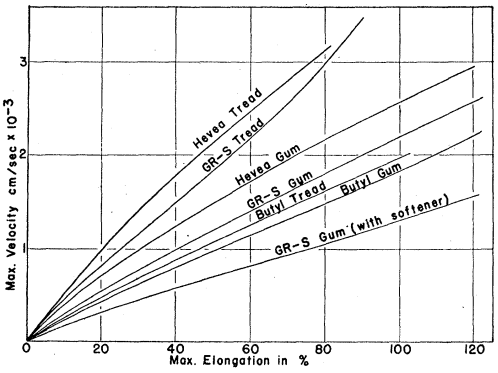

FIG. 4. Maximum velocity of tip *vs.* initial elongation for various stocks.

Simultaneously with our work, but independently, an interesting method to measure an average velocity of the tip of a sample, over a certain part of the retraction, was developed at the Goodyear Research Laboratories.[3] Whereas our method seems to be more suitable for quantitative work, the Goodyear method seems to be quite suitable for factory control purposes of stocks.

[1] F. Exner, Ann. d. Physik **153**, 62 (1874).
[2] Cf. H. M. James and E. Guth, Phys. Rev. **66**, 33 (1944).
[3] R. B. Stambaugh, Phys. Rev. **65**, 250 (1944).

Photographic Study of the Retraction of Stressed Rubber

B. ADALBERT MROWCA, C.S.C., S. LEONARD DART, AND EUGENE GUTH
Department of Physics, University of Notre Dame, Notre Dame, Indiana
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THE peculiar element by element contraction of rubber, discovered by the two-stylus experiments, has been described.[1] This behavior was checked by high speed photography. Instantaneous photographs of the progress of the retraction were taken by a camera in stroboscopic illumination. Figure 1 shows a set of such photos for Hevea gum. The white marks are equidistant at the initial elongation (about 100 percent). The wave pulse and its progress are clearly visible. Figure 2 shows a set of photos for Butyl tread. Here the pulse is quite diffuse and is reflected at the fixed end before the sample has contracted completely, leading to an early buckling. Of course, the contraction starts with the tip. Figure 3 shows the differential extension, i.e., the extension of each element as a function of the distance from the fixed end for two consecutive times t and t_2, respectively. Figure 3 was plotted from the photos in Fig. 1 and Fig. 2. For Hevea gum, the progress of the well-defined wave pulse is revealed again. For Butyl tread the velocity of each point is approximately proportional to its distance from the fixed end.

Instantaneous photos do not give a time scale. Of course, the timing may be obtained from our elongation-time curves.[1] Moreover, the timing may be obtained by using

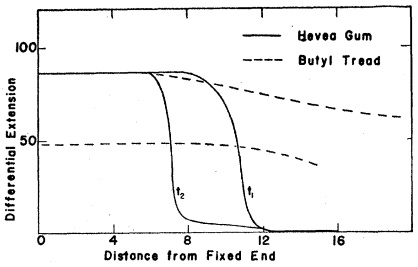

FIG. 3. Differential extension as obtained from stroboscopic photographs.

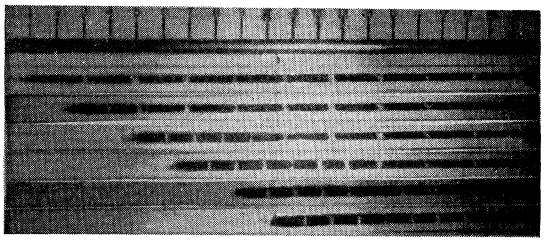

FIG. 1. Stroboscopic photographs showing retraction of Hevea gum.

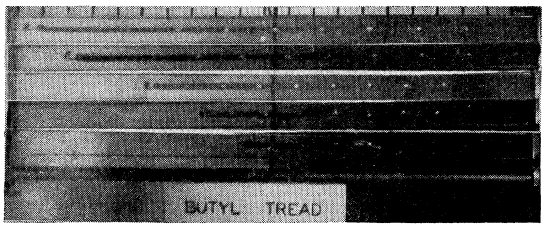

FIG. 2. Stroboscopic photographs showing retraction of Butyl tread.

Edgerton's high speed camera. We have obtained high speed movies with timing; the time was recorded on the film by a spark at 1/120 second intervals. These movies check well the timing obtained by our stylus experiments, namely, that the duration of the retraction for about 100 percent initial elongation is from 5 to 20 milliseconds according to the particular sample used. After the discovery of the element by element contraction by our two-stylus experiments, instantaneous photos were taken about simultaneously at the Goodyear Research Laboratories.[2]

A complete theoretical explanation of our findings is offered in the following letter by James and Guth.[3] Hevea gum and Butyl tread represent the two limiting cases of small and strong internal friction, respectively. The expression for the velocity of the tip: $v_t = \epsilon(E/\rho)^{\frac{1}{2}}$ agrees[3] rather well with experiment.

[1] B. A. Mrowca, S. L. Dart, and E. Guth, Phys. Rev. **66**, 30 (1944).
[2] R. B. Stambaugh, Phys. Rev. **65**, 250 (1944).
[3] H. M. James and E. Guth, Phys. Rev. **66**, 33 (1944).

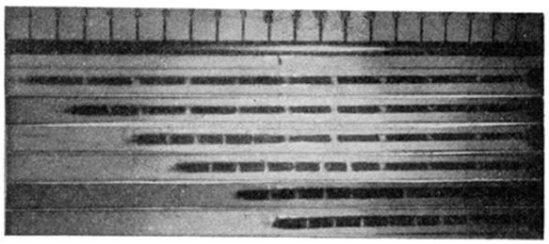

FIG. 1. Stroboscopic photographs showing retraction of Hevea gum.

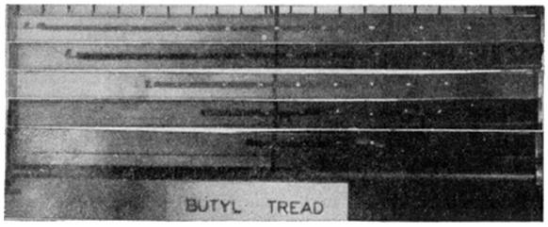

FIG. 2. Stroboscopic photographs showing retraction of Butyl tread.