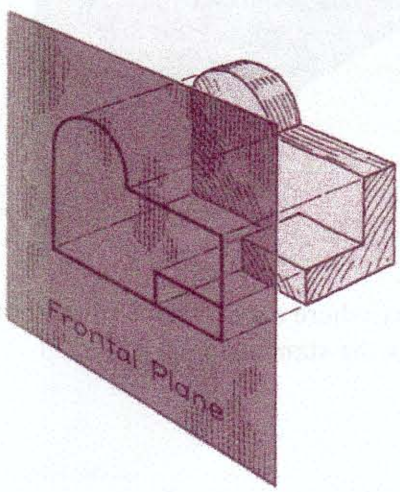
Orthographic Projection and Sectioning

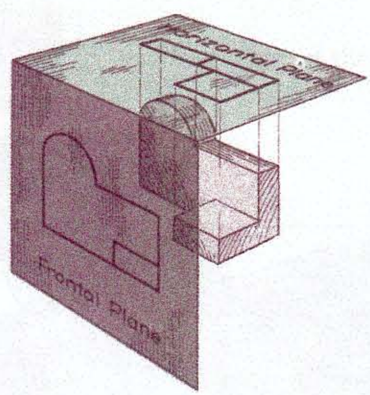
Orthographic projection is a formal drawing language. There is a well-established drawing vocabulary and grammar—if you do not use it your drawings may be ambiguous or even misleading. In this sense, orthographic projection is different from isometric sketching where a variety of styles may be used.

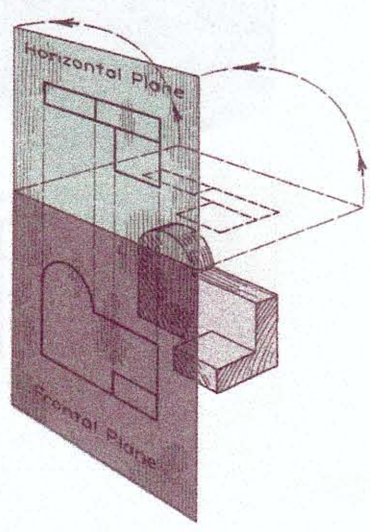
There are three distinct types of information conveyed by orthographic projection: the shape of the part; the nominal dimensions of the part; and dimensional tolerances (tolerable variation from the nominal) or other attributes such as surface finish.



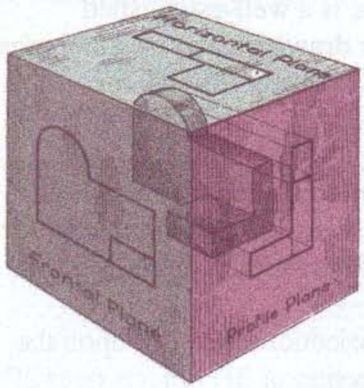
Orthographic projections are built upon the orthogonal projection of 3D objects onto 2D planes as illustrated on the left.

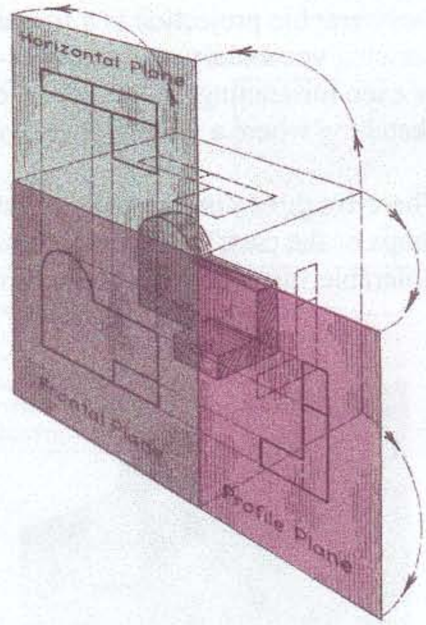
One can imagine placing multiple orthogonal planes around an object to creation projections that represent complementary views of the object. As shown on the right, if the horizontal plane is rotated into the same plane as the front, two views of the object can be provided on the same sheet of paper.



