There are four major elements which may become distorted in changing from a spheroid to a plane. These are shape, area, distance, and direction. When a map preserves spheroidal shapes in an acceptable fashion, it is labelled ***conformal*** or *orthomorphic* and all directions around each point are represented correctly. It does not mean, however, that this correctness applies from point to point. All parallels and meridians meet at right angles on the flat map. Local scale is constant but is not so over large areas.

Maps which preserve area relationships well are called ***equal-area*** or ***equivalent*** or ***homolographic***. This means that the areas are represented in correct relative proportions but spheroidal angles are distorted. Unfortunately, conformity and equivalency are two of the most sought after elements in the choice of projections and a map cannot maintain both at once.

The third element is accurate distance measurement, which derives from constancy of scale; i.e., the scale must remain uniform on a line connecting any two points. This is not perfectly attainable, but scale variations can be quantifiable. Scale may be maintained in one direction, for example north-south or east-west, or it may be maintained in all directions from one or two points only(equidistance). Overall, distance can only be correctly measured if you are aware of the inherent scale variations at any given point.

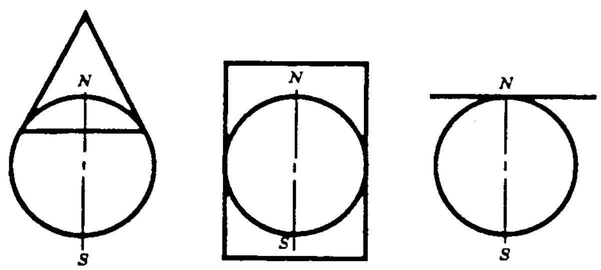
Lastly, we cannot represent all earth directions with straight lines on a flat map. Plotting true directions on a globe reveals that all great circles are straight lines which cross successive graticule lines at a constant angle. Some maps approach this by showing lines of constant bearing as straight lines, but these ***rhumb lines*** are not always great circles.

Bearing these limitations in mind, we should now look at various projections in common use. These projections fall into groups, those made on cones or cylinders or planes. These geometric forms are called “developable surfaces.”

There are over 250 known approaches to the problem of flattening the spheroid; in this part of the course, we will cover only the common ones we use every day. Each of these projections treats spheroidal coordinate characteristics such as parallel latitude lines or convergent meridians in a different fashion and none accomplish the perfect transformation.

The conic projections are formed by placing an imaginary cone over the earth so that it touches the spheroid at one circle around its circumference. Spheroidal data is projected onto the cone, which is then cut and laid flat. The cone can be placed over the earth in any aspect, but its axis usually coincides with the earth's polar axis. Azimuthal or plane projections involve a plane touching the earth at only one point. Cylindrical projections involve cylinders slipped over the globe and touching at one great circle.

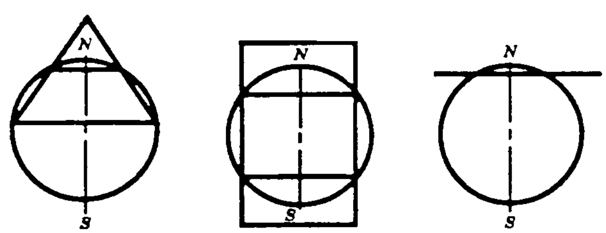
Figure 5.



When these developable surfaces are used, the map is truly accurate only at the line or point where the cone, cylinder or plane touches the spheroid. This line or point is said to be ***tangent*** and the ***standard line*** or point.

To improve the accuracy of maps made from these geometric forms, the points of tangency can be doubled:

Figure 6.



This procedure offers two lines on the projection which are accurate, the lines at which the surface intersects the spheroid. This intersecting condition is called ***secancy*** and the accurate lines are called standard lines or, if the projection is oriented north and south, ***standard parallels***. Secancy provides a predictable error factor for the areas between the intersections and for some distance outside of their boundaries.

The following pages acquaint you with the general characteristics of four different projections, the Lambert Conformal Conic, the Albers Equal Area Conic, the Polyconic, and variations on the Mercator, all of which USGS and SCS use extensively.