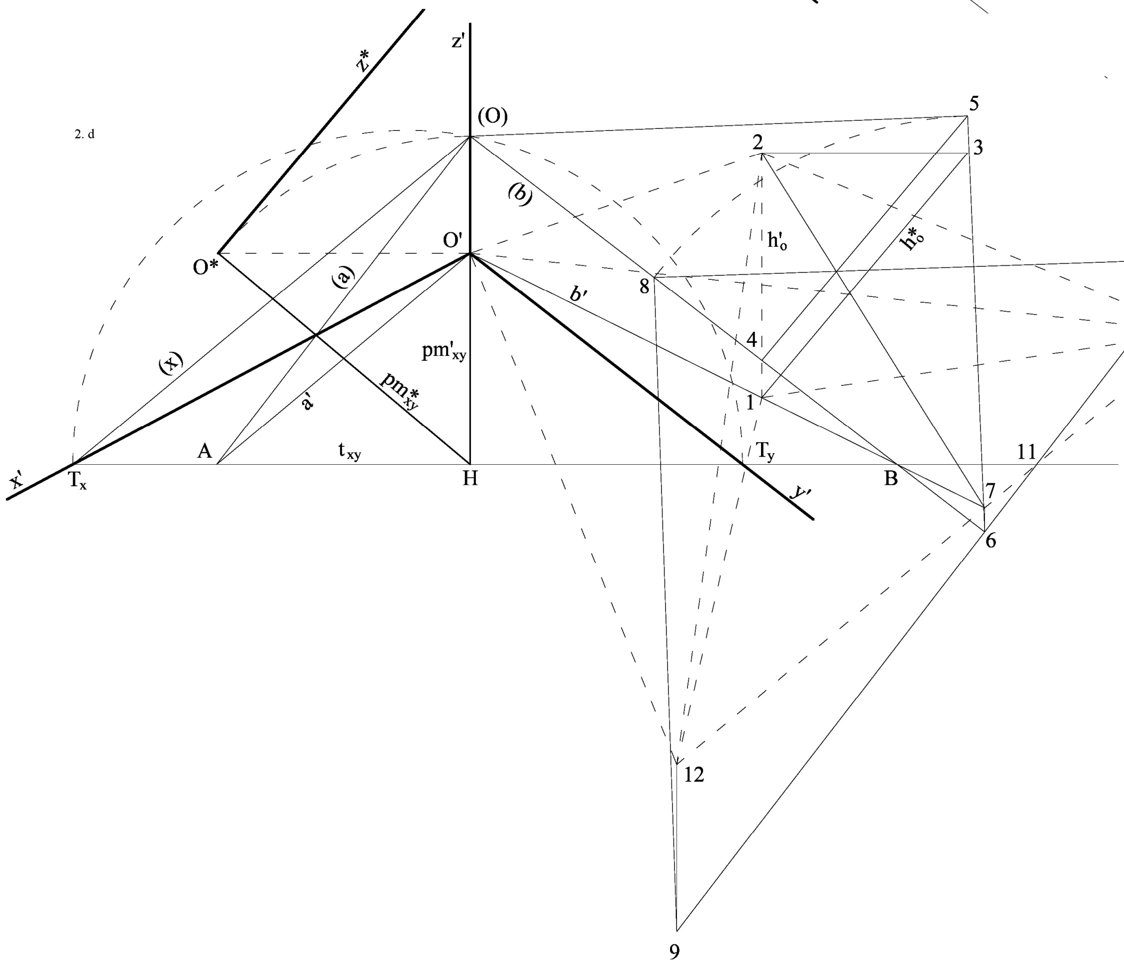
Every measure of parallel segment to z, shown on z*, is projected on z' according to the O*O', obtaining the shortening; conversely, in fig.2.d, the 2-3 parallel to O*-O' defines in 1-3 the real eight of the point O of Figure 2.d.





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The triangle (O)4-5(O), of the fig.2.d, in the fig.1.d is $T_zO'OT_z$; the 5-6 straight line completes the triangle (O)-4-6-5-(O), rectum in 5 and corresponds to the triangle T_z-O'-H-O-T_z in fig.1.d; in projection, in fig.2.d is O'-1-7-2-O'.