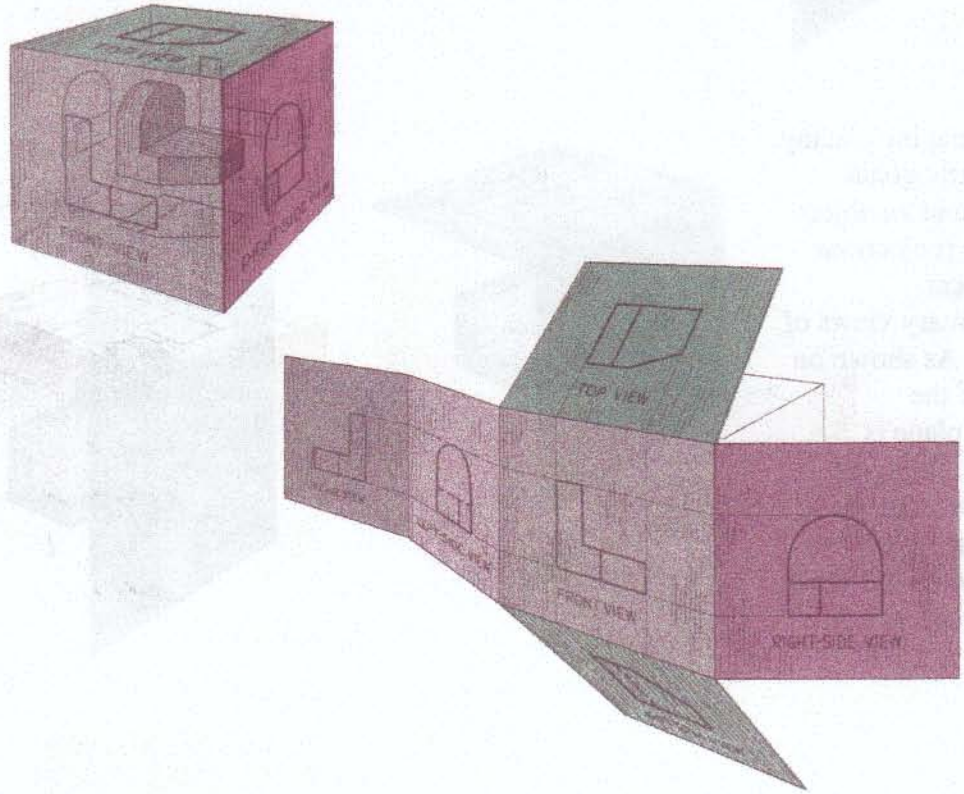


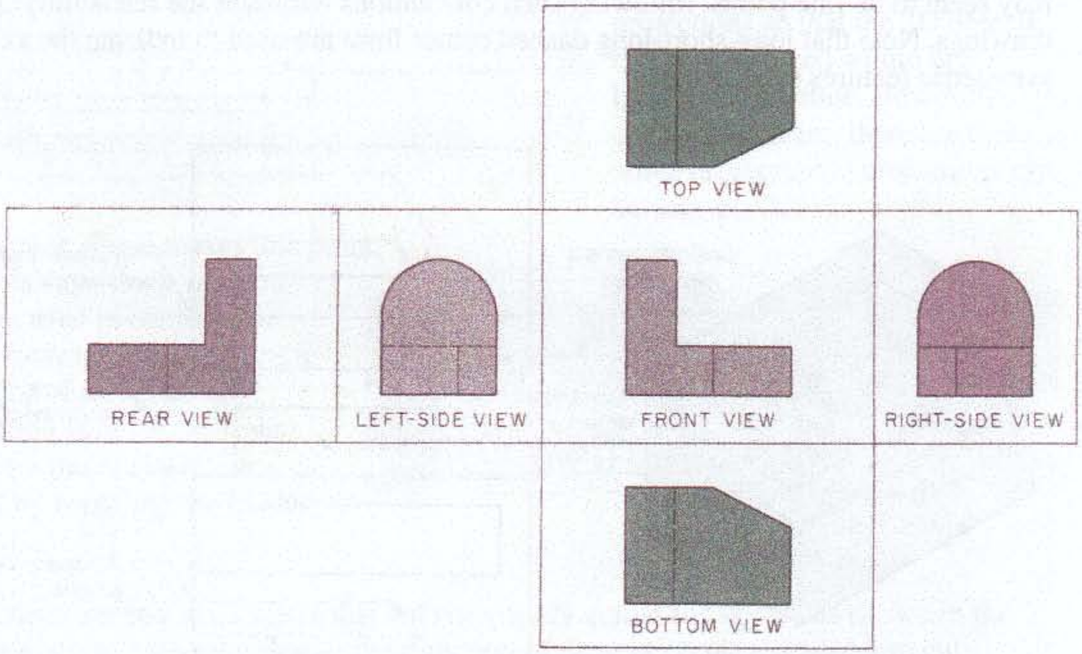
Additional planes can be added until a full description of the object is obtained from the projections as shown below.

