tendency of the glass to stick to everything it touches at this temperature. The effect of the last drop could be decreased by taking larger samples but this procedure, involving longer runs, increased the danger of temperature drift. At 500°, the viscosity changes by more than 2 percent per degree temperature change; the maximum change due to pressure was about 150 percent.

At 359°, where the viscosity is nearly 10^8, the glass was extruded as a straight rod slightly larger in diameter than the bore of the capillary, with no tendency to spread over the end of the tube. As this rod showed no inclination to drop off even if left overnight, it was easy to get accurate samples by cutting off the rod at the end of the tube with a special pair of nippers. As a result, more regular results were obtained at this temperature in spite of the fact that the viscosity changes here by 8 percent per degree.

Several sizes of capillary were used, with inside diameters of 0.041 and 0.063 cm at 500°, and of 0.159 cm at 359°, with lengths varying from 7 to 40 cm. The outside diameters were, respectively, 0.15, 0.23 and 0.80 cm. The shorter ones were almost entirely enclosed in the end of the pressure cylinder; the longer ones were coiled between this cylinder and the bottom of the copper block. Although the latter arrangement left the capillary somewhat more exposed to temperature fluctuations, with care equally smooth results could be secured in either case. The diameters of the capillaries were not measured accurately, since only relative values were needed, No great precision can be expected for the absolute viscosity, which agrees roughly, however, with the values of other observers.

The glass was prepared from Merck's "reagent" grade anhydrous B_2O_3 by fusing at 1100° in a platinum crucible, holding at this temperature overnight, with about an equal time at 900° under a water-aspirator vacuum. At the end of this time, the glass had been quiet and free from bubbles for several hours. The viscosity at 900° is of the order of 100 poises.

A total of about 3.5 g of glass could be extruded from the collapsible tubes. The times for the individual runs were regulated to yield about 0.2 g in each sample, so that 15 or more points, at different inlet pressures, could be obtained from a single charge. Since the duration of the runs was from 20 minutes to 10 hours, errors in the measurement of the time were negligible. The required pressure was built up in the press before the valve leading to the cylinder (A) was opened; the run was begun by suddenly opening this valve, and terminated by closing this valve and opening the release valve. Variation of inlet pressure during a run could be held within narrow limits by occasional pumping. At very low pressures, small changes of the zero of the manganin pressure gauge occasionally introduced uncertainties of as much as several percent. The chief sources of irregularity were temperature changes and variable retention of glass at the outside end of the capillary.

There is, however, a possibility of systematic error due to the heating effect of forcing the glass through the capillary. The mechanical energy lost in transporting a given quantity of glass from the upper pressure to the lower pressure is transformed into heat; if this heat were not dissipated, the rise of temperature of the glass in passage might be as great as 70° for a pressure difference of 1000 kg/cm². We wish to realize as nearly as possible an isothermal flow. This may be approached by diminishing the velocity for a given pressure drop, that is, by using longer or finer capillaries. The effect of the heating is evidently to reduce the viscosity, whereas the effect of pressure alone, for isothermal flow, is to increase the viscosity. If the flow were too rapid, the heating effects might completely mask the true pressure effect.

The temperature difference which can exist between the axis and the wall of the capillary even when equilibrium conditions are reached has been calculated by Hersey[8] and is negligibly small. The computation is more difficult when neither equilibrium nor adiabatic conditions exist; this case, which embraces all real experimental conditions, has been attacked by Hersey and Zimmer[9] with some success. Experimentally, the natural approach appears to be to decrease the velocity of flow for a given pressure drop, by using successively longer or finer capillaries. As the velocity is decreased, equilibrium is ap-

[8] M. D. Hersey, Physics 7, 406 (1936).
[9] M. D. Hersey and J. C. Zimmer, J. App. Phys. 8, 359 (1937).