A set of similar figures can be drawn for backward-facing waves. Figure 4 *d*) is then unchanged. The others are produced by reflection in the vertical axis, except that appropriate adjustments need to be made depending upon the magnitude and sign of u_0.

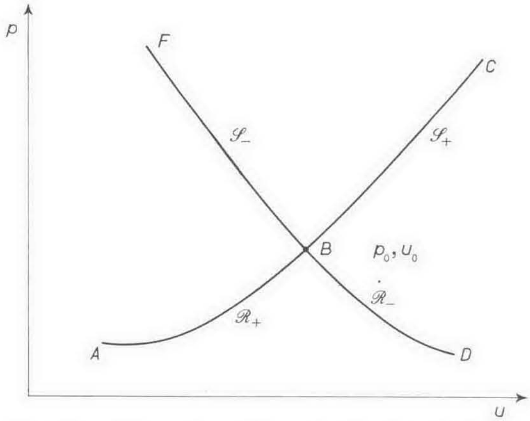

Fig. 5. – Wave transitions in the (p, u) plane.

The essential point of the following discussion is that states connected by shocks or by simple waves to an arbitrary state (p_0, u_0) must lie on fixed curves given by eqs. (32), (34), (35), (36), provided there are no time-dependent terms in the constitutive relations. This is illustrated in Fig. 5. *AB* is represented by eq. (35), *BC* by (32), *BF* by (34) and *BD* by (36). *AB* and *BC* have a second-order contact at *B*, arising from the second order contact between isentrope and Hugoniot at the initial state (p_0, V_0). So do *BD* and *BF*.

Some applications of the foregoing principles are illustrated in Fig. 6-13.

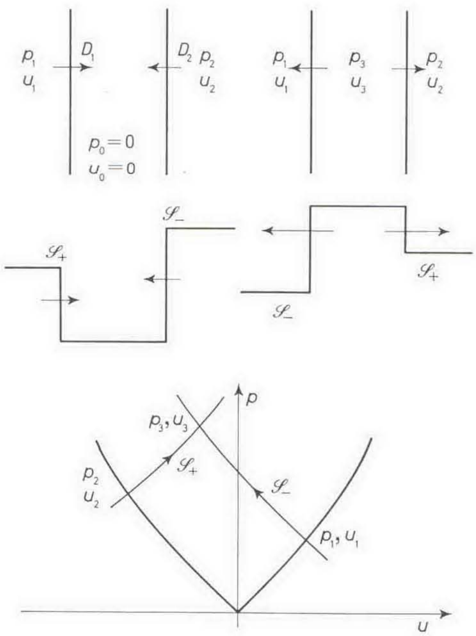

Fig. 6. – Collision of two shocks.

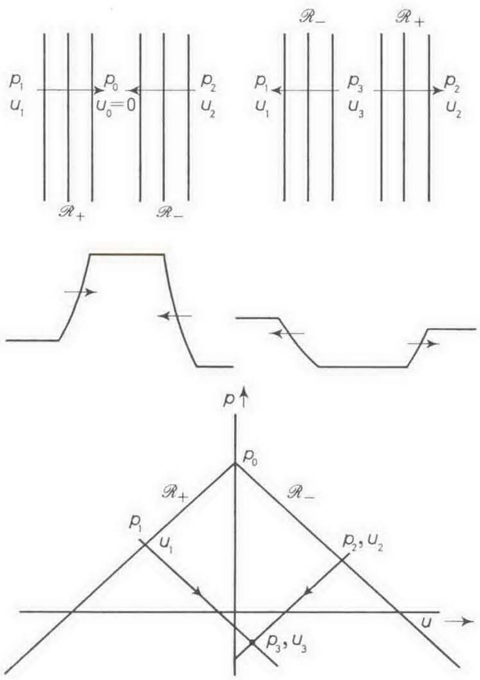

Fig. 7. – Collision of two rarefactions.

Figure 6: Two shocks approach one another, separated by a uniform state $p_0 = 0 = u_0$. They are represented by the points (p_1, u_1) and (p_2, u_2) in the (p, u) plane. After collision there are two waves drawing apart, separated by a new state (p_3, u_3) and running into the uniform states (p_1, u_1) and (p_2, u_2), respectively. The transition from (p_2, u_2) to (p_3, u_3) occurs across a forward-facing wave, that from (p_1, u_1) across a backward-facing wave. The state between the separating waves must be uniform in (p, u) because of continuity conditions on p and u. All these conditions are satisfied by the intersection of the $\mathscr{S}_-$ and $\mathscr{S}_+$ curves from (p_1, u_1) and (p_2, u_2), respectively.

Figure 7: Collision of two rarefactions: The argument is analogous to the previous one. The initial state p_0, $u_0 = 0$, is connected by rarefactions to (p_1, u_1) and (p_2, u_2). The final state reached from (p_1, u_1) and (p_2, u_2) must lie at the intersection of wave transition curves passing through these states and must be a state of uniform p and u. This is satisfied by (p_3, u_3).

Figure 8: Reflection of a uniform shock at a rigid wall: The initial shock, $\mathscr{S}_+$, carries material from $(u_0 = 0 = p_0)$ to (p_1, u_1). After reflection the state (p_1, u_1) is connected to the final state $(p_2, u_2 = 0)$ by a backward-facing wave. The final state must lie on the curve for backward-facing transitions in the (p, u) plane and also on the $u = 0$ axis. These conditions are satisfied at point A. Note particularly that if the $\mathscr{S}_+$ curve is concave upward in the (p, u) plane, $p_2 > 2p_1$. The $\mathscr{S}_-$ curve through B is the mirror image of the $\mathscr{S}_+$ curve in a vertical axis through B.

Figure 9: Reflection of a uniform shock at a free surface: This is similar to the preceding, but the final state must now lie on the $p = 0$ axis. For condensed

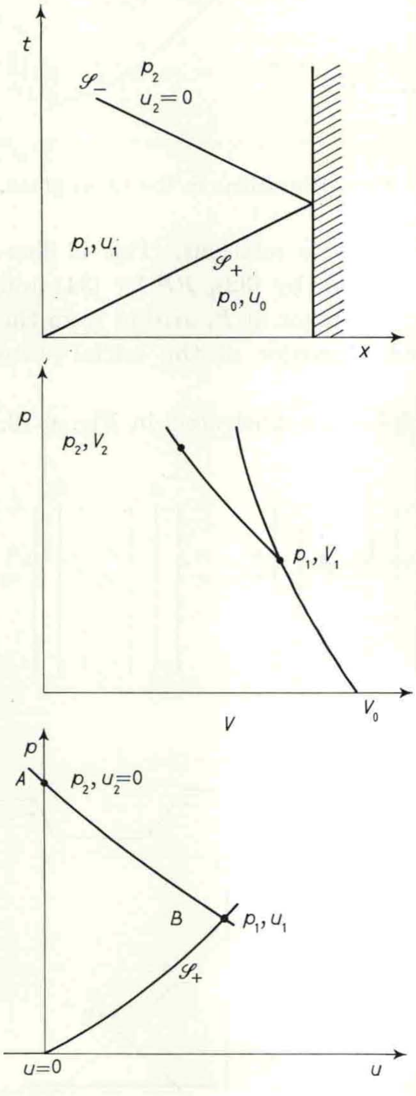

Fig. 8. – Reflection of a uniform shock at a rigid wall. $p_2/p_1 > 2$ if $d^2p/dV^2 > 0$.