Auxiliary Schemes for Axonometric Drawing to Add to its Practical Utility

著者	SUGINOME Akira, KUROSAWA Kazutaka, INO Satoru
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Auxiliary Schemes for Axonometric Drawing to Add to its Practical Utility

Akira SUGINOME, Kazutaka KUROSAWA and Satoru INO

Abstract

The present report is intended to help enhance practical utility of axnometric manual drawing techniques. As a pertinent aid, a simple geometrical scheme is introduced to make transformation easier of a trimetric system into its dimetric equivalent, and v. v.; specifically concerning rotation of both systems about any normal to a coordinate/principal plane they have in common.

The above subscheme coupled with now reconsidered auxiliary views to the main drawing and/or the customary resorts serves to make it easier in drawing to account for angular relations between the line of sight and the considered axonometric coordinate system and to address oblique or non-axonometric linear elements and circular segments of an object than only with those resorts, e. g. scale ratios for axonometric lines and coordinate plane revolution to deal with non-axonometric portions (with the known method of intersections as a generalization thereof).

Utility of the customary drawing routine combined with introduced partial alternatives thereto, notably in drawing to meet compound geometrical conditions, is noted in an example to show the agency of our present procedure and others to clarify relatedly conceived additional use of the conventional ellipse guides.

1. Introduction

Rapid progress in computer graphics techniques may be said to have undervalued the normal pursuit of improved skill in manual axonometric drawing. Still, its renovation even to any small extent plainly seems desirable in its reconstitution, e. g., to be more analytical, focused on geometrical basics, irrespective of whether its usage is solely manual or interactive with the former vehicles.

For now, as immediate considerations, certain of axonometric drawing routines, though largely unheeded so far, may be capable of improvement noted in the following.

As a practical need, in its initial sequence any axonometric drawing would rather include explicitly defining the angle between the viewer's line of sight and any relevant prinicipal plane e. g. using its edge views auxiliary to the main drawing. In other words, from the pictorial nature of the drawing that can duly involve artistic sketching, it is natural that the relative position between the viewer and the considered object or coordinate system had better be intuitively comprehensible.

However, serving the need implicitly alone, the whole preliminary scheme assumed in the standard drawing methodology still remains no more than the angles between the pictures of the system's coordinate axes and the accompanying scale ratios for dimetry and trimetry. In fact, such distinction and scale ratios become secondary as often as not by our subsequently reordering the drawing system taking account of the above priority.

Needed concurrently are appropriate subsystems or devices ancillary to axonometric transformations and to any other drawing work in line with the above primary consideration and to expedite overall geometrical construction; based on such elemental drawing operations as producing from the oblique or non-axonometric segment of a simplex object either its true length or shape and v. v.; fundamental transforms indispensable between an object and its picture.

Those ancillary means amount to auxiliary views of the system and the ordinary means of revolution of coordinate planes; the said devices signify, in the main: the reference points for easier rotation of the principal planes or axes, a simple construction to facilitate the drawing of the ellipse and more practical attempts to add utility to available ellipse guides.

Subsequently, through illustrated examples for developing their more or less combined utility, we are to consider proper use of the foregoing collateral measures to be conducive to axonometric manual drawing.

2. Assumption

In the following for brevity we synonymously refer to axonometric coordinate system as a(n) (axonometric) system unless on defining otherwise; to its coordinate axes/planes as principal planes/axes; to pertinent drawings as drawings or views. Generally, the system to be considered is the one as defined in Ref. [1] along with its auxiliary side view, with its three principal axes stretching toward the viewer of the object lying in principle between its origin and the viewer. Main notation for symbols and abbreviation is given below. With this, any main-auxiliary-combined view drawing is to follow the orthographic third-angle conventions e. g. [2] usual in this country; unless otherwise specified on occasion.

2.1 Notation

i) Literal: In principle, points pertaining to an object are designated by capitals A, B etc. in its drawing and by lower-cases a, b etc. as their projections in space onto a principal plane,

i. e. axonometric coordinate plane.

ii) Suffix : The letter or literal symbol for any point in auxiliary drawings is given suffix "1" or "2" additional to their orininal equivalent in the main drawing, respectively for a first or second auxiliary view. ; additional suffix "0" to literals for points on principal axes or others revolved on to a picture/image plane or parallels thereto, esp. in later discussed examples 1 and 2.

iii) Numeral : i's / i=k, 1, 2. . / refer to transferable points by a sequence of coordnate transformation, with k treated as one of them that is on a dimetric principal axes.