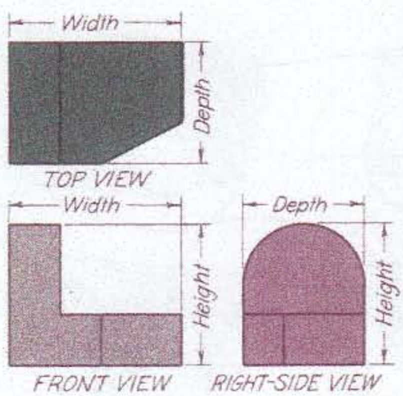




One can imagine enclosing the object in a transparent box where each surface of the box represents a projection plane. Unfolding the box provides the standard views used in orthographic projection as show below.





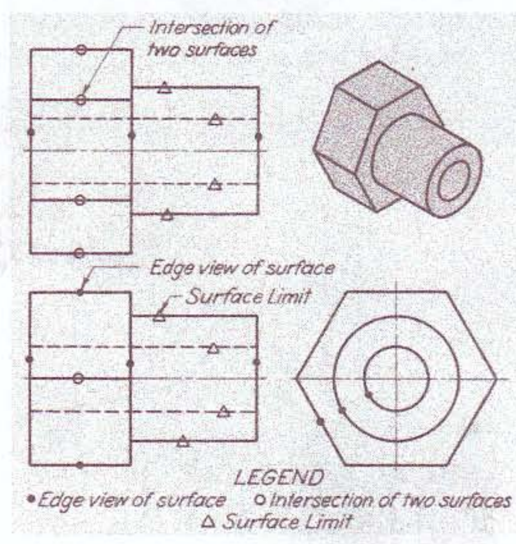


The relative positions of the six standard views used in orthographic projection are shown above. However, not all six views are needed to fully describe an object. The most common three views that are used are shown on the left. However in some cases, in particular for axially symmetric parts, only two views are required.

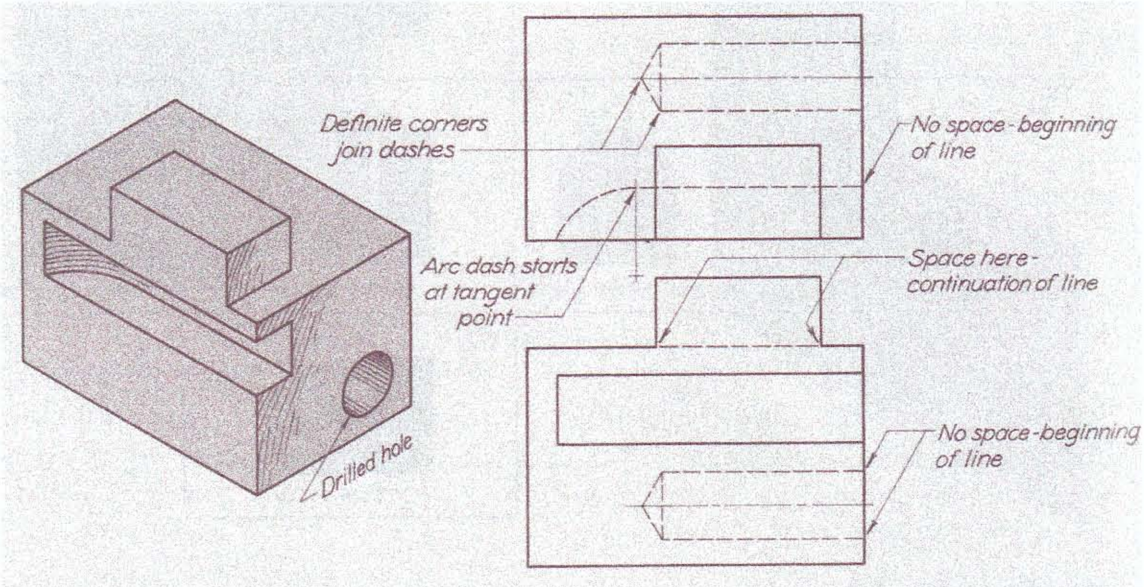
The figure on the left also defines the standard use of width, height, and depth.