The arc center 6and radius 6-5 identifies on the (O)-6 the point 8; the orthogonal to the (b) conduct for 6 intersects in the point 9 a radius led to pleasure to point 8 and in the point 10 the radius led to point 8 orthogonal to 8-9.

The homologues points 12 and 13 of 9 and 10 combined points to the 2 form the triangle 12-7-13-2-12 that in fig.1.d is the face T_x- H-T_y-O- T_x; working to carry parallel, the b' with its points O'-1-7 defines the T_z-O'-H, otherwise referred as to z'-pm_{xy}'; the O'-2-7 is seen in T_z-OH, also referred as to z and pm_{xy}; the triangle O'-13-12-O' is found in T_x-T_y-T_z-T_z.

We can see the pyramid upside down the triad that is projected in 1, combined with 12, 13, O', corresponding, in fig.1.d, to the triad x', y ', z', with the origin in O'.

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In conclusion, the essential ethical reason to offer the eye, also inexperienced, a figurative guide very seriously and correct, advise against the unfortunately very frequent, of images "spatial" overly committed to compliance with the rules implied, without a real effect exposure on the completeness of problems of the type discussed.

THE ELLIPSOID IN ORTHOGONAL AXONOMETRIC PROJECTION.

If that so far has treated the mathematical aspect of the ellipsoid, now, we try to plot the geometry of the quadric under consideration.
The objective of this study is to demonstrate the extreme graphic simplicity that fixes the problem, when using the homology.
The ellipsoid is a quadric in elliptic points, that’s means that every tangent plane has in common with its surface two conjugate imaginary straight lines, whose only real element is the point of tangency.
You can imagine to obtain the ellipsoid by the movement of a generating ellipse 10, of axes 6-0_{xy}-6, and 7-0_{xy}-7; the axes can be variables so that the extremes 6 describing with an orthogonal translation, and with an influenced variations, the ellipse 8 of axes 5-0_{xy}-5 and 6-0_{xy}-6 and, in connection, the extreme 7 describe, drawn in the above orthogonal translation and with variations influenced, the ellipse 9; the three ellipses are mutually orthogonal and have the three axes in common, called the ellipsoid axes.
More briefly, the points on the surface of the ellipsoid meet the requirements of a quadratic equation in space, hence being a quadric.
To define the ellipsoid to achieve its representation in orthogonal axonometric, are given in projection three mutually conjugate diameters, corresponding to the three axes, and that, in pairs, define the three ellipses that are the projection of the three major ellipses.
Fixed the homological ratio H-O': H-(O), check the projection of the first axis of the main ellipse, freely positioned on xy, in diameter 5-0_{xy}-5; its actual size is obtained in the direction 1-(O), homologous of the 1-O', parallel to the 5-0_{xy}-5.
The other axis of the ellipse becomes a diameter 6-0_{xy}-6 conjugated to 5-0_{xy}-5, parallel to 2-4, homologous of 2-3, orthogonal to 1-(O); construct the ellipse 8, using the pair of conjugated diameters or with axes made from them; I have highlighted the extremes of the axes.
The projection-7 7-0_{xy}, of the third axis, perpendicular to the main ellipse already described, belonging to the xy, is obtained by shortening of z * in z'; using 7-0-7 in tandem with 6-0-6 and with 5-0-5, I get the ellipses nine and ten, wich are the projections of the major vertical ellipses, orthogonal to themselves and orthogonal to xy.
The image of the ellipsoid is completed by the outline, to which the three main sections are tangents; for the ellipse 8 revenue the parallel tangents to the diameter of 7-0_{xy}-7, to the ellipse 9 revenue the parallel tangents to the diameter 5-5-0_{xy}, to the ellipse10 revenue the parallel tangents to the diameter 6-0_{xy}-6; the points of tangency are extreme of three diameters of the discernible outline.

