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STREAK CAMERA RECORDING OF INTERFEROMETER FRINGES

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DISCLAIMER

STREAK CAMERA RECORDING OF INTERFEROMETER FRINGES

We use an electronic high-speed camera* in the streaking mode to record the motion of interference fringes from a velocity interferometer. The wide angle Michelson interferometer must be adjusted so that mirrors M_1 and M_2 in Fig. 1 form a slight wedge angle to give a fringe pattern of approximately parallel lines. Since the line intensity varies sinusoidally, the resolution is poor and one must adjust for the minimum number of lines. At least three lines are required to obtain accurate measurement of fringe spacing; this allows two fringe maxima to be retained in view at all times. More lines will reduce contrast and line resolution; less will not allow accurate measurement. This fringe pattern is passed through a cylindrical lens, concentrating the light into a line with the focus at the camera entrance slit (see Fig. 1). There is enough light return from the target to produce good records with Type 47 (3000 ASA speed) Polaroid film. The camera is swept at ~20 km/s for tracing the flyer velocity profile and jump-off velocity tests. The sweep speed is set at 50 km/s for the pretimed jump-off velocity shot of a stainless-steel plate target.

We have found this method of recording fringe motion to have many advantages over the photomultiplier tube-oscilloscope (PMT-Scope) system now in use. These advantages are highlighted below.

- Simplicity of operation. The electronic camera requires one shutter control and two triggers — one to start the sweep and the other to trigger the light fiducial. The PMT-Scope system has 11 shutters, 11 triggers, and 5 electrical fiducials.
- One dry run with a streaking camera can replace four dry runs needed for the PMT-Scope system.
- Simplification of equipment. One $40K camera replaces more than $120K in scopes, scope cameras, PMT detectors, and optical components — a substantial cost advantage.
- The simpler system also allows fewer opportunities for experimental error, hence greater confidence in the data obtained.

*Imacon 700 made by Hadland Photonics Limited.

