

Rupture of Round Bars by Tension

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1. Introduction. Let Σ be a fixed surface in a solid. Suppose that an arbitrarily small slip of the material particles or discontinuity in the particle velocity, or its derivatives, develops over Σ as a consequence of applied stress. It may then happen that this initially small discontinuity must necessarily increase indefinitely *within a finite time*, in view of the basic equations assumed to govern the behavior of the material. In such a case we shall say that Σ is a surface of *strong instability*. Correspondingly, a moving surface $\Sigma(t)$, bearing a small discontinuity of the above type at time $t = 0$, will yield a surface of strong instability $\Sigma(T)$ if the initial discontinuity becomes indefinitely large as $t \rightarrow T$. Again, a surface of strong instability Σ^* , distinct from the moving surface $\Sigma(t)$, may be generated by points on $\Sigma(t)$ at which the above discontinuity is infinite. Now it is our contention that fracture will occur over such surfaces as the physical manifestation of the inability of the material to support these infinite discontinuities. Hence we shall also refer to the surfaces of strong instability¹ as *surfaces of fracture or rupture*.

It is commonly considered that fracture is produced as the result of the propagation of a crack² in the solid. According to the present theory such a crack will move³ along a surface of instability or rupture, as above defined, on account of the inherent weakness of the medium over this surface.

It is natural, from the standpoint of this discussion, to consider the surface of separation Σ of an elastic and plastic region in a solid as a possible surface of fracture since discontinuities in the velocity and stress, or their derivatives, must occur over such a surface, due to the differences in the character of the

¹ Discontinuities producing a weaker type of instability than the discontinuities considered in the definition of the surfaces of strong instability apparently do not result in rupture but may cause recognizable surface markings. See T. Y. THOMAS, *Plastic flow and fracture in solids*, Jour. Math. and Mech., 7 (1958) pp. 291-322.

² For a comprehensive account of the theory of cracks reference may be made to the article on fracture by GEORGE R. IRWIN, *Encyclopedia of Physics*, Vol. VII, Springer, Berlin, 1958.

³ With regard to the velocity of propagation of the crack see A. A. WELLS & D. POST, *The dynamic stress distribution surrounding a running crack—A photographic analysis*, Naval Research Laboratory, Washington, D. C., Report 4935, 1957. In this connection see also T. Y. THOMAS, *Plastic disturbances whose speed of propagation is less than the velocity of a shear wave*, Jour. Math. and Mech., 7 (1958) pp. 893-900.