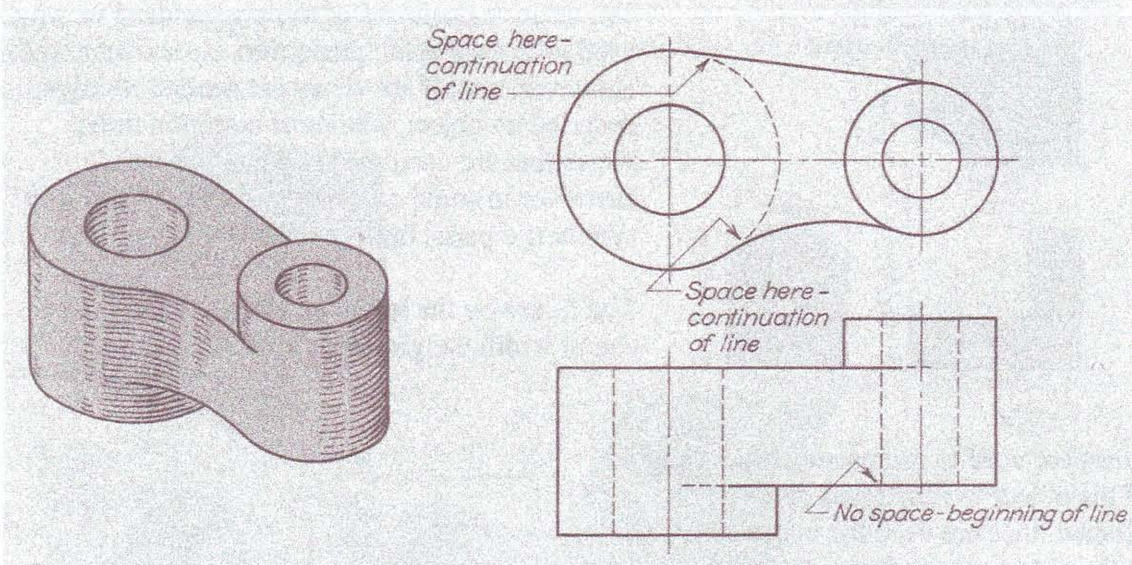
Lines are used to represent surface features of the object as illustrated on the right. Dashed lines are used for features that are not visible or 'behind the object surface' from the given view.

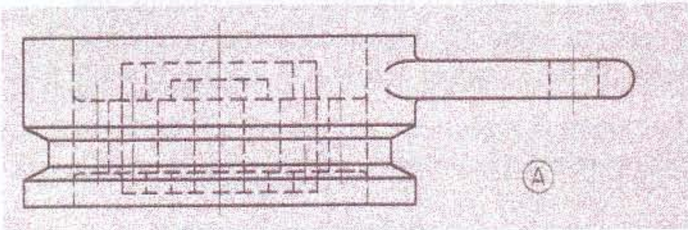
Also note that the hollow bolt in this figure really only needs two views to fully describe its geometry. In this case one would typically use only a front and right side view. One picks views to minimize the number of hidden lines.



Some of the conventions regarding the use of dashed lines are shown below. While these may seem to be fine points, following such conventions improves the readability of drawings. Note that long-short-long dashed center-lines are used to indicate the axes of symmetric features such as holes.