To illustrate the construction of the first diameter 15-0_{xy}-16, using the affine orthogonal homology of axis 11-0_{xy}-11 between the ellipse 8 and the homologous circle of diameter 11-0_{xy}-11; the homologous of the semi-minor axis 0_{xy}-12 is 0_{xy}-13; the 14-13, homologous of the 12-14, parallel to the 0_{xy}-7, is the direction of the tangent to the circumference of which I select the point of tangency considering the orthogonal radius to 13-14.
For it leads the parallel to 13-14, obtaining the homologous and the homologous 15 of the tangent point; the 15-0_{xy}-16 is the diameter of the ellipse c_e, the apparent contour of the projection of the ellipsoid.

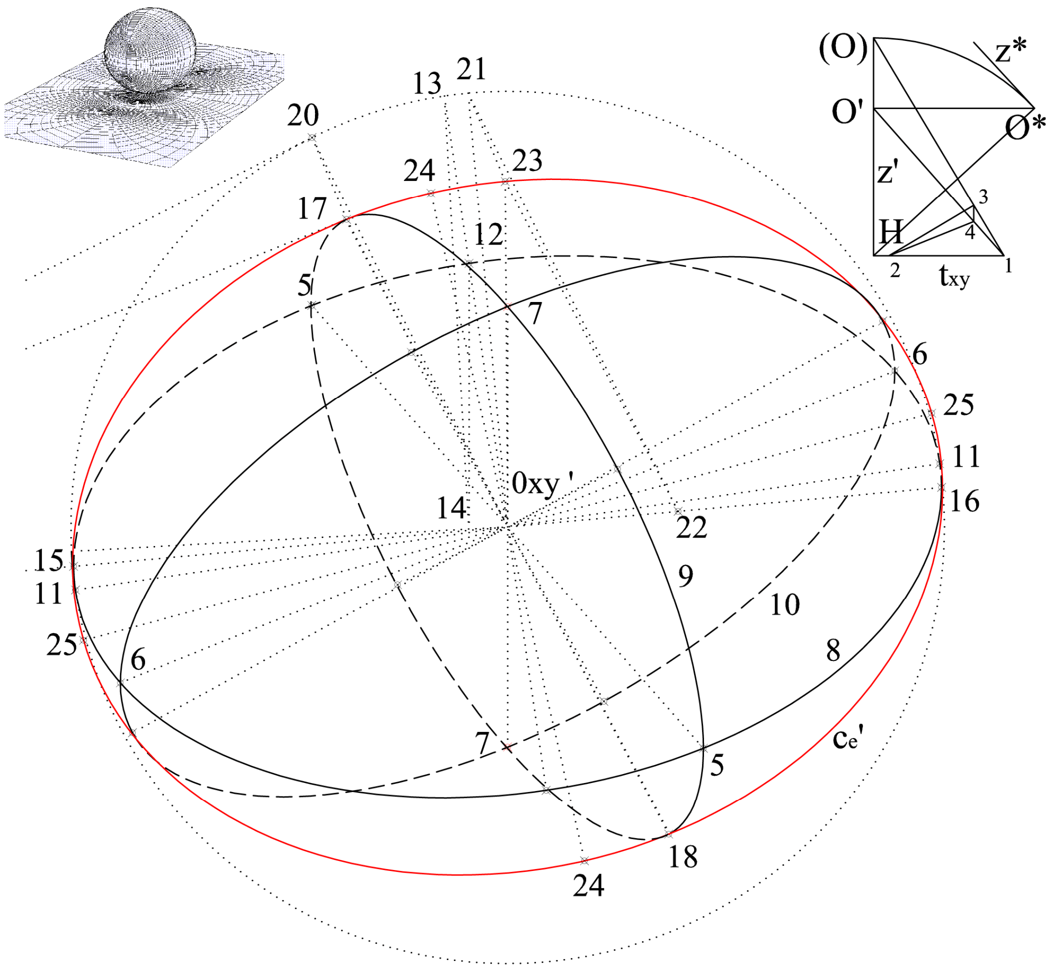


Fig.3. The ellipsoid in the orthogonal axonometric.

