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R & D NOTES

Modified Yerzaunis, Plowright, and Smola Equilibrium Still

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Yerazunis et al. (1964) have described an apparatus for the experimental determination of *V-L* equilibrium datum which, in its design, approaches very closely to what may be considered as the ideal equilibrium still. The still differs from others that have been described by Hala et al. (1958) in the very positive manner in which the liquid and vapor phases are brought together under constant temperature and pressure to insure that the composition of the coexisting phases represent the true equilibrium condition. In a research program, which involves the determination of the *V-L* equilibrium properties of liquid mixtures at low pressure, an equilibrium still has been constructed for use which is similar to the Yerazunis still in the design of the equilibrium section but differs in the location of the thermocouple for measuring the equilibrium temperature and in the method for withdrawing the samples from the still. Also, a separate insulating cap was constructed to fit over the equilibrium chamber to reduce the heat loss. These changes not only improve the design but greatly simplify the operation of the still.

The equilibrium cell was redesigned so that the thermocouple for measuring the equilibrium temperature is located in a well, imbedded in the equilibrium chamber, in order to insure a more precise measurement of the temperature. Next, the stopcock assembly was replaced by ports with rubber septums* through which samples of the equilibrium vapor condensate and the liquid could be withdrawn for analysis with a hypodermic syringe.

* Available only from Ace Glass, Inc., Vineland, New Jersey.

Figure 1 shows a schematic diagram of the modified still. The essential elements of the still are the Cottrell pump *A*, the *V-L* equilibrium chamber *I*, the condensers *F* and *F'*, the coolers *E* and *E'*, the sampling ports *D* and *D'*, and the tube *C* filled with glass beads for mixing the vapor condensate and liquid streams before returning the mixture to the pump for the recycle operation.

The Cottrell pump is activated by an internal electric heater *B* inserted in a well in the bottom of the pump. The partial vaporization of the liquid builds up a pressure which produces a pumping action that carries the mixture of liquid and vapor upward to the equilibrium chamber *I*, where the two phases are brought into intimate contact and separated. The liquid fraction leaves the equilibrium chamber and flows through the cooler *E'*, past the sampling port *D'*, to the mixing section *C*. The vapor is condensed in *F*, and the condensate flows through the cooler, *E*, past the sampling port *D*, to *C*, where it mixes with the liquid fraction and the whole is returned to the Cottrell pump for recycle.

Figure 2 shows a detailed section of the equilibrium chamber. The *V-L* mixture from the Cottrell pump enters at the top and passes downward concurrently through the mixing cell 3 packed with 5 mm glass helices and escapes near the bottom through holes 3 mm in diameter into the separation cell. The liquid fraction collects at the bottom and is drawn off through the liquid trap 8, while the vapor passes upward around the mixing cell, then downward around the outside of the separation cell to the condenser *F* (Figure 1). In this manner, the vapor forms a double vapor jacket around the equilibrium chamber. The double walled thermal cap 2, with inner walls silvered and evacuated, fits over the top of the equilibrium chamber. A narrow unsilvered strip in the well of the cap serves as a window for observing the flow of vapor and liquid through the chamber. Accessory equipment for the operation of the still is shown in Figure 1. The pressure in the still is determined by measuring the difference in the mercury levels in the *U* tube manometer *N*, with a cathetometer graduated in 0.01 mm divisions. To maintain the mercury at a uniform temperature, the manometer is immersed in a water bath *O* which is stirred by a small stream of air. Before putting the still in operation, the air is removed by the vacuum pump *P* and the system purged with nitrogen gas from the cylinder *Q*. The pressure of the nitrogen gas during admission is controlled with the aid of the barometric manometer *R* which serves as a safety valve in case the pressure should exceed atmospheric pressure. Fine adjustment of the pressure in the apparatus is possible with the aid of the stopcock assembly S and by including in the line a tank *T*, whose volume is many times greater than the volume of the system.