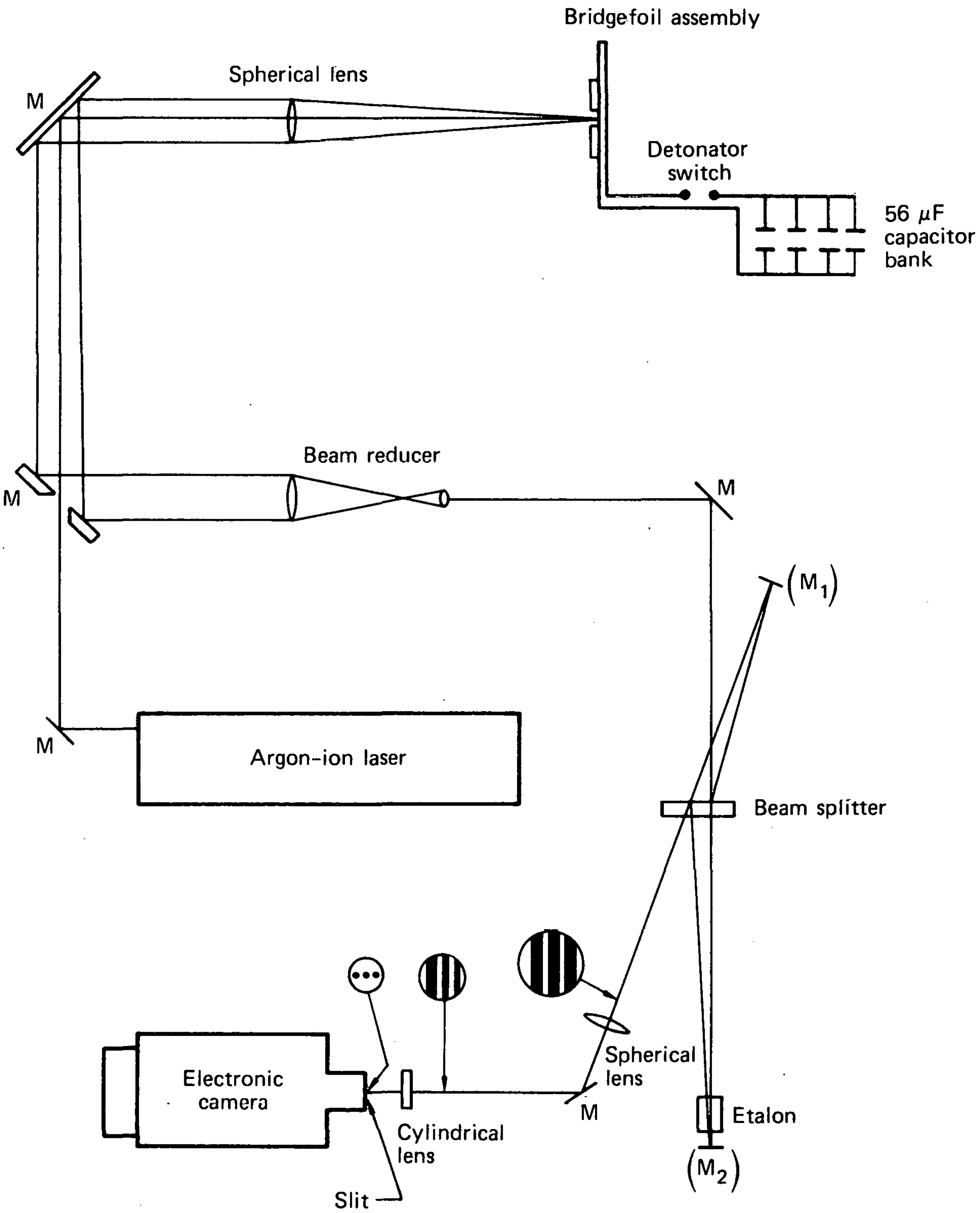


Fig. 1. Experimental setup using an electronic high-speed camera in the streaking mode.

To test this use of the electronic streak camera, we measure the velocity profile of a mylar flyer accelerated by an electrically exploded bridge foil and the jump-off velocity of metal targets struck by these mylar flyers. The velocity to be measured is a linear function of the displacement of the interferometer fringes. Thus, V = Nk where N is the number of fringes being displaced and K is the interferometer constant that corresponds to the velocity change per fringe shift. The expression for K is

$$K = \frac{\lambda c}{4h\left(\eta - \frac{1}{\eta}\right)(1.034)} \text{ km/s per fringe,}$$

where

λ = wave length of incident light

c = speed of light in vacuum

h = length of etalon

η = index of refraction of etalon material.

Figure 2 illustrates the conversion of a fringe motion pattern to a velocity plot. Until time at point A, there is no fringe motion and the velocity is constant. From A to B, the fringe moves one separation distance, giving a change in velocity equal to the interferometer velocity per fringe constant (0.400 km/s in this case). The one-quarter fringe separation displacement from B to C gives a further change in velocity of 0.1 km/s. Region C–D indicates constant velocity and D–E shows a repeat of A–C. Total fringe displacement at E is two and one-half fringe separations, which means a velocity change of 2-1/2 × 0.400 km/s per fringe or 1 km/s. In region E–F, the direction of fringe motion reverses, showing that the velocity decreases.

Photographic data and their corresponding velocity profiles are presented in Figs. 3 through 6. Figure 3 contains a velocity profile of a mylar flyer projected by an electrically exploded aluminim bridgefoil. Data were taken to the time the flyer reached the end of the 200-mil-long barrel at 3.41 μs after the bridgefoil current start. Foil burst time was ~1.38 μs. Figure 4 contains a plot of the jump-off velocity of a thin aluminum target struck by a mylar flyer. In the data photograph, the fringes move more than 1-1/4 times the fringe separation distance at jump-off. The experiments for Figs. 5 and 6 were with thick stainless steel targets. Jump-off time in Fig. 6 was earlier than in Fig. 5 because of the shorter flight to impact for the flyer. The velocity curves are typical of spalled material.