2.2 Abbreviation

Points, line and plane may respectively be abbreviated as pnt., ln., and pl., with "s" to their plural ; point/line of sight as p./l. o. s. ; auxiliary view as a. v. ; true length as TL ; In figures, entries M, A_1 and A_2 signify image planes ; the main, a 1st and a 2nd auxiliary, respectively on both sides of a folding line as intersections between those combined.

3. Subsystems

As is well-known, considerable part of the orthographic drawing technics including those axonometric are usable as eventually equivalent alternatives to each other. Admittedly, the more of them are the better for drawing objects easily subject to visual angles or directions ill-conditioned for analytical drawing operations. In the following, an additional alternative is introduced so that it may be usable combined with other subsystems to the main drawing routine duly including the said auxiliary views and revolution procedure. Their utility will be discussed only as their use correlated or combined with other means.

3.1 Reference Subscheme for Rotation of a System

Though usually needed, still cumbersome seems a mere rotational transformation about a principal axes of any arbitrarily given trimetric system into its dimetric equivalent (though the reverse of this transformation is obvious), without any direct and simple means available even in well-documented textbooks, e. g. [3].

Currently, such a one is introduced. Pertinently, an arbitrarily chosen trimetric system is shown in Fig. 1 with the relatedly assumed axonometric triangle (trace triangle) X_iY_iZ of any size (where i can be any cardinal). Then a circle is drawn with diameter OZ and Center C. Line Mk tangent to the circle at k is drawn from midpoint M of the base of the triangle. Both k and intersection A of horizontal line kk and Z-axis are the necessary reference points in the following sense. Referring at first to point k, intersection X_k of line Ck with the preceding base can directly determine OX_k as the relevant axis of the required dimetric coordinate system with X_k-, Y_k-and Z-axis ; with symmetry readily giving Y_k-axis too.

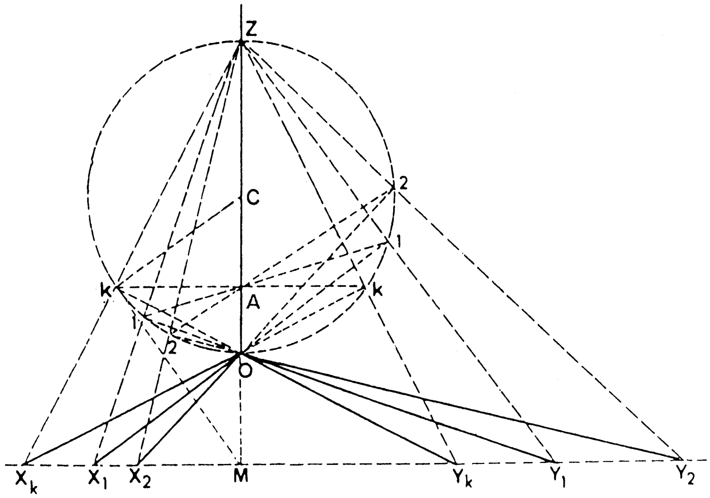


Fig. 1 A geometric relation for transformation between a dimetric system and its trimetric variations.

Next, relating to point A, let arbitrarily assumed $X_{i(i=k,1,2..)}$-axis belong to any trimetric system to be obtained by rotating the above dimetric system about Z-axis. X_i-axis and the said circle obviously intersect at point $i_{(right)}$; and the line drawn though both $i_{(right)}$ and A determine $i_{(left)}$ on the circle (circle C) ; then line through both O and $i_{(left)}$ provides point Y_i or desired Y_i-axis.

Namely, point k has provided the dimetric system from any of its trimetric counterparts ; while point A has commonly served as reference point for any degree of axial rotation above.