To reduce surging during the operation of the Cottrell pump, a glass check valve *K* is installed in the return

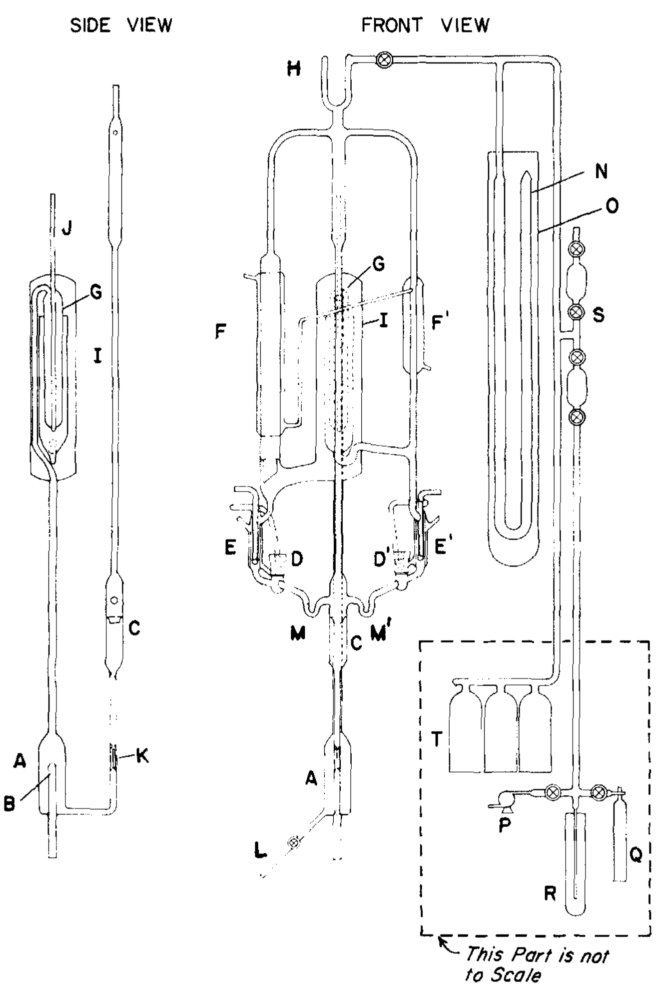

Fig. 1. Modified Yerazunis-Plowright-Smola equilibrium still. A, Cottrell pump; B, electric heater; C, liquid mixing cell; D,D', sample ports with septums; E,E', coolers; F,F', condensers; H, vapor condenser; I, equilibrium chamber; J, thermocouple well; K, check valve; L, drain; MM', liquid traps; O, water bath; P, pump; Q, compressed nitrogen gas tank; R, barometric safety manometer; T, surge tanks.

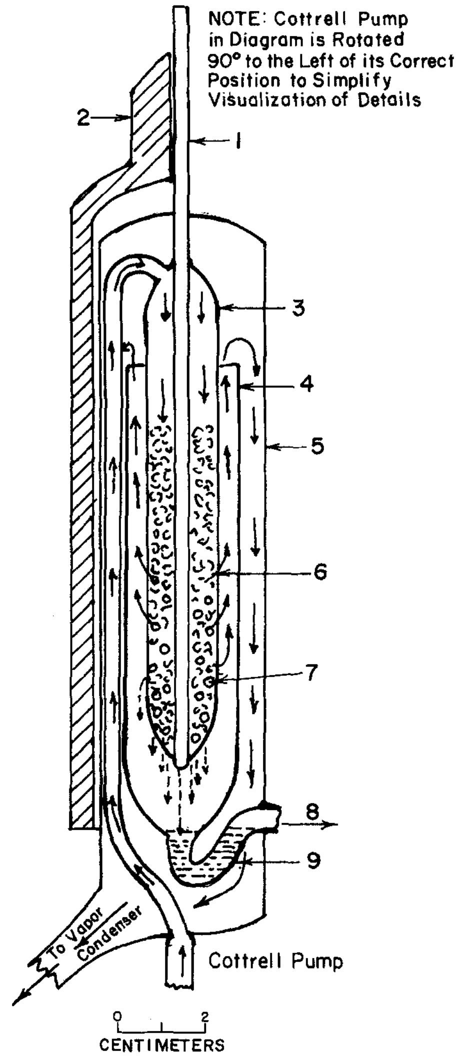

Fig. 2. Equilibrium chamber. 1. Thermocouple well. 2. Half-section of removable vacuum jacketed cap. 3. Mixing cell. 4. Separation cell. 5. Equilibrium chamber. 6. Packing, 5 mm glass helicies. 7. Three millimeter holes. 8. To liquid cooler. 9. Liquid trap.

liquid line to the pump. A measured volume of liquid is introduced into the still with a hypodermic syringe through one of the sample ports. Minute samples of the equilibrium vapor condensate and equilibrium liquid are removed from the apparatus without disturbing the pressure on the system at pressures below or above atmospheric pressure by a pressure-lok liquid microsyringe.* The composition of the samples are determined by chromatographic analysis or by a measurement of the refractive index, having previously established the relation between the refractive index and composition experimentally.

