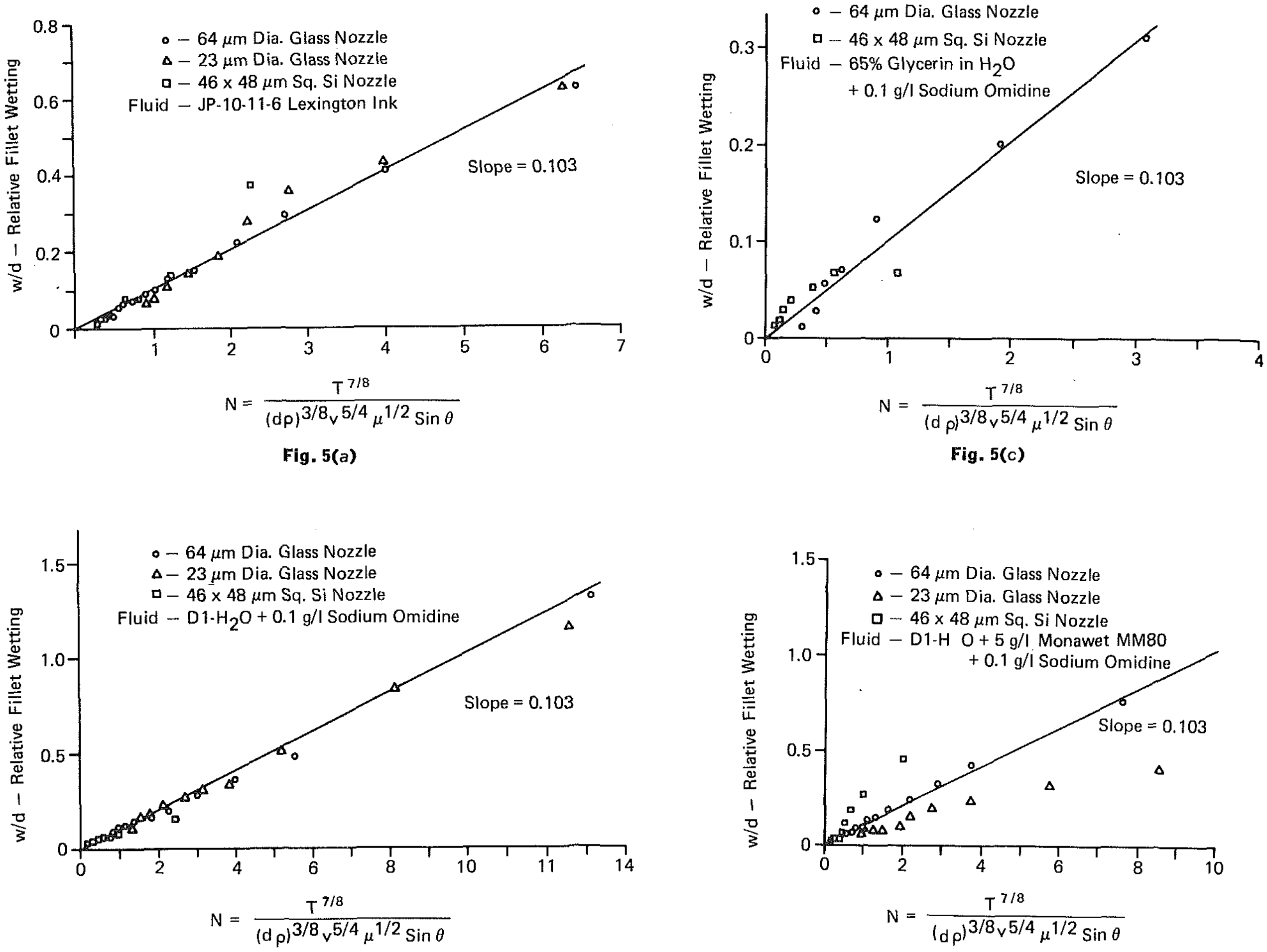

Fig. 5(*a*)

Fig. 5(*c*)

Fig. 5(*b*)

Fig. 5(*d*)

Fig. 5 Correlation of the data with nondimensional number—relative fillet size versus the nondimensional number. (Accuracy of the data presented: *w/d*, ± 15 percent; *N*, ± 12 percent.)

number of relevant parameters. From these experiments, the following empirical correlation was discerned:

$$\frac{w}{d} = 0.103\,N \qquad (2)$$

where N is a nondimensional number as defined in equation (1). It should be emphasized that this correlation is entirely empirical in nature, and no theoretical rationale is presented to explain its validity.

Fillets of larger relative sizes exhibit greater lack of stability and azimuthal symmetry. This is particularly true of a contracting fillet. Even for presumably steady-state conditions, this instability for larger fillets is exhibited and results in continued flicking of aim of the jet.

There is no one value of the relative fillet size which separates the stable fillets of smaller sizes from those unstable ones of larger sizes. However, it is possible to observe that fillets of relative sizes greater than 0.18 are quite prone to display this undesirable instability. This would indicate that one should always operate an ink jet in a region of parameters where the nondimensional parameter, N, is less than about 7/4.

References

1 Schiller, L., "Die Entwicklung der laminaren Geschwindig Keitsverteilung und ihre Bedeutung fur Zahigkeitsmessungen," *Zeitschrift fur angewandte Mathematig und Merchanik*, Vol. 2, 1922, pp. 96–106.

2 Langhaar, H. L., "Steady Flow in the Transition Length of a Straight Tube," ASME *Journal of Applied Mechanics*, Vol. 64, 1942, pp. 52–58.

3 Dekker, A. J., *Solid State Physics*, Prentice-Hall, Inc., 1957.

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DISCUSSION

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The authors have obtained a useful dimensionless correlation of a broad range of data. It appears fortunate that a single equation is adequate since a dimensional analysis shows w/d to be a function of l/d, θ and two independent dimensionless groups representing the balance between surface tension, viscous and inertia effects. Even if l/d is irrelevant and θ can be combined with w/d in the composite ($w \sin \theta/d$) there still remains the

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balance of three forces to consider. In the limit of an inviscid fluid we should expect the solution to be only a function of Weber Number, whereas the stresses in a very viscous fluid can be balanced against surface tension by the group $v\mu/T$, or W_e/R_e (probably in this case there is no real "jet," the liquid oozing out of the hole and falling from it). The authors found empirically that the result depended on $(R_e^{1/2}/W_e^{7/8})$ or $(W_e/R_e^{4/7})^{-7/8}$ which is intermediate between the limiting cases.

If a more general picture of the solution were desired it might be useful to combine the Reynolds and Weber numbers to give the group $\mu^2/T\rho d = W_e/R_e^2 =$ "M," a dimensionless balance between viscosity and surface tension that is independent of velocity. For small M, $w \sin \theta/d$ would depend only on W_e, whereas in the limit of the large M we would expect a dependence on the product (W_eM) (perhaps with gravity playing a role when velocities are low enough). The authors' correlation might then appear as a good fit to an intermediate region of a more general multidimensional surface.