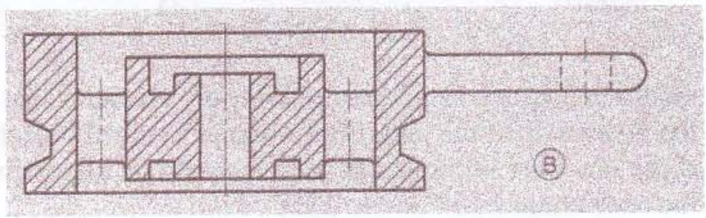




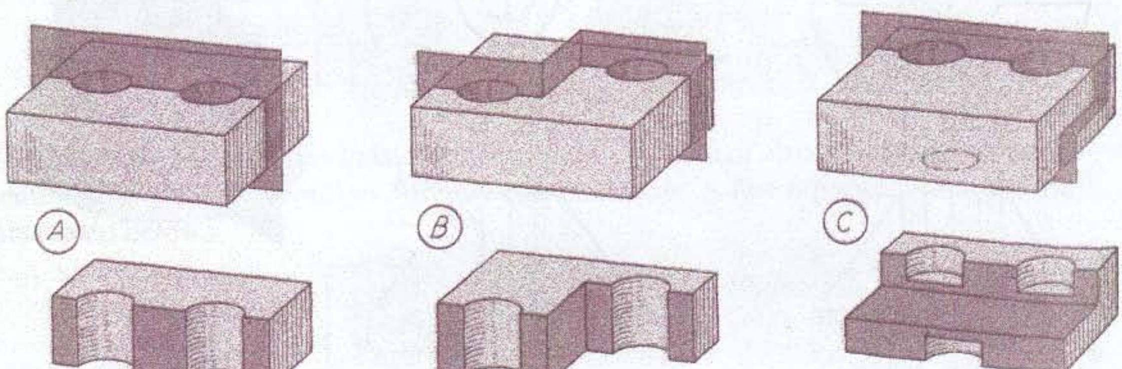


Learning to read orthographic projections so that the 3D objects can be visualized within one's head takes practice. However, even when fluent, there are times when orthographic projections can be very confusing.

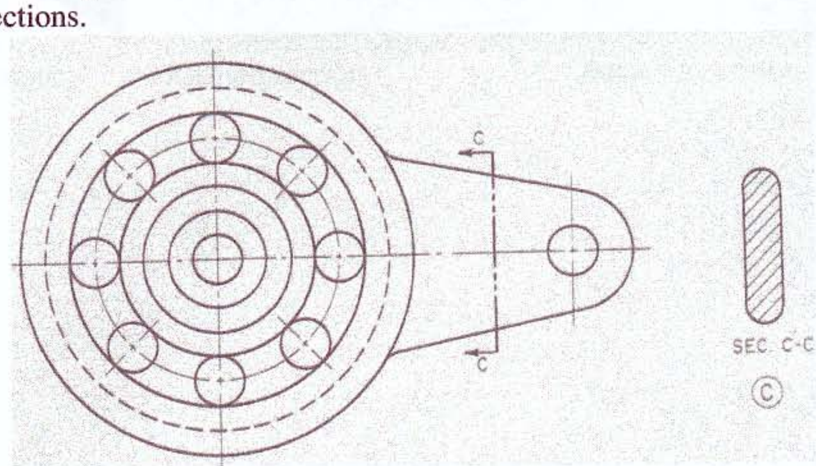
The drawing above makes this point. Thus cutaway views, or *sections* are often used in conjunction with orthographic projections to clarify the object geometry. The section view on the right provides a much clearer view of the part by revealing the hidden features.



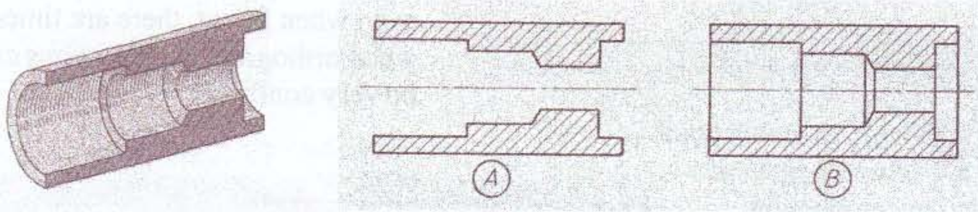
Full sections are sectional views that cut completely across the object, as shown in the examples below. One may change the direction of the section plane in order to cut through features of interest.