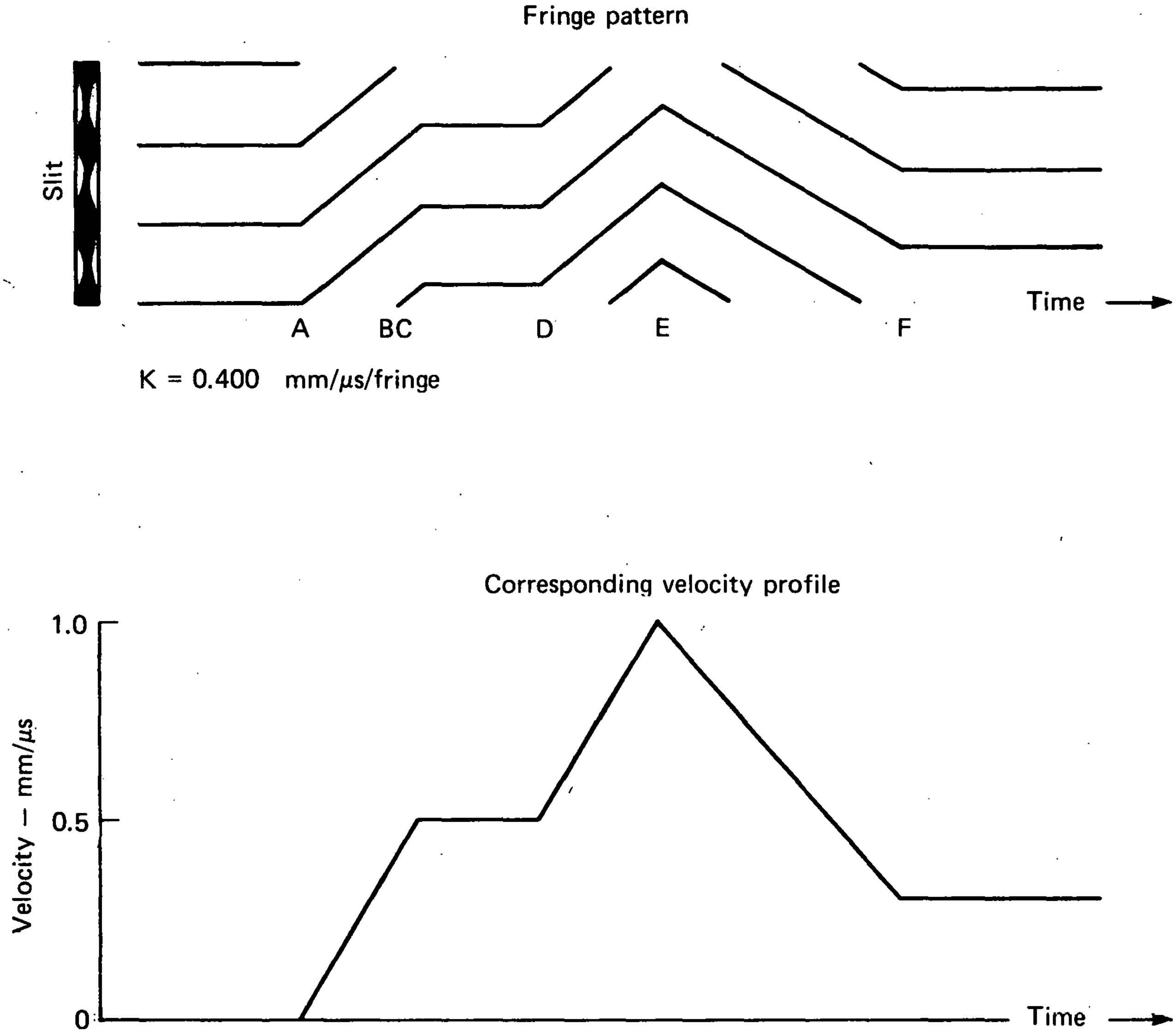
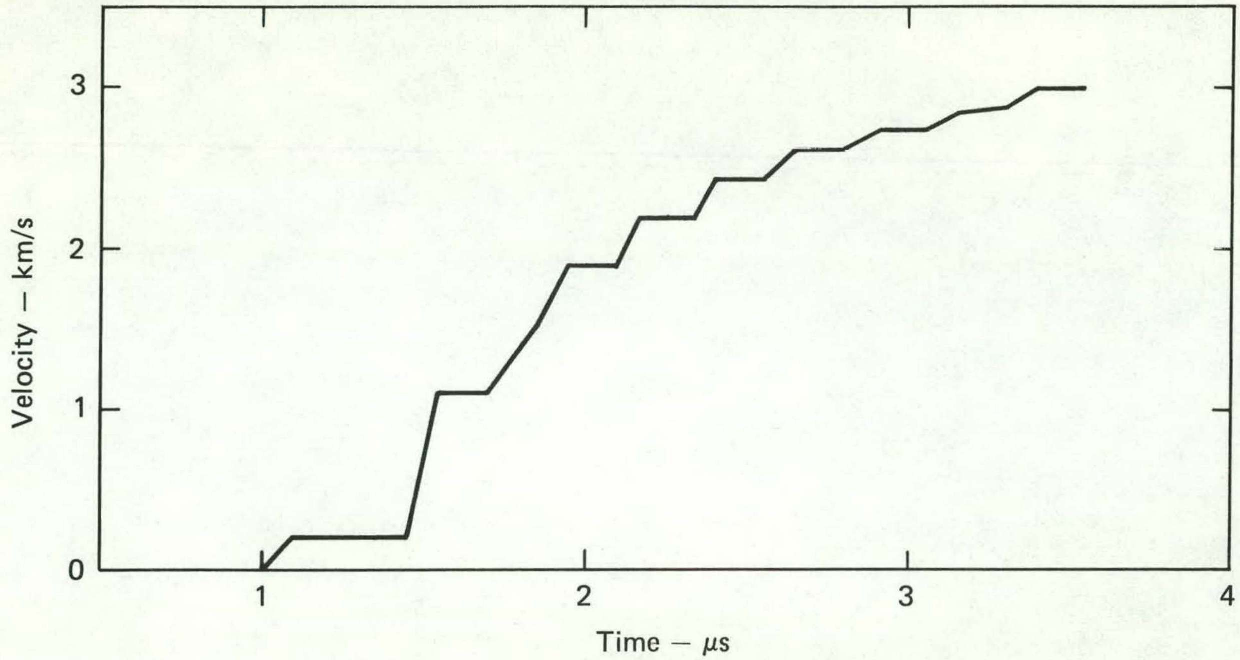