The validity of the above concepts is easily confirmed. Shortly noted at least on drawing is for circle C to be the locus of feet i (i=k, 1, 2..), notably including point k, of the perpendiculars to the legs (oblique sides) of trace triangle X_iY_iZ from its orthocenter. Obviously required for any system under consideration to be dimetric is symmetry of points $i_{(left)}$ and $i_{(right)}$ with respect to Z-axis. This holds only when i=k, with symmetric points k obtainable as points of tangency of lines drawn from point M to circle C.

3.2 Major and Minor Auxiliary Circles

Rather than its trimetric variations, a dimetric system now made to be easily afforded is more fitted e. g. for drawing circular objects or revolution loci on a principal plane as in Fig.

2, practically because assuming major and minor auxiliary circles for elliptic drawings can dispense with an auxiliary side view or other ancillary means required in trimetry.

When an ellipse is the revolved entity of a circle lying on the picture plane onto a principal plane as in Fig. 2, the direction of any radius of the circle from its radius vector is not directly detectable without the ellipse drawn beforehand, while most simple is the reverse : to find the direction of ellipse radius vector by use of the circle. Though seemingly too trivial to have been documented so far, the ensuing process fills the purpose.

In Fig. 3, radius vector OX_i is initially given its direction. From intersections (pnts. 1 and 2) of this direction line with the respective major and minor auxiliary concentric circles, a vertical and a horizontal line are drawn to give their intersection, pnt. 3, and the desired radius OX_0. Such pieces of knowledge are convenient in reality e. g. for drawing tangent planes to surfaces of revolution (by applying concentric circle construction [4] or otherwise) and treatment of non-axonometric lines in general.

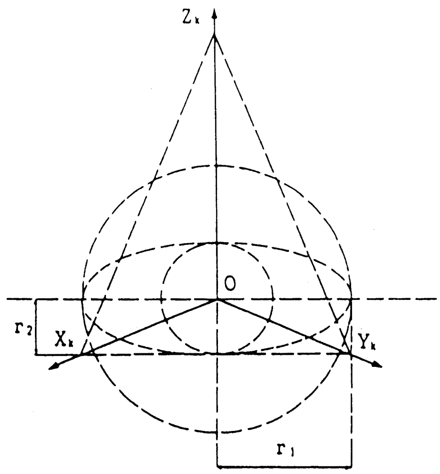


Fig. 2 A dimetric reference system directly affordable by concentric circles or a foreshortening ratio, r_2/r_1.

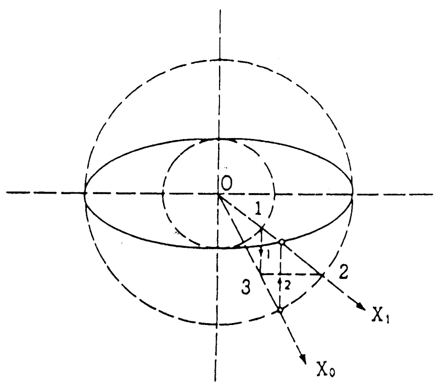


Fig. 3 A way of locating radius of an object circle from a given radius vector of its elliptic view.

3.3 Auxiliary Views to Main Drawing Combined with Other Ancillaries

Despite their apparent inactive practical use so far, auxiliary views to a main axonometric picture seem in fact indispensable in theory and practice, with a trace triangle to the main drawing notably accountable for perpendicular relations between elements of a drawn object. Fig. 4 is intended to exemplify two major aspects of their use : aids to revolution (as the equivalent for the Mongean term *rabattement* of a principal plane and rotation of line/plane elements of the objects in the context of graphics routine. In that illustration of the ordinary multi-view drawing operations for dihedral angle of planes ABC and BCD, noticeable seems the depicted rotation of the relevant cross-sectional angled lines using a first and second auxiliary view, attended with drawing its locus.

By the nature of a pictorial drawing aimed to be self-explanatory based on the known principles of orthographic drawing and for reasons of space, we let the illustration need no additive accounting for its contents.