Repeat the construction for the ellipse 9 and revenue diameter 17-0_{xy}-18, using the affine oblique homology of axis 15-0_{xy}-16 between the ellipse c'_e and the homologous circumference of diameter 15-0_{xy}-16; the tangent in 17, parallel to the 6-0_{xy}-6, intersects the axis 15-0_{xy}-16 in 19 overs; the 19-20, homolog of 17-19, is tangent to the circumference in 20; the 0_{xy}-21 is orthogonal to 15-0_{xy}-16; the 21-22 is parallel to 0_{xy}-20, and 22-23 is parallel to 0_{xy}-17; 0_{xy}-23 is conjugated radius to 15-0_{xy}-16; revenue axes 24-0_{xy}-24 and 25-0_{xy}-25 and the ellipse c'_e.
Some observations: of the ellipse 10 is not necessary to determine the points of tangency; the plane parallel sections are always homothetic, so a chord of the ellipse 8, parallel to the 5-0_{xy}-5 has the conjugate vertical diameter proportion 0_{xy}-7: 0_{xy}-5.
A parallelogram with parallel sides to the axes, projection of a rectangle inscribed in 8, concentric, may be the trace on xy of four vertical planes; ellipses sections, in pairs, have in key a different height and have a different light sets.

We impose constant upstream and keys points belonging to the horizontal section; it generates a sailing ellipsoidal and so a volte with plumes ellipsoid.
I can repeat all of the assumptions made for the sphere: cups, cupolas, domes, fused, areas, triangles, wedges, holes, aggregations, drums and above ellipsoid domes, lunettes, modulated compositions of elements, but also, cruises elliptical arc, etc...
The “making” must goes in pair with the imagination; the ellipsoid can be round, if, for example, the main section, in projection the ellipse 10, is not an ellipse but it is a circumference, in which case it is a surface and a solid rotation; the director is circular and the generating is an ellipse.
The projection of an ellipse may be a circumference; the ellipsoid with circular and parallel director to the π, appears as a circle. We must reflect.

THE ELLIPSOID IN ARCHITECTURE.
When we talk about the applications of the geometrical shapes in architecture we must be very careful because some times we read that a shape is corresponding to a particular and definite geometrical primitive but if we conduct a serious survey we discover a different geometrical shape. Some times that seems like an ellipsoid could be a revolution solid or a part of a elliptical hyperboloid or an elliptical paraboloid. So I report below some ellipsoid applications but I declare that I obtained the information by some project indications and not trough a scientific survey. Some times we have just a part of an ellipsoid and there is a parameterization of the shape in according to the project. Some times we have a shape that’s presented like an egg shape but is an ellipsoid and some other times we have a shape that’s presented like an ellipsoid but is an egg.
One of the most famous example in the world of the application of ellipsoid in architecture is in China. I’m talking about the National Centre for the performing Arts “The egg” Built for the Amazing Olympic Architecture in Beijing. The Centre (fig. 4. a), an ellipsoid dome of titanium and glass surrounded by an artificial lake, seats 6,500 people in three halls and is 200,000 m^2 in size. It was designed by French architect Paul Andreu. Construction started in December 2001 and the inaugural concert was held in December 2007. This structure that’s called “egg” is an ellipsoid shape.
In China we have the Henan Art centre too (fig 4. b).. Situated at the CBD of Zhengzhou City, it is being constructed on a site of 100,000 sq m with total floor area of 75,000 sq m and is constituted from five buildings. The Henan Art Centre Concert Hall has been designed to resemble a butterfly from the outside. It can hold up to 800 people at a time who come to enjoy a wide range of concerts and performances. The geometrical shape is a parametric ellipsoid.
Another famous ellipsoid structure is in Asturias at Jurassic museum (MUJA), Spain (fig 4. c). The headquarters of Jurassic Museum of Asturias (MUJA), is located in an exceptional site on the Cantabrian coast in the municipality of Asturias Colunga. Designed by architect Rufino Uribelarrea, The museum opened in 2004. This is a spectacular building with a striking cover in the form offingerprint countermould kittiwake, characteristic of the dinosaurs. The large deck space is articulated by the intersection of three vaults ellipsoidales that form a large open space of 2500 m^2 exhibition.
In India there is one of the centre of the Infosys Company in Pune. It’s about a new ellipsoid structure that’s angulated respect the road plane (fig. 4. d).
In Italy, we have a project that entails glass distillation bulbs dedicated to the celebrated Nardini distillery (fig. 4. e). Two 'worlds': the first 'suspended', formed by two ellipsoidal transparent bubbles that enclose the laboratories of the research centre, and the other 'submerged', a space carved in the earth like a natural canyon that accommodates an auditorium and a foyer. The ramp descending to the auditorium is the original matrix of the 'canyon' space. It is utilizable as an open-air platform, creating one big auditorium space to host larger events. The audience is surrounded by a landscape generated by the arrhythmic configuration of the inclined walls. A stainless steel lake, at ground level, atopped with roof lights like outsized water drops. The lean columns with varying inclinations create a dynamic tension.