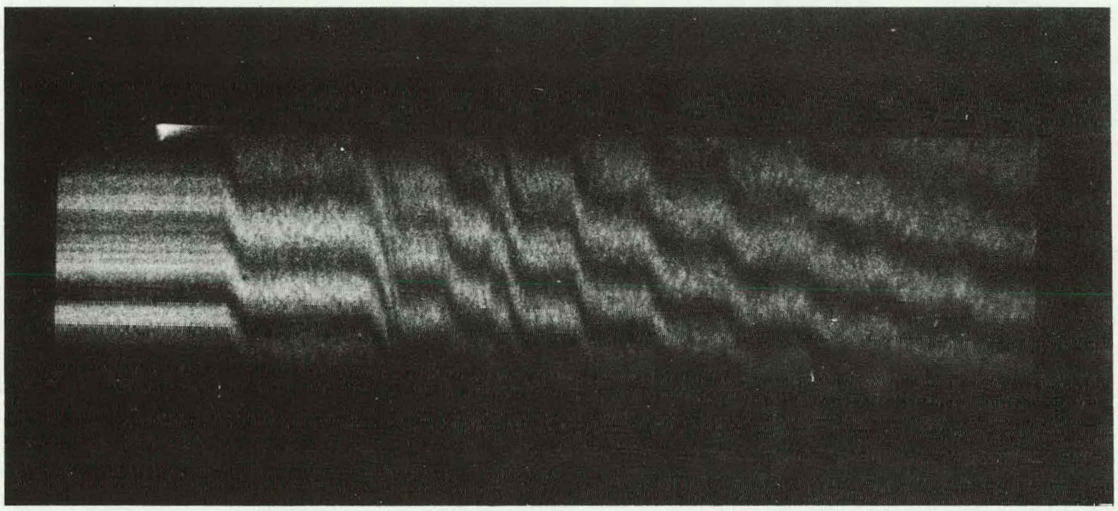