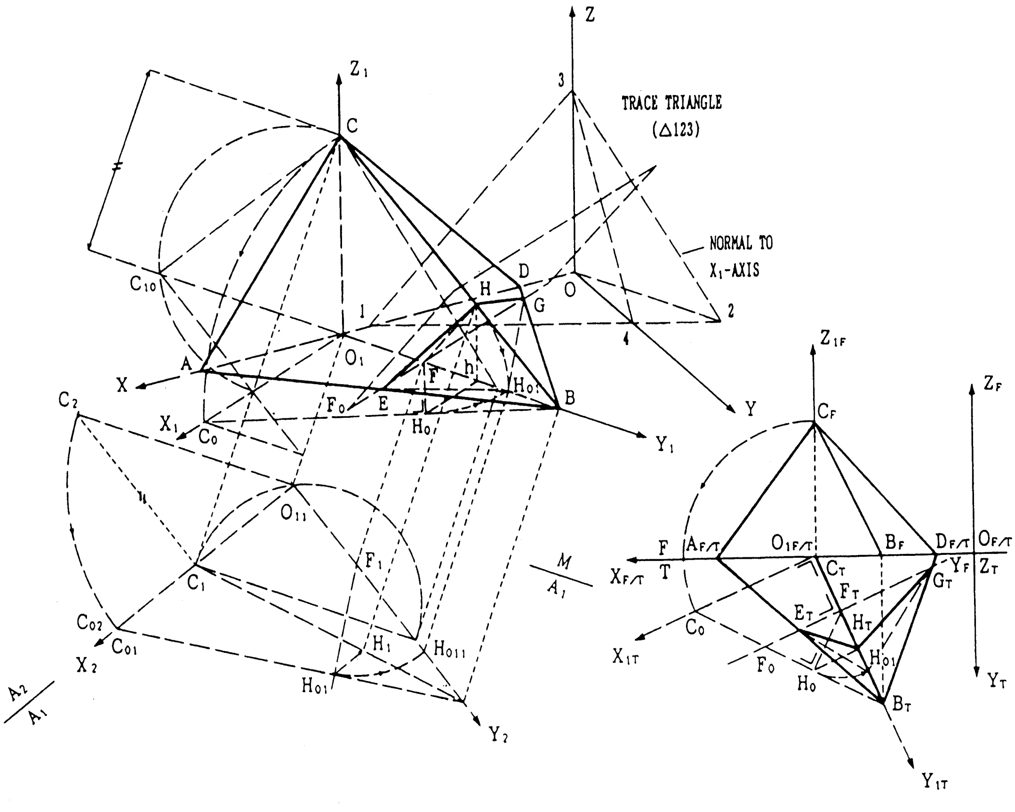


Fig. 4 An axonometric illustration of constructing a dihedral angle by the descriptive geometry.

4. Use of Ellipse Guides

As examples of more practical application of the currently surveyed auxiliary measures, Figs. 5 and 6 introduce a sequence of drawing steps or two for added efficacy of ellipse guides/templates to their customary utility.

