A METHOD OF GRAPHIC RECONSTRUCTION IN ISOMETRIC PERSPECTIVE

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SEVEN FIGURES

During the course of an embryological investigation, the need arose for an accurate graphic representation that would aid in the interpretation of certain complex structural arrangements. Since many of the structures under consideration were behind others in the same plane of section, it was not possible to show clearly their true location by the usual graphic reconstruction method. If the standard graphic method could be modified to give a three-dimensional illusion, structures might then be shown in their relative spatial positions. Techniques have been published that show the three-dimensional aspect in graphic reconstruction by means of stereoscopic illustrations (Lebedkin, '26; Sauer, '37). Lebedkin ('26) reviewed the techniques involved in several types of graphic reconstructions and contributed a modification of the standard technique in an attempt to produce a three-dimensional illusion. Since these methods are not as simple as might be desired, the system presented below was devised in the attempt to produce an accurate three-dimensional illustration simply and directly. It is based upon a simple geometric construction. The basic principles incorporated in the theory of perspective gave the author the solution to the present problem.

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METHOD

If a square figure is tilted out of the vertical plane, the base nearest the observer will appear longer than the side away from the observer giving the tilted square, as seen in two-dimensions, the appearance of a trapezoid (fig. 1). The parallel sides of the square will appear as converging lines meeting at some imaginary vanishing point in the distance. These observations are valid for any object in space since those points nearest the observer will always appear larger than the more distant points. This can be nicely illustrated by the familiar sight of railroad tracks and telegraph poles extending across a plain (fig. 2). By applying these tenets to sections of embryos, similar illusions can be obtained. If each section of a series were tilted away from the vertical the same degree and realigned in sequence, a three-dimensional view of the embryo would result (fig. 5). To achieve this effect without having to draw each section separately in a perspective view, a "perspective millimeter grid" was devised. By means of this grid the normal sections could be directly transposed and reconstructed by the standard graphic method to give a three-dimensional illusion.

In the construction of the "perspective grid" it is assumed that each section is to be tilted the same constant, arbitrary angle away from the vertical. Since the apical angle of the triangle to be constructed determines the degree of tilt, this angle is arbitrarily chosen. The more acute this angle is, the less is the degree of tilt. Once the apical angle is chosen, the base angles of the triangle are known. A desired length base line is drawn and an isosceles triangle is constructed upon it using the previously determined angles as the base angles (fig. 3). A perpendicular is dropped from the apex of the triangle to the base. It serves as the center line of the system. At some arbitrary distance from base to apex a point is marked on the midline. This distance is arbitrarily chosen because in order to give the best perspective illusion of a tilted square the proper distance must be gauged by the naked eye. A line DE is drawn at this point parallel to the base (fig. 3) and the base line is divided into 5-mm segments which are connected to the apex of the triangle by lines transecting line DE. Triangle CDE (fig. 3) can be discarded. On the trapezoid ABED (fig. 4) diagonals AE and DB are drawn intersecting the converging lines connecting the bases AB and DE. Parallel to the bases, lines are drawn between the points on the diagonals made at the intersection with the converging lines and are extended to the sides AD and BE (e.g. fig. 4 lines WXR and YZS). This produces a square grid seen in perspective. The rationale behind this construction lies in the basic geometrical theorems that apply to an equilateral parallelogram. It should be borne in mind that the construction of this trapezoid and the smaller trapezoids within it to form the grid is nothing more than the construction of a subdivided parallelogram seen in perspective. Thus the distances EV, VU, UT, etc. represent equal distances shown in perspective illusion. By the same token $\frac{AF}{DF'} = \frac{FG}{F'G'} = \ldots$ etc. In other words, this trapezoidal figure represents a perspective view of a 5-mm grid square. The constructed "perspective grid" is the basis for the following graphic reconstruction.

The reconstruction can be simplified if 100 diameters magnification is used and 10 μ can then equal 1 mm. The sections of the embryo are traced at 100 times magnification by projection. Each magnified section drawn has the pertinent structures located on a normal millimeter grid. The midline of the embryo passes through the notochord and serves as the ordinate. The abscissa also passes through the notochord and is perpendicular to the ordinate. Coordinates of the structures to be reconstructed are determined from these axes.

A sheet of tracing paper is placed over the large sheet of millimeter grid paper on which is recorded the cephalo-caudal level of each section to be plotted. A midline is drawn on the tracing paper for the ordinate. The abscissa is drawn perpendicular to this. On the "perspective grid" this abscissa is drawn a distance of 50 mm from the dorsal base line DE. This distance is measured by counting down 10 squares from the dorsal base line; each square represents 5 mm. The "perspective grid" is placed under the tracing paper and the axes are made to coincide with those of the "grid." The coordinate points of the structures on the magnified tracings are plotted on the tracing paper using the "perspective grid" placed beneath it for localization.