Fig. 2. Conversion of a fringe motion pattern to a velocity plot.

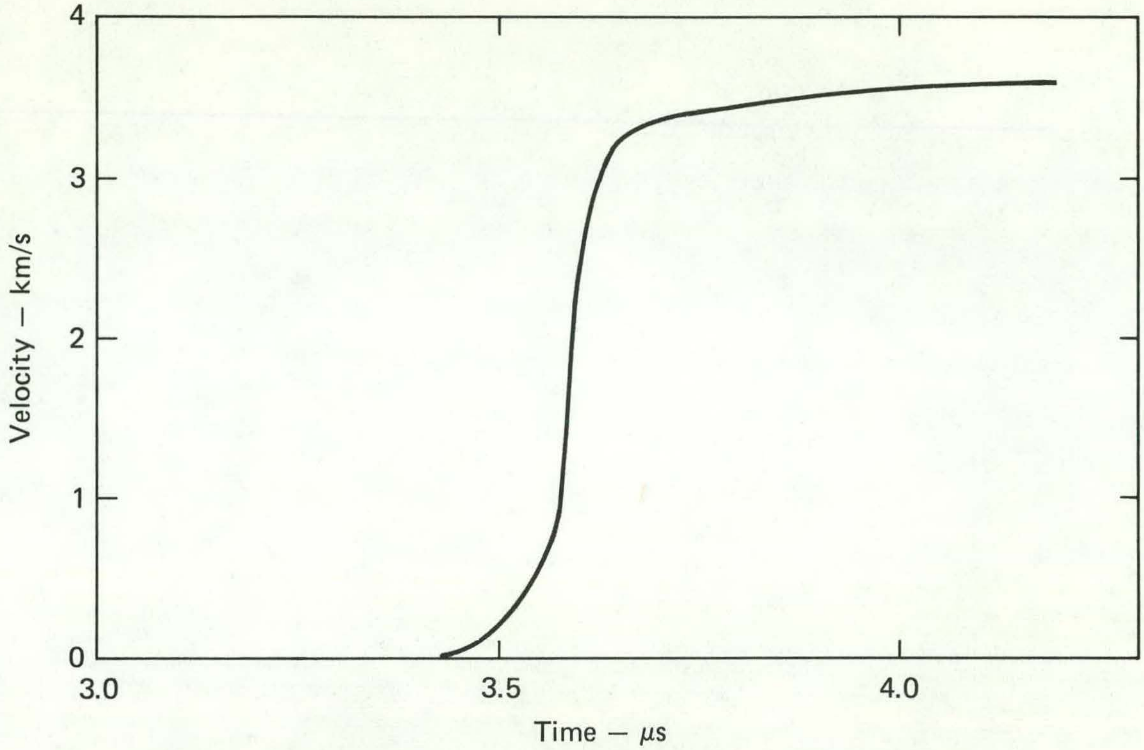


0.002-in. X 1.0-in. square aluminum bridge foil — 20 kV bank voltage
0.010-in. X 7/8-in. diam mylar flyer



