Nu_{max}. In the Krall and Sparrow paper, the relation between Nu_{max} and Re, as derived from their test data, is given as Nu_{max} = 0.398 Re^{0.66}, independent of step size. The exponent in this relation lies between the exponents of equations (5) and (6). A difference is that, for the geometry of the current investigation, the specific value of Nu_{max} is a function of step size while, for the round duct configuration, the Krall and Sparrow data show Nu_{max} to be independent of step size within the range of their investigation.

Perhaps a more meaningful comparison can be made on the basis of the Nu_{max}/Nu_0 values for the current study were obtained from equations (5) and (6), taking Nu_0 = 0.0157 Re^{0.4} based on the data from Kays and Leung [5].

The values of the ratios obtained by Boelter [2] and Krall [4] are generally bracketed by the two values of the current investigation for the long and short stalls. The data of Ede [3] appear to be consistently lower than the ratios for either stall under comparable conditions. This same trend is noted by Krall [4] in comparing his data to those of Ede [3]. Krall suggests that, in his case, the difference is possibly due at least in part to heat transfer to the fluid upstream of flow separation.

The Krall and Sparrow experiments, as well as those of Boelter, et al. [2], and Ede [3], were carried out in a circular pipe, and the reported Nusselt numbers presumably represent averages around the pipe perimeter. Thus there was no "short stall" and "long stall" distinction as in the present investigation. If the maximum Nusselt numbers for the two sides in the present investigation are averaged, the result is very close to the single maximum Nusselt number data of Krall and Sparrow, as can be seen from Table 1.

### Summary and Conclusions

Experimental heat transfer data have been presented for the wall region downstream of an abrupt enlargement in flow cross section for flow in a flat duct. Two area ratios, w/w_0 = 1.125 and w/w_0 = 2.10, were considered, and Reynolds numbers covered the range 70,000 to 205,000.

It was found that boundary-layer reattachment occurs at different distances on the two walls of the duct, that these distances are independent of Reynolds numbers, and that the "long" and "short" stalls can be moved to the opposite walls by use of a vane well upstream of the separation point. Furthermore, maximum heat transfer (maximum Nusselt number) occurs at the point of reattachment.

### DISCUSSION

**P. R. Trumpler**

The authors' study is a welcome addition to our store of heat transfer data. I have a question on the experimental technique: Did the authors attempt a heat balance, presumably by equating the heat gained by the water to the enthalpy and kinetic energy change in the air? I assume that the observed data in raw and corrected form, are available in the reference thesis. The complete data may well be too voluminous to include in the normal tables in a paper, but I would still like to see some data, as many as practical. Perhaps the day will come when the data for a work like this will be readily available to the reader of the paper by having tables reproduced in the smallest resolvable printing, to be read with a magnifying glass. This will get a lot of data into a small space. Data are so important that representation in correlation, or by lumping in variable groups, may hide some factor that is important in subsequent use or study.

My other comments deal with the problem of generalizing or interpreting the data. Hydraulic diameter, as a characteristic length, when comparing nonsimilar geometries, never appealed to me, even when I did it myself. Perhaps the authors had no better choice than to group circular pipes with rectangular ducts by hydraulic diameter, despite the major difference in the way...
both perform in this kind of test. What are the prospects of establishing correlation on the basis of boundary layer parameters? It seems to me that this problem offers an interesting challenge in boundary layer theory. This does not imply that the authors should have made such an analysis; their contribution is the experimental work. But I would encourage further effort to attempt a quantitative explanation of these interesting results.

Authors' Closure

Dr. Trumpler’s comments regarding the importance of tabulated data are well taken and are certainly in line with the authors’ own thoughts on the subject. Since space did not permit publication of tabulated data in this instance, we might add that anyone interested might contact either of the authors or obtain a copy of the original thesis on loan from the Stanford Library.

To answer Dr. Trumpler’s question regarding heat balances during the experimental phase, quite a number of such heat balances were performed during calibration of the instrumentation. The results are described in the thesis from which this paper is drawn, and in even more detail in the references quoted in the thesis.

We are unaware of any successful attempts to date to analytically explain the observed results on the basis of boundary-layer theory. This area remains a fertile one for continuing investigation.