The procedure from this point on follows that of the usual graphic reconstruction with each point locus in the embryo being transposed directly to its relative spatial locus. The end result, however, is a three-dimensional, isometric drawing (fig. 6). Figure 6 is a finished drawing done by this method. It shows relationships of portions of a venous plexus around the great vessels of the heart which would be obscured otherwise by the more superficial parts of the plexus. To indicate the planes of section at different levels, a congruent trapezoid is drawn through the desired planes utilizing the "perspective grid" for accurate reference (fig. 7).

In the final drawing, the proportional distortion of the structures makes those that are closer to the notochord smaller than those closer to the ventral body wall. Consequently, an illusion of depth is created. Structures lying behind others and their relative distances apart can now be visualized. This method is not only applicable to embryo sections, but to any serial sections, gross or microscopic, that are to be reconstructed.

SUMMARY

A method of graphic reconstruction utilizing a trapezoidal grid is described. This method produces a finished drawing giving a three-dimensional illusion to the structure reconstructed. It has the distinct advantage of visualizing more distant objects in relation to structures that overlie them.

LITERATURE CITED

LEBEDKIN, S. 1926 Zur Technik der graphischen Rekonstruktion: Projektionsrekonstruktionen und Stereoskopische Rekonstruktionen. Zeitschr. f. wiss. Mikrosk., *43:* 1–86.

SAUER, F. C. 1937 A method of making stereoscopic illustrations. J. Optical Soc. Am., *27:* 350–354.

PLATE 1

EXPLANATION OF FIGURES

1 and 2 Illustration of the principles of perspective.

3 and 4 Geometrical basis of the construction of the perspective grid.

5 Method of aligning sections to produce a three-dimensional graphic reconstruction.

6 Finished, three-dimensional isometric drawing.

7 Method of illustrating planes of section in the finished drawing.

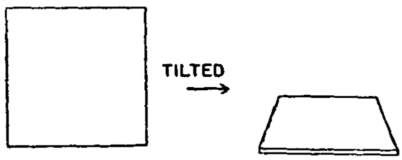


FIGURE 1

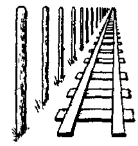


FIGURE 2

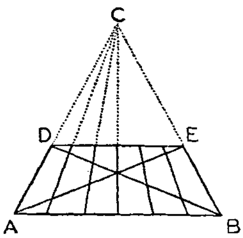


FIGURE 3

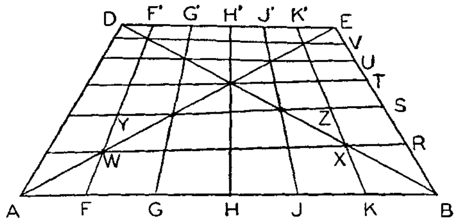
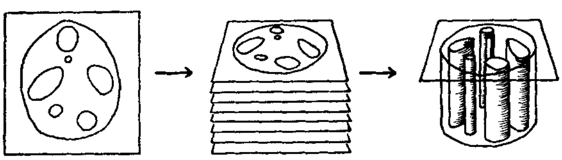


FIGURE 4



SECTION

TILTED AND ALIGNED

RECONSTRUCTION

FIGURE 5

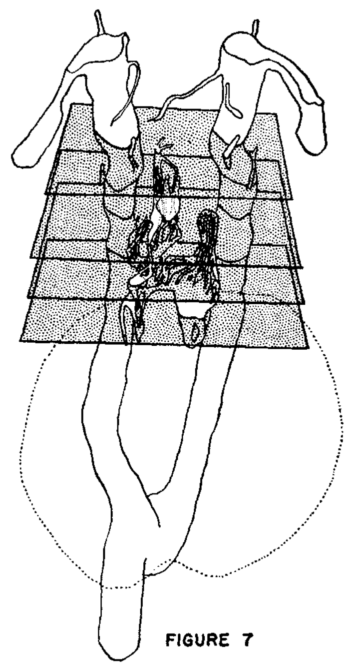


FIGURE 7

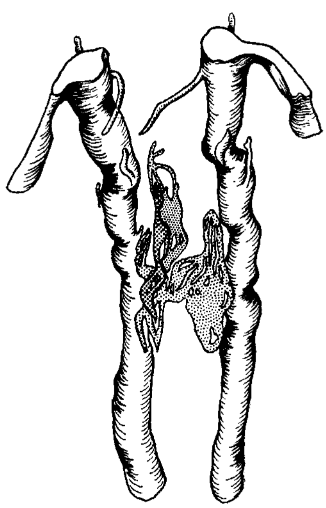


FIGURE 6