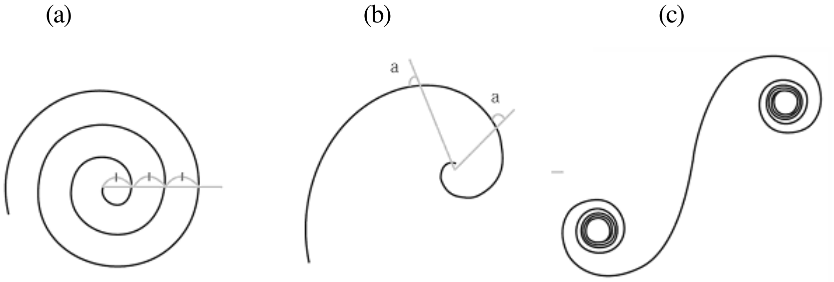

Fig. 1. Three basic spirals. (a) The Archimedean, (b) the logarithmic and (c) the Comu's spirals.

as a function of the length variable measured along the spiral curve. This method is explained in the next section, and results of its application to three geometrical spirals are shown. In Sec. 3 results for some spirals from archaeological monuments and crafts are shown, along with those for visualized vortex patterns obtained by the present authors. In the last section a proposition is made to classify spirals into four types.

2. Method of Analysis

It is assumed, as discussed above, that a spiral pattern is characterized by the variation of its curvature along the spiral curve. Although this idea is convincing, it is difficult to say that it is the best way of characterizing spiral curves. The present authors have assumed it, because the length and the curvature of spirals are easily measured.

Now, let a spiral curve is expressed by a distribution of the radius of curvature $R(l)$ as a function of the length along the curve l. In this work a center of a spiral curve was fixed by naked eyes, and the curve was divided into small arcs with 30 degree around the center. The radius of curvature was measured by fitting a curvature ruler (a plastic plate available at stationary shops), and the length was obtained by accumulating the lengths of the arcs (average distances of the arcs from the center multiplied by $\pi/6$). The origin of the length coordinate is adjusted later to compare several spiral curves.

In order to compare types of spirals with different sizes, their images were expanded or compressed to have common horizontal sizes, i.e. they were normalized, so that the l – R relations are compared in the same diagram.

Validity of the present method was examined by applying it to the three representative spiral curves (Fig. 1), the Archimedean, the logarithmic and Cornu's spirals (LOCKWOOD, 1961). The asymptotic forms of $R(l)$ for $l \to \infty$ for the Archimedean and the logarithmic spirals are $R(l) \sim al^{1/2}$ and $R(l) \sim al$, respectively, where a is a constant. The Cornu's spiral is similar to the logarithmic spiral, but the radius of curvature grows suddenly at a certain distance from the center of spiral.

Results of the curvature measurements are shown in Figs. 2(a), (b) and (c), where the measurement of Cornu's spiral was made only for its half part. In spite of a rather rough method of measurement these results show agreements with expected behavior. In fact the