# Pogo Instabilities

All of the other discussion in this chapter has assumed that the turbomachine as a whole remains fixed in a nonaccelerating reference frame or, at least, that a vibrational degree of freedom of the machine is not necessary for the instability to occur. However, when a mechanism exists by which the internal flow and pressure oscillations can lead to vibration of the turbomachine as a whole, then a new set of possibilities are created. We refer to circumstances in which flow or pressure oscillations lead to vibration of the turbomachine (or its inlet or discharge pipelines) which in turn generate pressure oscillations that feed back to create instability. An example is the class of liquid-propelled rocket vehicle instabilities known as Pogo instabilities (NASA 1970). Here the longitudinal vibration of the rocket causes flow and pressure oscillation in the fuel tanks and, therefore, in the inlet lines. This, in turn, implies that the engines experience fluctuating inlet conditions, and as a result they produce a fluctuating thrust that promotes the longitudinal vibration of the vehicle. Rubin (1966) and Vaage *et al.* (1972) provide many of the details of these phenomena that are beyond the scope of this text. It is, however, important to note that the dynamics of the cavitating inducer pumps are crucial in determining the limits of these Pogo instabilities, and provide one of the main motivations for the measurements of the dynamic transfer functions of cavitating inducers described in sections (Gbc).

In closing, it is important to note that feedback systems involving vibrational motion of the turbomachine are certainly not confined to liquid propelled rockets. However, detailed examinations of the instabilities are mostly confined to this context. In sections (Gb), we provide an introduction to the frequency domain methods which can be used to address problems involving oscillatory, translational or rotational motions of the whole hydraulic sytem.