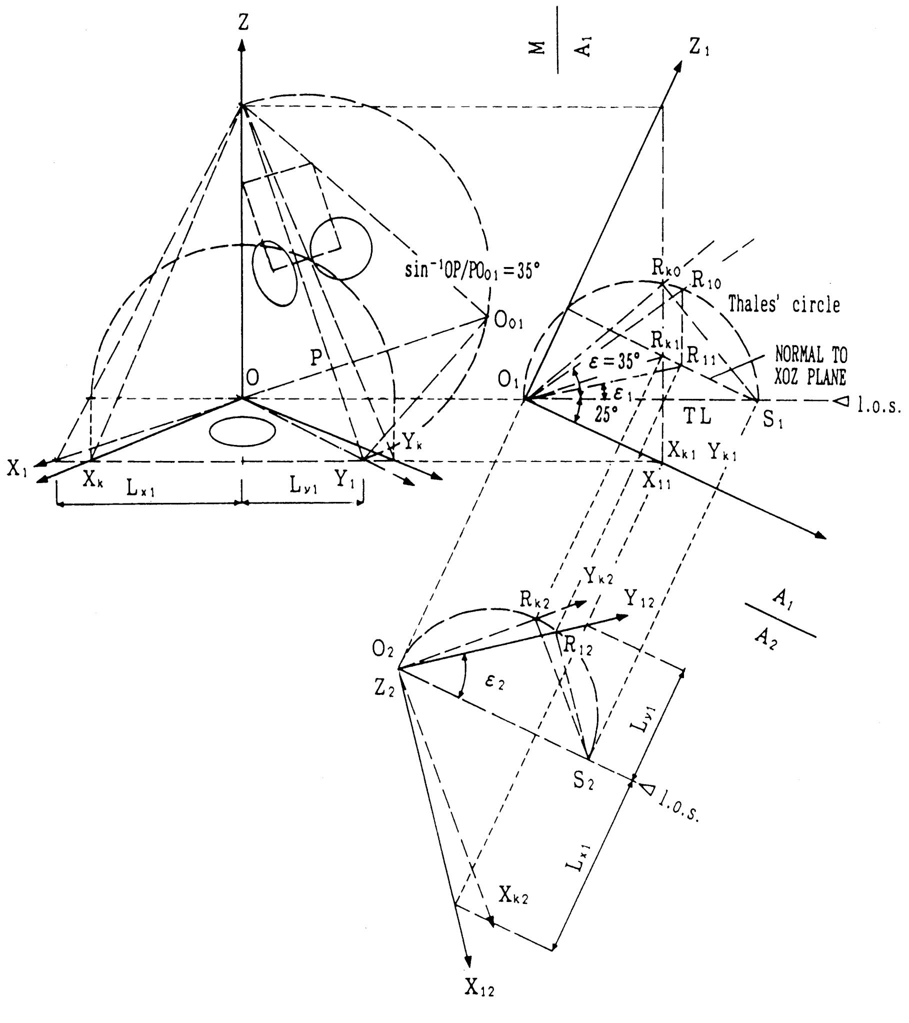
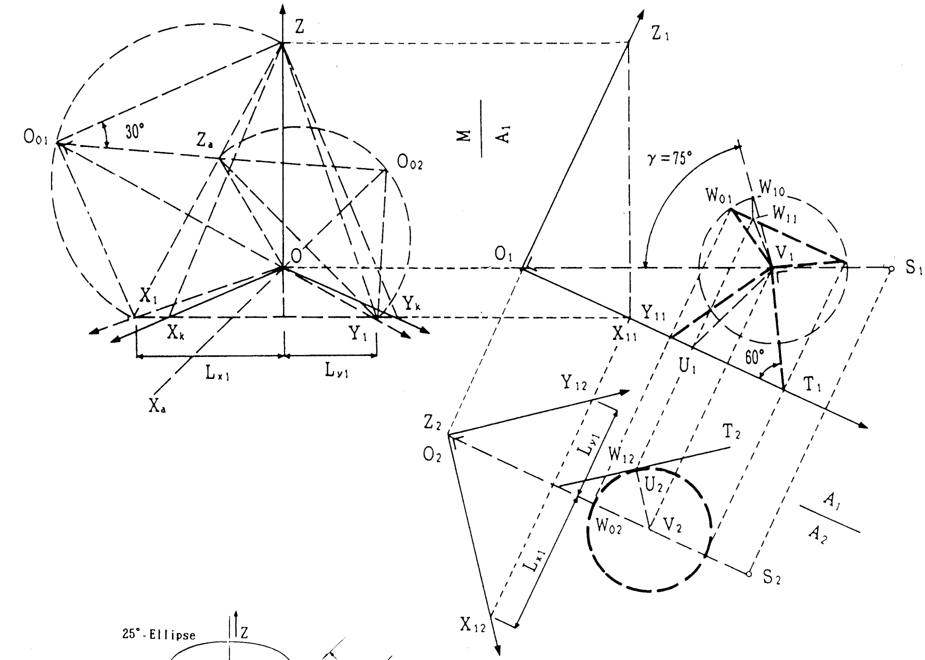
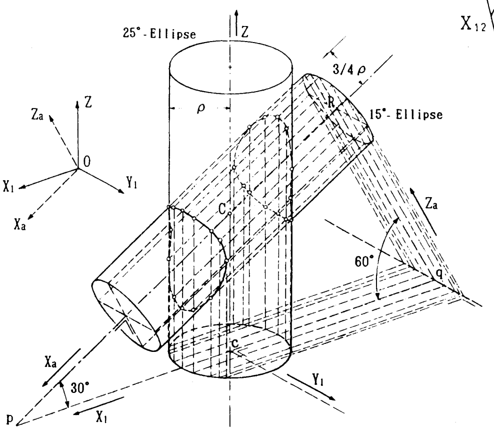


Fig. 5 Example 1 for drawing object circles, laid on different principal planes, as template ellipses of 25- and 35-deg. ellipse angle.