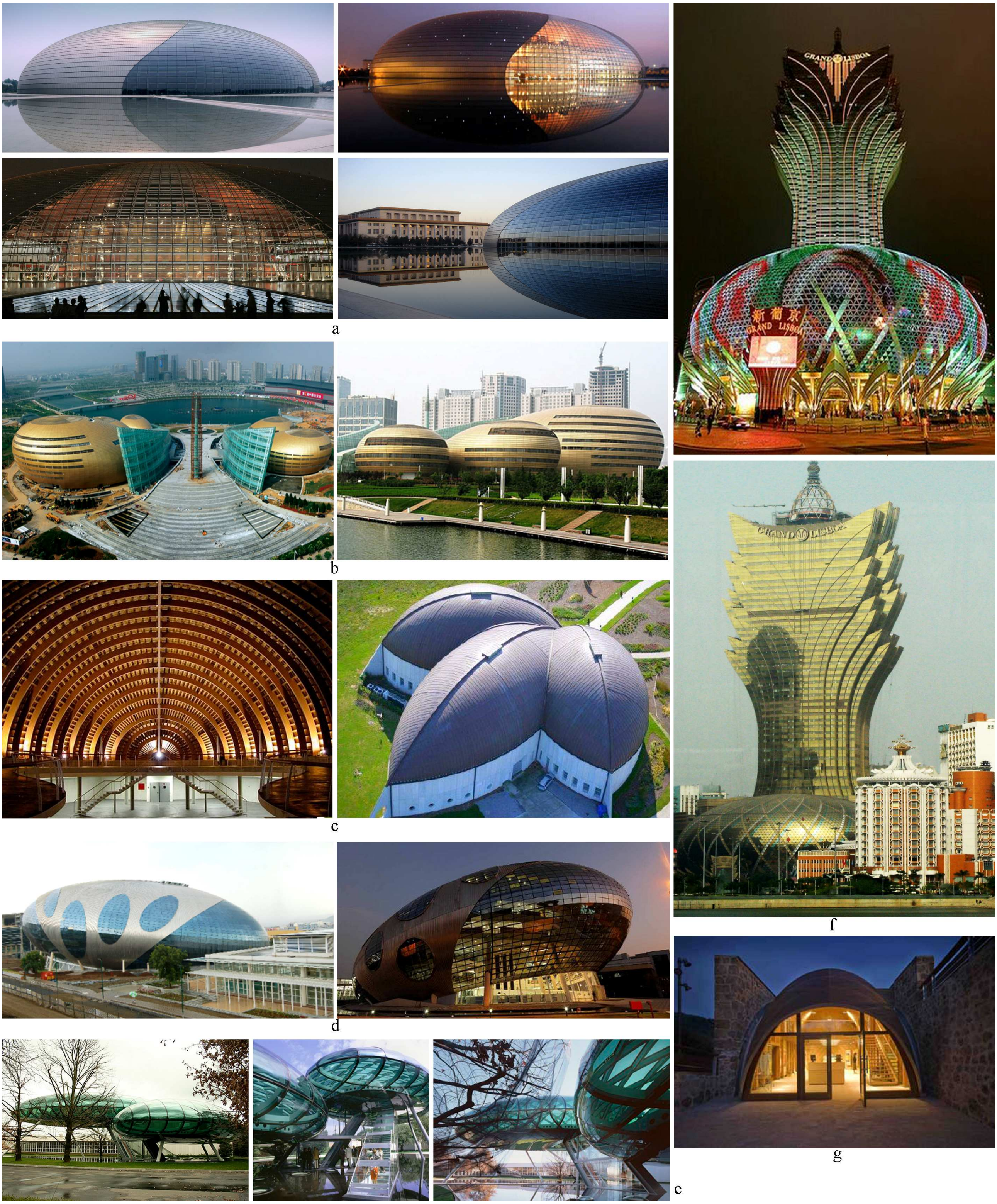
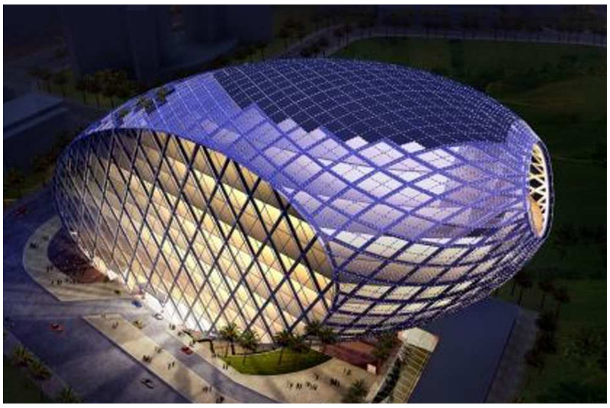


