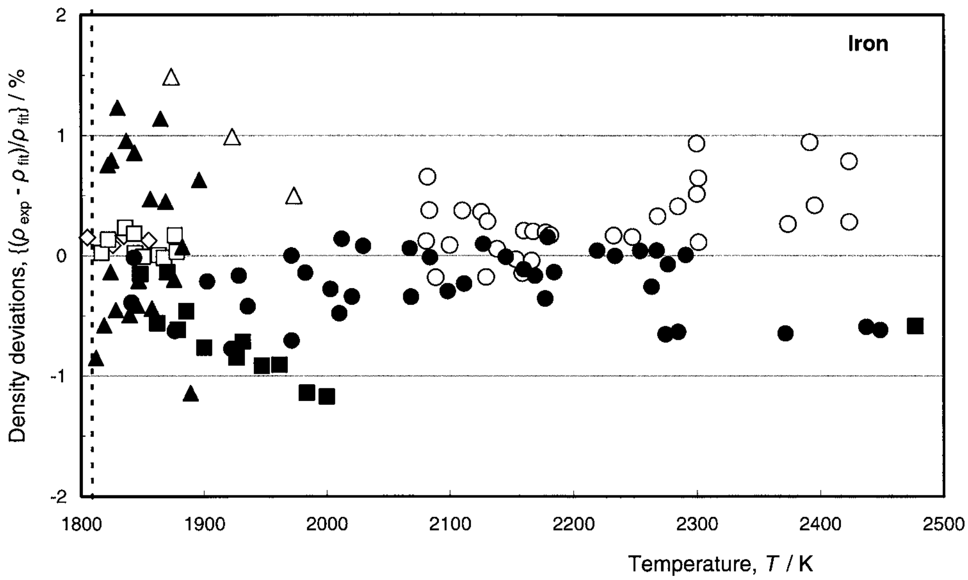

FIG. 4. Percentage deviations of the density primary data for liquid iron from the values calculated by Eq. (2), as a function of the temperature: (◇) Brillo and Egry (2004); (□) Sato (2003); (△) Lucas (1972); (○) Saito *et al.* (1969); (▲) Frohberg and Weber (1964a); (●) Kirshenbaum and Cahill (1962); (■) Lucas (1960); (- - -) melting point.

In determining the viscosities of metallic liquids by the capillary method, an especially fine and long-bore tube (in general, $r<0.15-0.2$ mm, $l>70-80$ mm) is needed so as to satisfy the condition of a low Reynolds number for ensuring laminar flow. This in turn requires a furnace with a similarly long and uniform hot zone. Blockage of the capillary by bubbles or oxide inclusions is a common problem, particularly with aluminum alloys, and due to materials problems a temperature limit of 1200 °C is often imposed, but metals such as bismuth have been successfully measured [Iida and Guthrie (1988)].

4.1.2. The Oscillating Vessel Viscometer

Most measurements of the viscosity of metals use some form of oscillating vessel viscometer. A vessel, normally a cylinder, containing the test liquid is set in motion about a vertical axis and the motion is damped by frictional energy absorption and dissipation within the liquid. The viscosity is determined from the decrement and time period of the motion. The main advantages of the method are that the time period and decrement are easily measured and the amount of liquid is relatively small which allows stable temperature profiles to be attained. One of the major difficulties is relating the measured parameters to the viscosity through the second order differential equation for the motion of an oscillating system and there are a number of mathematical treatments appearing to yield different results [Knappworst (1952); Shvidkovskiy (1955); Roscoe (1958); Kestin and Newell (1957); Brockner *et al.* (1979)] with the same experimental data. Since this is the most commonly used method it will be discussed in more detail below.

TABLE 3. Recommended values for the density of liquid aluminum and liquid iron

Liquid aluminum		Liquid iron	
Temperature (T/K)	Density (ρ/kg m^{-3})	Temperature (T/K)	Density (ρ/kg m^{-3})
950	2372	1850	6999
975	2364	1900	6953
1000	2357	1950	6906
1025	2349	2000	6860
1050	2341	2050	6814
1075	2333	2100	6767
1100	2325	2150	6721
1125	2318	2200	6675
1150	2310	2250	6628
1175	2302	2300	6582
1200	2294	2350	6536
		2400	6490
		2450	6443
		2500	6397

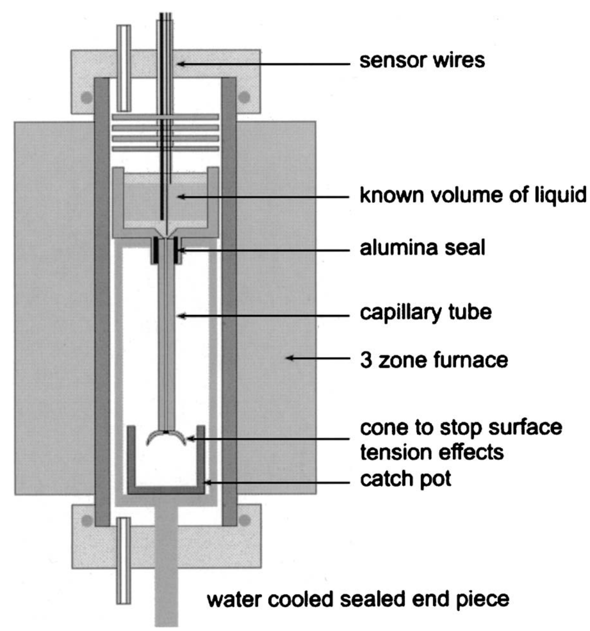

FIG. 5. Diagram of a capillary viscometer.