

be constructed most easily on transparent paper by simply tracing the appropriate curves. The upper halves, if needed, can be traced on the reverse side of the transparent paper. The isentrop is to be used for all homentropic parts of the flow (as is the Busemann Epicycloid in the  $\omega$ ,  $\delta$ -plane). For instance, in example 2 from Crawford's paper<sup>1</sup> if the merging of the two shocks sheds a reflected rarefaction wave (for  $M_\infty^2 < \{3 + [9 + 16/(\gamma - 1)]^{1/2}\}/4$ , point of inflection of the isentrop) the situation is as sketched in Fig. 2. Though nowadays numerical methods have taken over in the engineering field, the use of graphical methods is still, and will remain, valuable in teaching and analyzing. We fully agree with Crawford in this respect. It is sad to report that Dr. Weise, who was Professor Emeritus from the University of Stuttgart, died on July 25, 1973.

### References

- 1 Crawford, D. H., "A Graphical Method for the Investigation of Shock Interference Phenomena," *AIAA Journal*, Vol. 11, No. 11, Nov. 1973, pp. 1590-1592.
- 2 Weise, A., "Die Herzkurvenmethode zur Behandlung von Verdichtungsstößen," *Festschrift der Lilienthal-Gesellschaft zum 70. Geburtstag von L. Prandtl*, 1945.
- 3 Franke, H., ed., *Lexikon der Physik*, 3rd ed., Franckh'sche Verlagshandlung, Stuttgart, 1963 (catch-words "Herzkurvenmethode," "Verdichtungsstoß," "Stromfadentheorie").
- 4 Ehrhard, A. and Franke, H., eds., *Lueger Lexikon der Technik*, Vol. 1, Rowohlt, Reinbek, 1971 (catchword "Herzkurvenmethode").
- 5 Weise, A., "Theorie des gegabelten Verdichtungsstoßes," *Jahrbuch 1943 der Deutschen Luftfahrtforschung*, Vol. 10, Heft 12, IIa, 011, 1943, pp. 1-12.
- 6 Courant, R. and Friedrichs, K. O., *Supersonic Flow and Shock Waves*, Interscience, New York, 1948, pp. 118-120.
- 7 Shapiro, A. H., *The Dynamics and Thermodynamics of Compressible Fluid Flow*, Vol. 1, Ronald Press, New York, 1953, p. 136, Fig. 5.17.
- 8 Brieden, K., "Die anisentrope Überschalldurchströmung des Streckgitters," *Zeitschrift fuer Angewandte Mathematik und Physik*, Vol. IXb, Fasc. 5/6, 1958, pp. 132-161.
- 9 Förster, K., "Die graphische Bestimmung eindimensionaler, in-stationärer, anisentroper Gasströmungen entsprechend den Grundgedanken des Herzkurvenverfahrens nach A. Weise," Dissertation T.H., 1961, Institute for Aerodynamics, University of Stuttgart, Stuttgart, F.R. Germany.

was concerned primarily with lower Mach number applications and made more frequent use of critical (\*) conditions as reference or normalizing quantities. In the author's work, the shock-polar curves are aligned along the  $y$  axis according to the values of  $M_1$  and  $p/p_{ns}$  at the cusp. Mach number and  $p/p_{ns}$  are the customary nondimensional velocity and pressure values used in hypersonic aerodynamics rather than  $u/a^*$  and  $p/p^*$ . The two symmetric parts of the pressure-deflection curves which correspond to positive and negative deflection are very convenient when complex shock interactions are being studied.

The paper<sup>4</sup> did not intend to present all possible interference calculations which can be made by this method, but rather to illustrate its use with two simple examples. Example 2 is that of two successive shocks; Förster carries these shocks to the point of confluence where a contact discontinuity and an expansion wave occur.<sup>5</sup> Solution to this problem, which is Edney's type-VI interference,<sup>6</sup> can be readily determined by the logarithmic-shock-diagram with extrapolation of the correct heart-shaped curve below the point for the isentropic expansion. Since the distance for extrapolation is so short, it can be accomplished with little uncertainty.

### References

- 1 Förster, K. M., "Comment on 'A Graphical Method for the Investigation of Shock Interference Phenomena,'" *AIAA Journal*, Vol. 12, No. 8, Aug. 1974, pp. 1167-1168.
- 2 Weise, A., "Die Herzkurvenmethode zur Behandlung von Verdichtungsstößen," *Festschrift der Lilienthal-Gesellschaft zum 70. Geburtstag von L. Prandtl*, 1945.
- 3 Weise, A., "Theorie des gegabelten Verdichtungsstoßes," *Jahrbuch 1943 der Deutschen Luftfahrtforschung*, Heft 12.
- 4 Crawford, D. H., "A Graphical Method for the Investigation of Shock Interference Phenomena," *AIAA Journal*, Vol. 11, No. 11, Nov. 1973, pp. 1590-1592.
- 5 Courant, R. and Friedrichs, K. O., *Supersonic Flow and Shock Waves*, Interscience, New York, 1948, pp. 118-120.
- 6 Edney, B. E., "Anomalous Heat Transfer and Pressure Distribution on Blunt Bodies at Hypersonic Flight Speeds in the Presence of an Impinging Shock," FFA Rept. 115, Feb. 1968, The Aeronautical Institute of Sweden, Sweden.

## Reply by Author to K. M. Förster

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THE author appreciates Förster's<sup>1</sup> pointing out the similarity of earlier work in shock interaction<sup>2,3</sup> to the subject paper<sup>4</sup>; unfortunately, Weise's work has not been widely circulated in this country. The present publication<sup>4</sup> carrying the logarithmic-shock-polar-family to hypersonic Mach numbers essential to analysis of entry problems was the result of an independent study of shock interaction. The earlier work performed during an era of intense research in turbo machinery

## Errata

### Analysis of Bonded Joints in Vehicular Structures

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IN Figs. 7 and 9, the normalized normal stress should be labeled  $\sigma_x h/p_o$  rather than  $\sigma_x l/p_o$ , where  $h = h_1 + h_2 + h_3$ .

Received March 14, 1974.

Index category: Supersonic and Hypersonic Flow.

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Received March 21, 1974.

Index categories: Structural Composite Materials; Aircraft Fabrication.