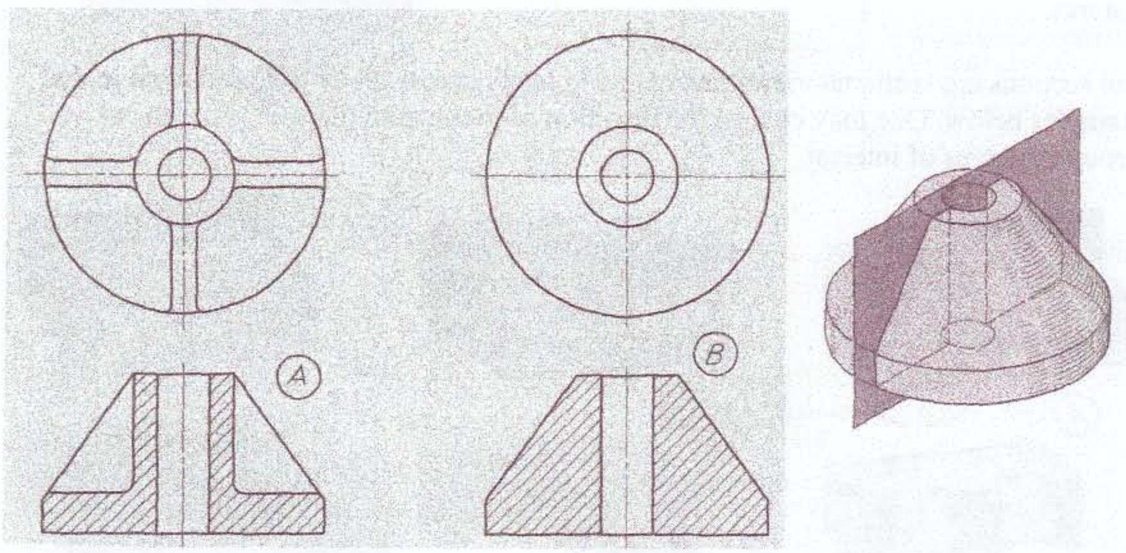
In order to understand a sectional view, one needs to know where the section passes through the object. This is done with a heavy dashed line as shown below. The arrows indicate the viewing direction from which the section is drawn from, and letters are used to identify sections.



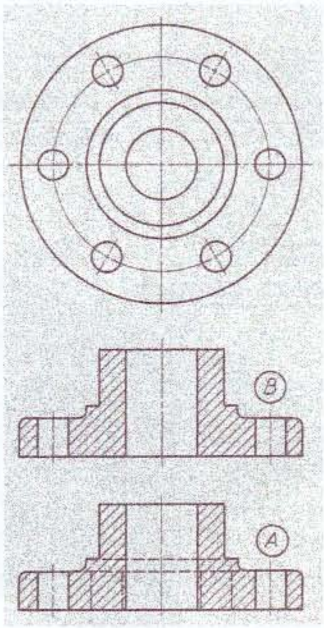
Although sections are very helpful, there are a number of important conventions that should be followed so that they are understood correctly. One must always remember to show all visible edges in the section view. In the example below *A* is incorrect, while *B* is correct.

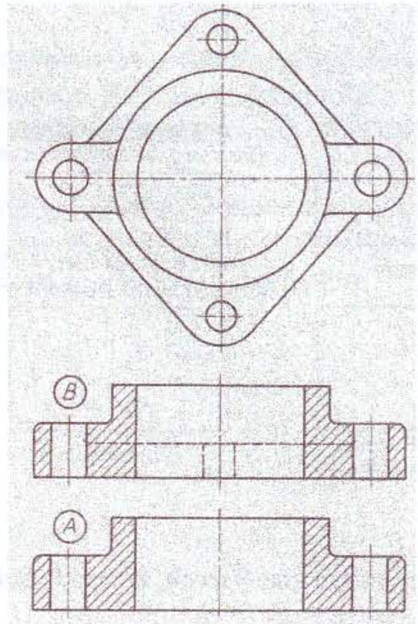


Additionally, one should not section any elements that are not solid or continuous about the given axis of the part. For example, a ribbed object is correctly sectioned in *A* below. If the ribs were sectioned as in *B*, it would be impossible to distinguish the object from the cone-shaped part on the right.

