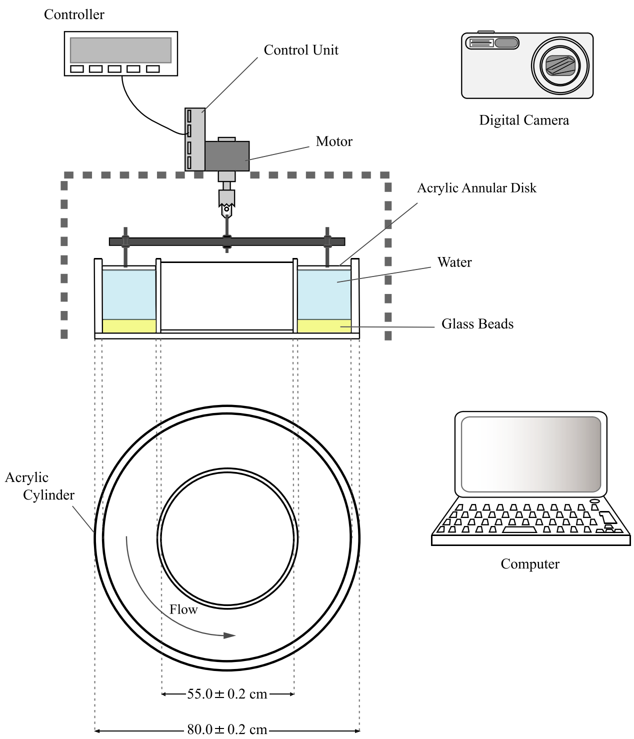

Fig. 1. Schematic diagram of the experimental apparatus.

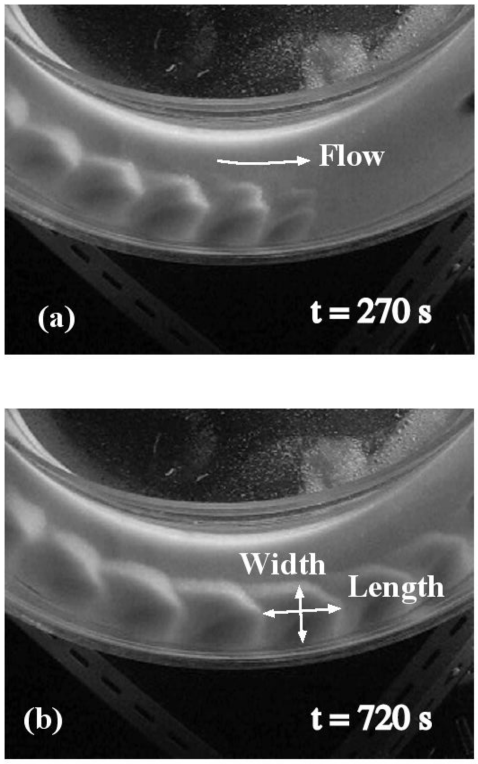

Fig. 2. Growth of sand ripples and the definition of width and length of the ripple.

"reduced shear stress excess" difficult. In the case of the aeolian sand ripple, Yizhaq *et al.* (2004) reported the initial power-law growth of the wavelength with exponent about 0.35 in a nonlinear continuum model, whereas Andreotti *et al.* (2006) did not show such behavior of the wavelength, although they suggested an exponential growth of the amplitude in the initial stage. Thus the formation process and the long time behavior of ripples are still disputable partly because of the difference in Bagnold number (i.e., air vs. water), partly because of the experimental difficulty of determining accurate time of the start of depression on the "flat" surface (i.e., smooth surface with respect to the grain size) of the granular layer, and partly because of the limited size of experimental apparatus.

A lot of works on the stability of erodible beds have been made, which are found in review articles and papers by Kennedy (1969), Engelund (1970), Fredsøe (1974), Richards (1980), Engelund and Fredsøe (1982), Sumer and Bakioglu (1984), Werner and Gillespie (1993), etc. These stability analyses, however, were concerned with the formation of dunes rather than ripples, the former being larger scale wave pattern on the granular bed. Betat *et al.* (1999) also compared their experimental results with stability criteria and discussed the growth of Fourier modes, but their Froude number $Fr \equiv V/\sqrt{gH}$ does not seem to be comparable with that of the theory. Recently an experiment on the dynamics of a bed of particles using similar experimental setup, i.e., an annular channel sheared by a viscous Couette flow, has been made by Charru *et al.* (2004). Their study, however, was focused to fundamental problems of the particle motion near the threshold flow velocity, in which ripples were not formed. In the succeeding papers (Charru and Hinch, 2006a, b) they concluded, on the basis of the erosion-deposition model, that increase of fluid viscosity suppresses the ripples under steady flow and that the only possibility of ripple formation remains for oscillatory flow. In our experiment, however, we observed the formation of ripples as long as three hours, so that the newly generated ripples took over to the previous ones in the annular channel. Although no steady state were achieved because of incommensurate sizes and wavelengths of the ripples that met the old ones, the surface undulations did not look suppressed by the main flow. This discrepancy may be attributed to their assumptions of higher viscosity of the fluid, long wave and small amplitude deformation, etc. which may not be satisfied because the Reynolds number is much higher in our case, and because the observed local flow field near the bottom is spatially and temporally varying.

In our previous paper (Hori *et al.*, 2007; Oshiro and Sano, 2007), we have reported the onset of barchans and growth of ripples due to a viscous flow in an annular region, as well as the interaction and self-adjustment of wavelength of the ripples. In this paper, we show our experimental results on the onset and growth of ripples, and propose models that describe the initial growth of the ripples as well as the effect of the container wall and the long time behavior of the interaction of ripples.

2. Experimental Apparatus

We show our experimental setup in Fig. 1. Our experimental apparatus is basically the same as the one reported in our previous papers (Hori *et al.*, 2007; Oshiro and Sano, 2007). It has two transparent acrylic resin cylinders of diameters 80.0 ± 0.2 cm and 55.0 ± 0.1 cm (average diameter