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Langley Research Center

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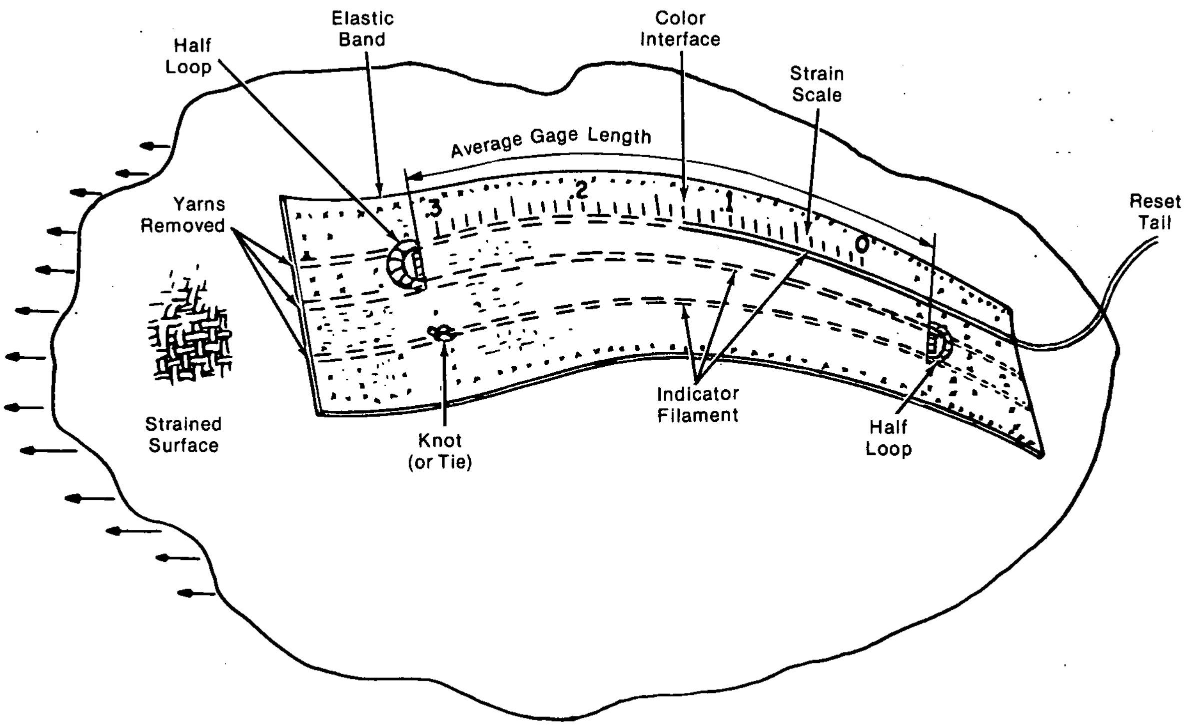
Amplifying Ribbon Extensometer

The accurate measurement of strain on flexible membranes and/or fabrics has long been a challenging objective. High-strain measurement capability is required in mapping strains in parachute canopies, in stressed fabric structures, balloons, sails, and inflatables in general. Numerous measuring devices are available, but are, in general, oversophisticated and too bulky and heavy for the base upon which they are attached. In many devices, the gage extraction forces are so large that the strain field to be measured is grossly altered by the gage installation.

A new flexible-ribbon extensometer can function successfully with extraction forces of 1 percent of the ultimate membrane force of the base material on which it is installed. It is compact and lightweight, has a strain-amplification capability up to five and has an accuracy better than 1 percent.

A number of configurations are possible, but the simplest is an amplified version and modification of the Ranes nonelectrical strain gage reported in NASA Compilation SP-5926 (02), Measurement Technology, page 28. That extensometer is fabricated from a highly-elastic base ribbon. Some of the elastic warp yarns are removed on equal spacing as required and are replaced by a relatively inelastic yarn called the indicator filament. An amplification factor of three is made possible by reeving the indicator filament as shown in the illustration.



Amplifying Ribbon Extensometer Installed

(continued overleaf)

The indicator filament enters the ribbon at the knot and exits only for the half loops. The turns are 180 degrees and are facilitated by the semicircular fabrications of surgical tibing called "half loops." For gains higher than five, units of concentric half loops of varying radii are fabricated, and successful gages with gains as large as 10 have been made. The indicator filament is dyed a different color, extending from the zero point on the strain scale to the end of the reset tail. A suitable scale is printed on the base ribbon to permit direct reading of strain by observing the position of the color interface on the indicator filament relative to the printed scale. The illustration shows a strain reading of 0.13.

For large values of amplification, the observable, detectable, or indicated measurement provides increased accuracy, particularly if both the strain and the base ribbon are small. The amplification level is limited, however, by the friction in the half loops and between the base ribbon and the filament. The gage extraction force increases essentially exponentially with the gain and becomes too large for most fabric and film applications as the gain exceeds five.

Successful gages for gains with amplification factors of 10 are called "open-faced gages" or "partially-open-faced gages." For such gages the friction is reduced by not threading or by threading only the tail end of the indicator filament through the base ribbon. When there is no threading, the recording end of the indicator filament is tensioned and constrained to the maximum experienced strain by adding a unique tensioner to the half loops.

For the type of gage illustrated, the encapsulation of the indicator filament within the base ribbon minimizes the possibility of the recorded strain being altered by external factors such as wind, surface abrasion, or dynamic motions. The low profile is interrupted only when the indicator filament exits the ribbon weave to effect the turns at the half loops. For open-faced gages, the encapsulation feature of the ribbon must be replaced by encasing the half loops and reeved filaments in an envelope sleeve of high-elongation, low-resistance material such as rubber dental dam or Hytrel.

While being primarily of value in aerospace applications, in design and research test functions, it is conceivable that such devices could be useful where maximum displacements of strain excursions are required for critically packaged items, for recording and verification of maximum shipping dynamics on delicate packaged devices, for accounting for life consumed from strain of known cyclic frequency, or for biomedical measurements of mobility and strain of muscles. The amplification feature is acquired in a passive way, at a low cost, with light weight, an essentially planar geometry, and a reset capability. In addition, the extensometer is easy to install.

Note:

Requests for further information may be directed to:

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Patent status:

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Categories: 06 (Mechanics)
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