Summary
1. Based on experimental data obtained on smooth tubes over a wide range of operating conditions, it is believed that a pseudofilm boiling phenomenon can occur at supercritical pressures.
2. The occurrence of pseudofilm boiling and its characteristics are affected by pressure, bulk fluid temperature, mass velocity, heat flux, and tube diameter, and the effect of each variable has been described.
3. An internally ribbed tube will suppress pseudofilm boiling and permit operation at higher heat fluxes than would have been possible with smooth tubes.

Acknowledgment
The author wishes to acknowledge the contributions of A. R. Brunsvold, S. C. Garg, and J. S. Slotnik, who assisted in obtaining and analyzing the data presented.

References

Discussion
B. S. Shiralkar

The author is to be complimented on a comprehensive experimental study of heat transfer to supercritical pressure water. It was gratifying for us to find many of the trends in this data qualitatively similar to those for carbon dioxide described in our paper 09-WA/HT-1.7

We feel that the author has not stressed the differences between the results for small and large diameter tubes, which we believe to be due to free convection. An examination of data for water and carbon dioxide shows that the nature of the temperature peak changes considerably when free convection is dominant. In this case, the temperature peaks are much sharper and not as well behaved, i.e., do not occur in a well defined subcritical bulk enthalpy range. The same phenomenon can be seen by comparing Fig. 5 for the 0.375-in. tube versus Fig. 7 and 8 for larger tubes in the paper. Based on previous data for water, we had suggested that this transition occurs when a free convection parameter Gr/Re is of the order of magnitude of 2 x 10^3, where the Reynolds number and Grashof number are based on viscosity at the wall temperature.

For the data shown in Figs. 5, 7, and 8 we have calculated approximately, the value of Gr/Re as shown in the following:

<table>
<thead>
<tr>
<th>Gr/Re</th>
<th>Nature of Temperature Peak</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 0.55 x 10^3</td>
<td>Not Sharp - free convection not important</td>
</tr>
<tr>
<td>7 9.25 x 10^3</td>
<td>Sharp - free convection dominant</td>
</tr>
<tr>
<td>8 12.70 x 10^3</td>
<td>Sharp - free convection dominant</td>
</tr>
</tbody>
</table>

These values appear to support our value of 2 x 10^3 for Gr/Re as a transition value. We would be interested to know whether sharp unpredictable peaks were obtained in the wall temperature profile, with the 0.375-in. tube and if so, the mass velocities at which they occurred.

There are also indications that in large diameter tubes, temperature peaks do not occur in downflow. Did the author perform any tests in downflow?


The general philosophy of The Babcock & Wilcox Company, in regard to pseudobubbling heat transfer at supercritical pressure, is to avoid temperature peaking rather than design for it. Because the nature of peaking is sensitive to operating conditions, we feel the best approach is to define the conditions that cause peaking not predicted by our correlations, and then design our steam generators to avoid these conditions entirely.

Accordingly, we have not stressed differences in the nature of temperature peaks observed on small and large diameter tubes. These differences are of only minor importance to us. We are more interested in the conditions that cause initiation of temperature peaking.

Because of our concentration on initiation of peaks, we are unable to agree or disagree with Mr. Shiralkar's analysis of the nature of peaks. However, we can say that all data on small diameter tubes are like that presented in the paper.

For anyone who is interested in analyzing data from the 0.37-in-dia tube, the data are available from the Library of Congress. (Request document 8110 from Chief, Photo Duplication Service, Library of Congress, Washington, D. C.)

No tests were run with downflow, although tests are continuing on both smooth and internally ribbed tubes at various inclinations.