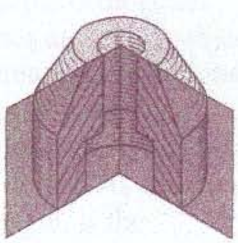


When showing hidden lines on a sectional view, the rule of thumb is to avoid creating unnecessary clutter, but hidden lines should not be left out if they are needed to clarify the part geometry. Axially symmetric parts (below left) do not require section lines (*B* is correct) while for the part on the right it is important to show hidden lines so that it is not assumed to be a symmetric revolution (*B* is correct).

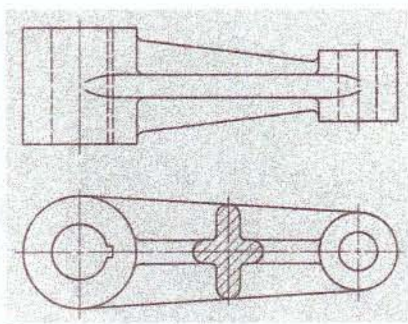




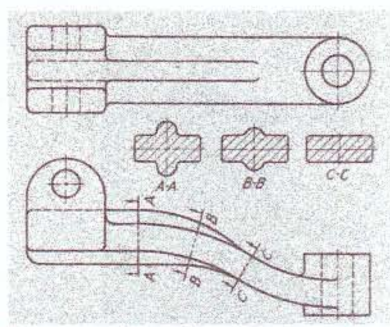
Thus far, only full sections have been considered. There are also a number of other section types that are useful in different circumstances. A few other section types are illustrated below.



Half section

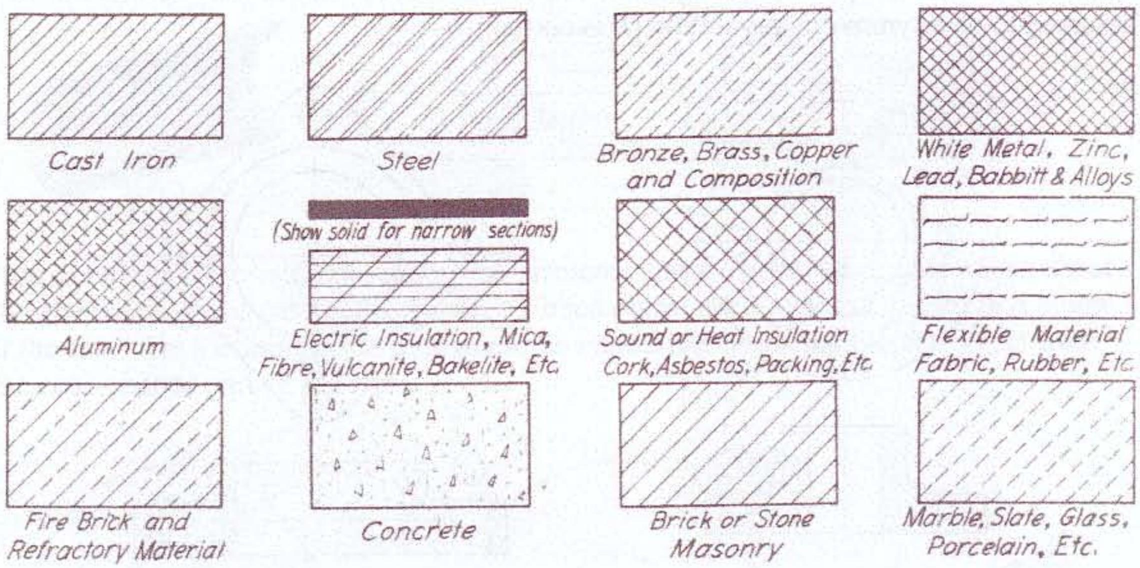


Rotated section



Removed section

Finally, it is also possible to convey information about the object's material by using an appropriate type of section cross-hatching. Sectional cross hatching symbols for a number of common materials are shown below.



Reference: French and Vierck, *Graphic Science and Design*, McGraw-Hill Book Company.