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RIDGES IN THE STOCK ON FOURDRINIER WIRES CONSIDERED AS WAVE MOTION

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The limitations of the original publications on stock instability are briefly stated. The possibility of treating free surface instability as wave motion is discussed; an elementary approach is inadequate and a theoretical treatment would be impractical. Such difficulties might be overcome by mathematically modelling the effects of drainage elements on disturbances in the stock passing over them.

A careful reading of publications of 1956-1964 on the instability of stock on the wire suggests that although all relevant factors were at some time considered, no adequate model for the amplification of ridges and growth of spouts was developed. Current interest in the use of controlled instability to improve the formation therefore justifies a brief reappraisal of this topic. An adequate model of free surface instability should be applicable not only to ridges but also the hexagonal pimple patterns and also ejection of spouts from the bottoms of craters left by bubbles in the stock surface, both of which were noted by Burkhard and Wrist (27).

The limited applicability of Taylor instability theory was mentioned in response to a question by Dr. Jim Luce. The otherwise excellent work by Culver and Mardon (28), whilst recognising the effect of surface tension on wave motion and also the existence of an upper limit to the amplitude of gravity waves and surface tension ripples (see also Lighthill, (19)), ignored both the upward acceleration of stock after drainage elements and also the inversion of troughs and ridges regularly noted at this point prior to the development of spouts. (Pimple patterns undergo a similar phase inversion.) In the work of Yih and Spengos (29), the rings of liquid that form on the outside of rotating cylinders were studied in relation to stock instability during downward acceleration over table rolls. The further suggestion by Debler and Yih (24) that Taylor vortices developed in the stock during the subsequent upward acceleration, (as in a ring of liquid spinning inside a more slowly rotating cylinder), seems to be ruled out by the lack of MD shear between the stock and the wire. Up to a point it is possible to consider MD ridges on the wire as surface tension ripples moving slowly across the wire or forming standing wave patterns. their wave velocity, **c**, would depend both on surface tension and on gravity (19):

$$c = [\lambda(g+a)/2\pi + 2\pi T/\rho\lambda]^{1/2}$$

where **a** is the upward acceleration of the wire
λ is the wavelength of the ripples
ρ is the stock density
T is the surface tension

This relationship only applies when the stock depth is greater than about 0.27λ. Also, as the stock travels down the wire, the effective value of **a** varies, reaching -60g over table rolls and perhaps +150g immediately after them.

It is obvious that negative values of **a** are inadmissible in the above expression; a more sophisticated treatment is required. Ocean waves break if their peak-trough height is forced to exceed about 0.1412λ through excessive energy input (19). By analogy, ridges would be expected to spout under similar conditions. A means of simulating this is needed. A further difficulty is that if ridges are considered as low amplitude sinusoidal ripples is that of explaining energy input from drainage elements. If such ripples are subjected to a vertical "jerk", comprising successive equal and opposite impulses of downward and upward acceleration, little energy would be fed into them, because the motion induced by the first impulse would be annulled by the second. In practise significant energy input occurs at drainage elements; to explain it, one must consider the non-linear effects associated with waves of relatively high amplitude.

For the above reasons I recently experimented by modelling a standing wave using a simple finite element approach. In a very limited time it was possible to demonstrate spouting from the crest of waves. Others may care to pursue this approach in the future. To indicate what might be achieved, consider an isolated

MD ridge in stock of otherwise uniform depth approaching a table roll. This ridge resembles a jet of liquid projected parallel to the surface of the stock. At the drainage element most of the stock would be drawn down uniformly, following the profile of the wire. The ridge would however be projected forward to impinge on the stock after the element, burrowing into its surface and causing new ridges to form to either side, as suggested in Fig.1 below.

Using a suitable model it should be possible to derive a quantitative version of the sequence of sketches, shown in Fig.1, of the proposed sequence of changes to the CD profile of the stock surface at a drainage element.

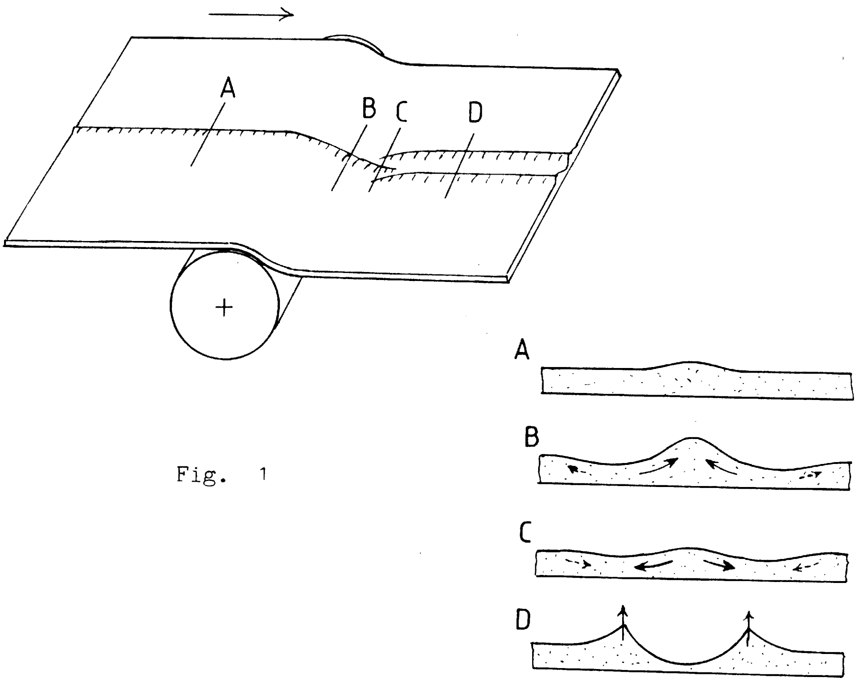

Fig. 1

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