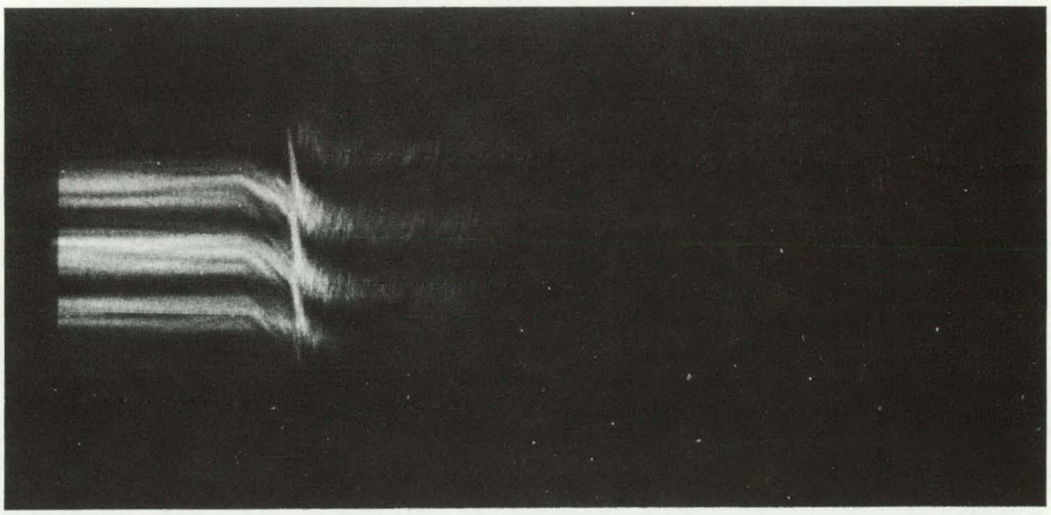
Sweep speed: 48.5 ns/mm — K = 0.400 km/s per fringe

Fig. 3. Streak record flyer velocity vs time.



0.002-in. X 1-in. square aluminum bridge foil
0.010-in. X 7/8-in. diam mylar flyer