Ex. 1 : Using at first two template ellipse sets different in ellipse angle we are to effect the trimetric drawing of two sets of circles lying on different principal planes ; such usually being the case e. g. in engineering illustration centering on objects with mainly linear and/or circular outlines. Relevantly in Fig. 5, given plane X_kOY_k, beforehand, inclined e. g. through 25 deg. to the picture plane, X_k- and Y_k-axis are to be rotated to the position of X_1- and Y_1-axis so as to turn axonometric projections of circles laid on plane Y_kOZ into ellipse with any assumed ellipse angle, i. e. 35 deg. in the present case.

Such an angle, the same as that of inclination of l. o. s. SO to plane Y_iOZ, where i=k, 1 etc., is measurable as angle SOR_i with pnt. R_i as the foot of a normal from expediently chosen p. o. s. S to the plane. Attendant on the rotation through varied angles pnts. R_i'$s_{(i=k,1\ etc.)}$ form a circular locus with diameter O_2S_2 which is projected as a line horizontal and a circle in the respective 1st and 2nd a. v. ; while forming another with diameter O_1S_1 on the vertical plane assumed through ln. OS in space, when being revolved about axis OS onto that plane.





Selecting the prescribed triad of reference coodinate axes in Ex. 2 (above)

A case in point of using 25- and 15-deg. ellipse guides in drawing intersected cylinders with coplanar axes and radii of ρ and $3/4\rho$ (left)

Fig. 6 Example 2 for methodizing the drawing of object circles, laid on X_1OY_1-principal plane and a plane with a specified 60-deg. inclination to it ; to be respective templete ellipses of 25- and 15-deg. ellipse angles ; and a directly relevant depiction of intersected objects.

Assumed pnt. $R_{io(i=1)}$ on the latter circle in the 1st a. v. so that angle $R_{io}O_1S_1(=\varepsilon)$ should equal the said 35 deg. is to correspond to R_{11}, in the direction normal to ln. O_1S_1, and further to R_{12} on the former of Thales' circle in a. v. the 2nd, deciding O_2Y_{12} and O_2X_{12} and hence OY_1 and OX_1 in the main drawing.

Ex. 2: In a related context, when an oblique circle lying on a plane is needed to be axonometrically drawn as a template ellipse e. g. with ellipse angle $\varepsilon=15$ deg., provided the object is inclined to plane X_kOY_k through a specified angle e. g. of 60 deg., its position can be decided in a scheme of Fig. 6.

There two cones in a pair, one laid on plane X_kOY_k with that angle as base angle and another, inverted, composed of the normals to the former at its vertex, V, are introduced. Among varied angles that SO, a l. o. s. passing through V, makes with the generatorices of the inverted cone, $\angle$WVU can be chosen as γ, the complementary to ε, for the reasen to follow.

Because those generatorices may be revolved about l. o. s. SO onto the vertical plane containing this, into the radii of a circle with radius V_1W_{10}, an assumed true-length generatorix V_1W_{10} to make $\gamma=\angle O_1VW_{10}$ with ln. SO can be revolved back into $W_{01}V_1$, which is readily to give the plane or any parallel thereto that can contain the said circle. Namely it is the tangent plane to the first cone through generatorix UV and trace WT, for pnts. U and V correspond in the direction of Z-axis, with plane X_aOZ_a being such a parallel with X_a-axis normal thereto. Incidently included in that figure, as a case in point, is an appropriate axonometric view of two intersecting circular cylinders.

5. Concluding Remark

Though explicitly with only a few specific illustrations, major combinations of the introduced subsystems, including some presumedly novel, seem to have proved of additional use to the conventional means in probable cases of their practical application in constructions under more of quantitative geometrical constraints than those relatively elemental mainly with axonometric lines.

Hence the introduced variations of means are expected to aid types of pictorial drawing where the drawer's depicting compound objects with their circumstantial transfiguration, necessarily grasping their mutual and relative position to the viewer, as part of a total scene tends to be an intricate consideration, unlike simply delineating discrete objects themselves as has mostly been the case.

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