* Available only from Precision Sampling Corp., Baton Rouge, Louisiana.

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The Influence of Inlet Flow Disturbances on Transition of Poiseuille Pipe Flow

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The stability of fully developed Poiseuille pipe flow to infinitesimal disturbances has been abundantly demonstrated theoretically. Recent work (Huang and Chen, 1974*a*, *b*; Sarpkaya, 1975; Wygnanski and Champagne, 1973; Wygnanski et al., 1975) with developing flows and inlet flows has suggested rather strongly that the source of instabilities which lead to the well-known transition to turbulence in a Poiseuille pipe flow lies in the entry of the pipe.

As a part of a study of transitional flow phenomena in concentric annuli, the experiments reported in this note were performed. A series of large disturbances were introduced into a fully developed laminar flow which was impinging upon the entry of a second pipe. The effects of these disturbances on the transitional flow behavior of the downstream flow were observed and are reported.

EXPERIMENTAL

A recirculating flow loop, described in detail elsewhere (Peterson, 1979), was used for the measurements herein reported. Solutions of Dow polyglycol* 15-200 in water were pumped through a 7.3 m long vertical test section consisting of a 3.66 m long, 38.1 mm ID heavy walled aluminum pipe in series with a 3.66 m long, 19.1 mm ID aluminum pipe. A precision machined aluminum block, illustrated in Figure 1, coupled the pipes and served as the disturbance-generator holder.

Flow rates were measured by calibrated turbine flowmeters, and pressure losses were measured in the smaller diameter pipe with sensitive differential pressure transducers. Data were collected in the smaller diameter pipe for each of the following configurations:

1. Disturbances caused only by the 2:1 diameter reduction.
2. Symmetric disturbance device (Figure 2*a*) pinned rigidly in the holder.
3. Swirl disturbance device (Figure 2*b*) in the holder allowed to rotate freely about the pipe axis as fluid passed through, thus imparting a swirl to the disturbances generated.

From the pressure drops and flow rates obtained, friction factors ($f = D\Delta p/2L\rho V^2$) and Reynolds numbers ($Re = DV\rho/\mu$) were calculated. For Poiseuille pipe flow,

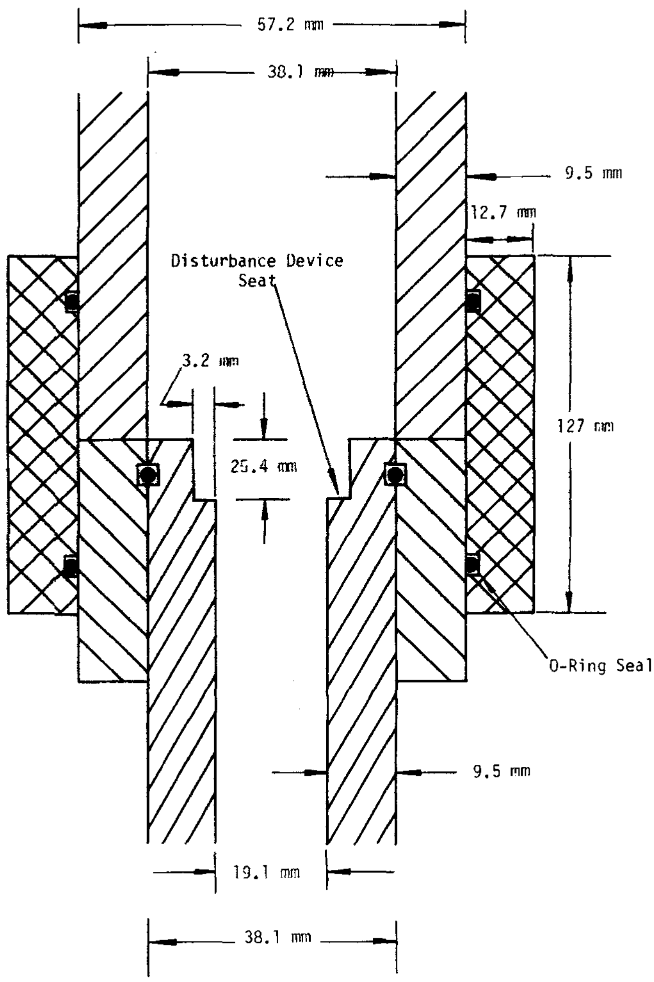

Fig. 1. Details of pipe coupling and disturbance device holder.

* Dow Chemical Co. trademark.

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