Fig.4. a. The National Centre for the performing Arts "The egg" Built for the Amazing Olympic Architecture in Beijing, China; **Fig.4. b.** Henan Art centre, China; **Fig.4. c.** Jurassic museum (MUJA), Asturias, Spain; **Fig.4. d.** Infosys Company in Pune, India; **Fig.4. e.** Nardini distillery in Bassano del Grappa, Italy; **Fig.4. f.** ; **Fig.4. g.** Saltworks at Añana, Spain.

Grand Lisboa is a 58-floor 261 metres (856 ft) tall hotel in Macau (fig. 4 f), China, owned by Sociedade de Turismo e Diversões de Macau and designed by Hong Kong architects Dennis Lau and Ng Chun Man. Its casino and restaurants were opened on February 11, 2007, while the hotel was opened in December 2008. The Star of Stanley Ho is on permanent display at the Casino Grand Lisboa. According to the Gemological Institute of America, the 218.08 carats (43.62 g) diamond is

the largest cushion shaped internally flawless D-color diamond in the world. The base of the tower is an ellipsoid.
At the end, in Spain we have the saltworks at Añana (fig. 4. g). The plan to upgrade the site entails converting the old canteen, left with only its perimeter wall standing, into a museum and retail outlet for salt. A large ellipsoid recalling the upturned hull of a ship greets museum visitors as soon as they set foot inside the old stone perimeter. Plans for this came from the Spanish firm of Landa-Ochandiano; inauguration took place in October 2008.

THE ELLIPSOID IN CYBERTECTURE.
James Law's intention while designing the Cybertecture Egg, was to bring together iconic architecture, environmental design, intelligent control systems, and evolutionary engineering towards creating this innovative building for the city of Mumbai and for India in the 21st Century.
According to James Law "In the 21st Century, buildings will not be created by just concrete, steel and glass as in the 20th Century but with the intangible materials of technology, multimedia, intelligence and interactivity. This enlightment gives rise to a new form of architecture – Cybertecture". Through its design itself, the building aspires to give its inhabitants both a dynamic physical world as well as access to virtual spaces of the connected world. With 33,000 square meters of office space stacked in 13 stories with highly intelligent building management systems, the building boasts 3 levels of basement providing 400 car parking spaces. The shape is from a truncated ellipsoid.

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