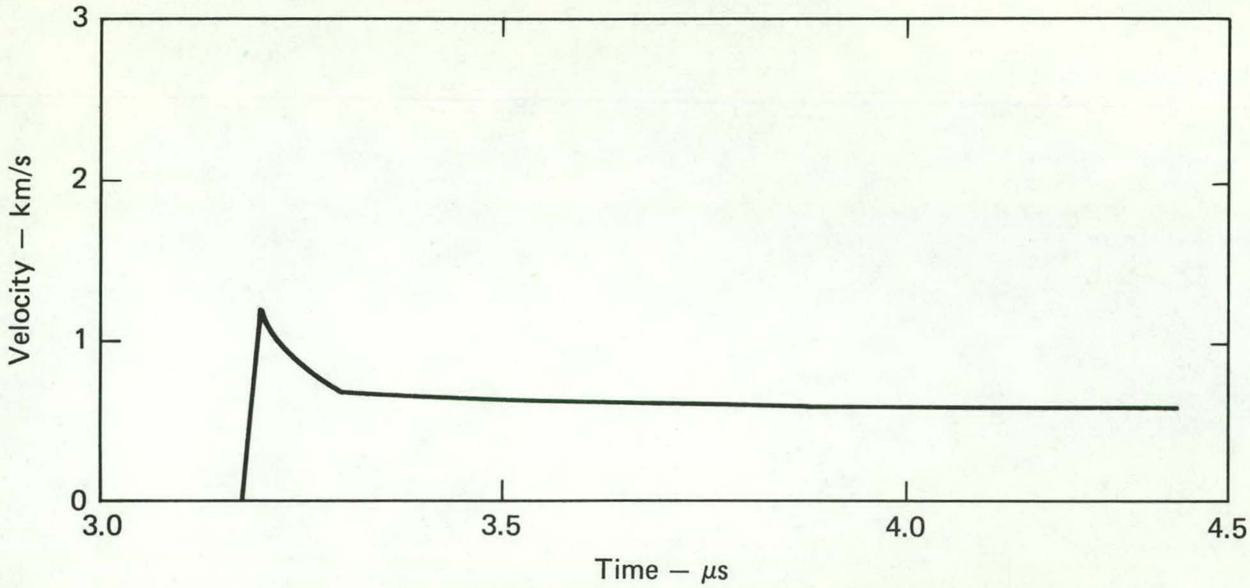
20 kV bank voltage



Sweep speed: 48.5 ns/mm

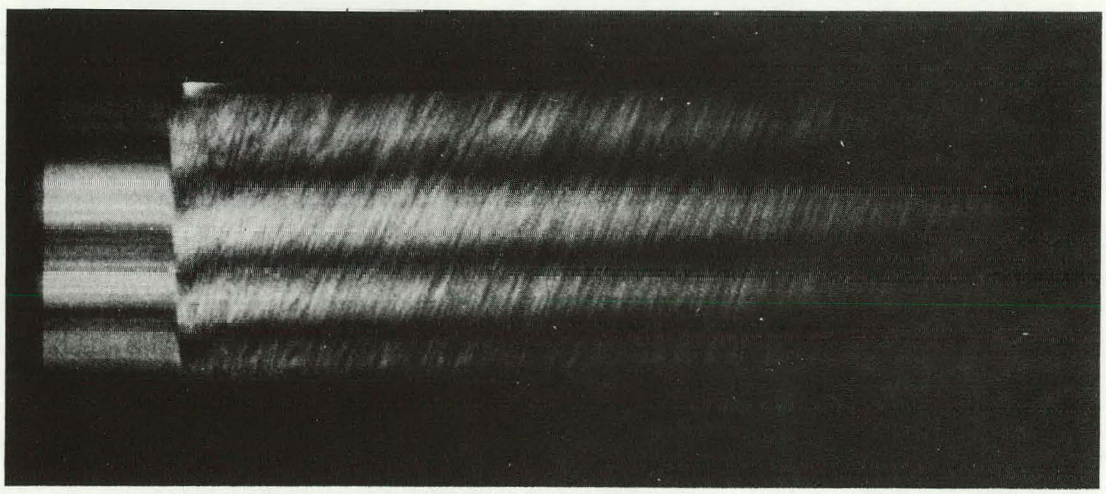
K = 2.269 km/s per fringe

Fig. 4. Streak record aluminum jump-off velocity vs time for a 0.001-in. aluminum target at 0.200 in.



0.002-in. X 0.375-in. square aluminum bridge foil
0.010-in. X 0.325-in. diam mylar flyer

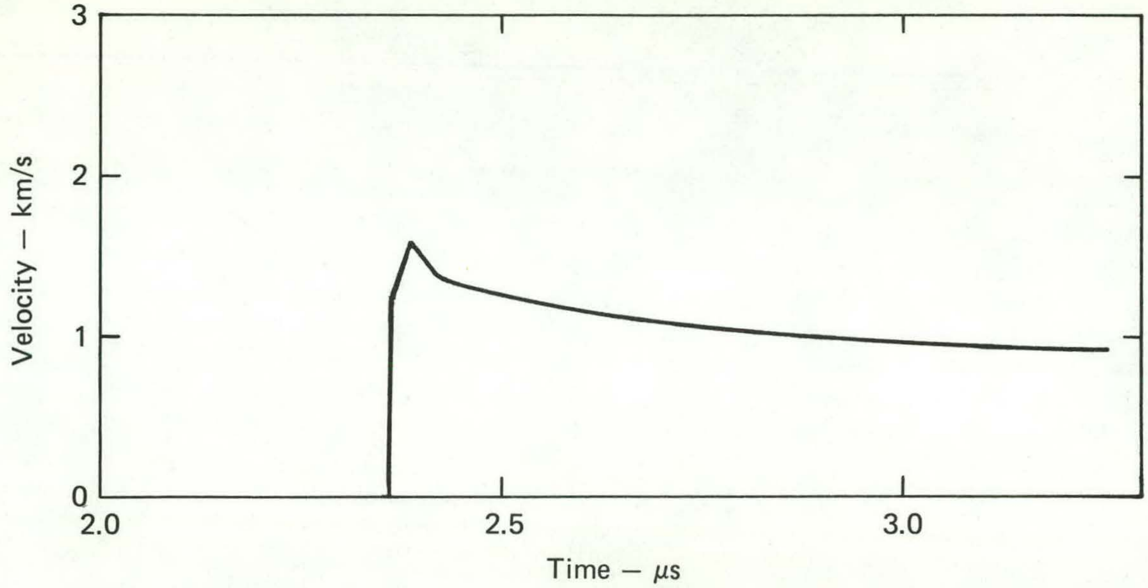
30 kV bank voltage



Sweep speed: 48.5 ns/mm

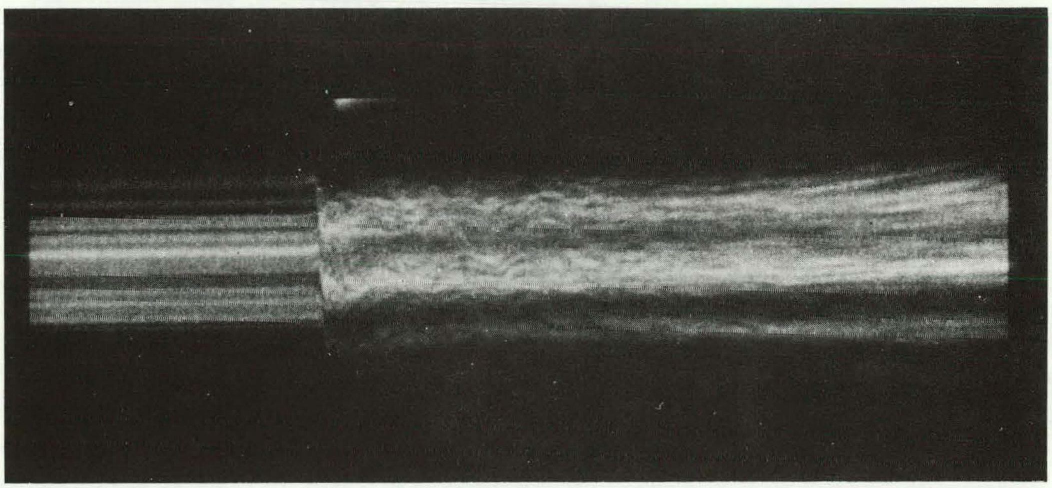
K = 2.269 km/s per fringe

Fig. 5. Streak record steel jump-off velocity vs time for a 0.110-in. stainless steel target at 0.300 in.



0.004-in. × 0.375-in. square aluminum bridge foil
0.010-in. × 0.325-in. diam mylar flyer

30 kV bank voltage



Sweep speed: 20 ns/mm

K = 2.269 km/s per fringe

Fig. 6. Streak record steel jump-off velocity vs time for a 0.112-in. stainless steel target at 0.125 in.

The electronic streaking camera is an advantageous method for recording interferometer fringe motion because

- Recording costs are low.
- It is simple to maintain and operate.
- It is portable.
- Data analysis is fast and straightforward.
- All data are on one photograph.
- Interferometer optics are simplified.

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