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Preliminary Fabry Perot Testing - 1986

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Contents

Abstract

Fabry Perot interferometry is a method of determining instantaneous velocities of an object in motion. The interferometer system is composed of the Fabry Perot interferometer, a laser, an electronic streak camera, and several focusing lenses. The first tests discussed were done on exploding bridgewire devices. During these tests, several system parameters were changed. These changes did not seem to affect the data, which appeared to be consistent. The second tests performed focused on slapper-type devices. It was determined that sandblasted, vapor-deposited aluminum on the slapper material would be required to yield quality data. Streak camera failure prevented much data from being collected. An effort is being made to replace the current streak camera. After it is replaced, a Fabry Perot and velocity interferometry system for any reflector comparison will be made. The results will be published as the conclusion to this report.

Introduction

The Fabry Perot test system made several testing advances during 1986. This report summarizes those advances. The first section reviews the necessary hardware involved in the Fabry Perot and the functions this hardware performs. The testing portion is split into two areas: (1) tests with exploding bridgewire (EBW) devices and (2) tests with slappers. The final section explores future testing as well as system upgrades.

Test System Hardware

Fabry Perot Principles

Fabry Perot interferometry is a method of determining instantaneous velocities of an object in motion. Typical ranges of velocities measurable with the Fabry Perot are 0.01-10 mm/μs. The Fabry Perot consists of two highly parallel mirrored surfaces which face each other. Light entering the mirrored cavity undergoes constructive and destructive interference as a result of reflections back and forth between the two surfaces. This interference creates alternating bright and dark rings in the shape of a bull's-eye fringe pattern. Changes in the phase of the light approaching the Fabry Perot result in a change in this pattern. Measuring these fringe patterns using the static fringes, dynamic fringes, and some mathematical conversion factors will yield a velocity/time correlation. The development Fabry Perot is a Burleigh, Model RC-Sys11. Cavity spacing is 0-150 mm, with an aperture of 50 mm.

System Setup

Mound's Development Fabry Perot interferometer system setup can be seen in Figure 1. The setup consists of a laser (tunable to 514.5 nm), the Fabry Perot interferometer, an electronic streak camera, and various focusing lenses. Velocity measurements are achieved in the following manner. The laser beam, adjusted to 514.5 nm by an etalon, is focused through a holed mirror and through a lens onto the test object. The test object reflects the

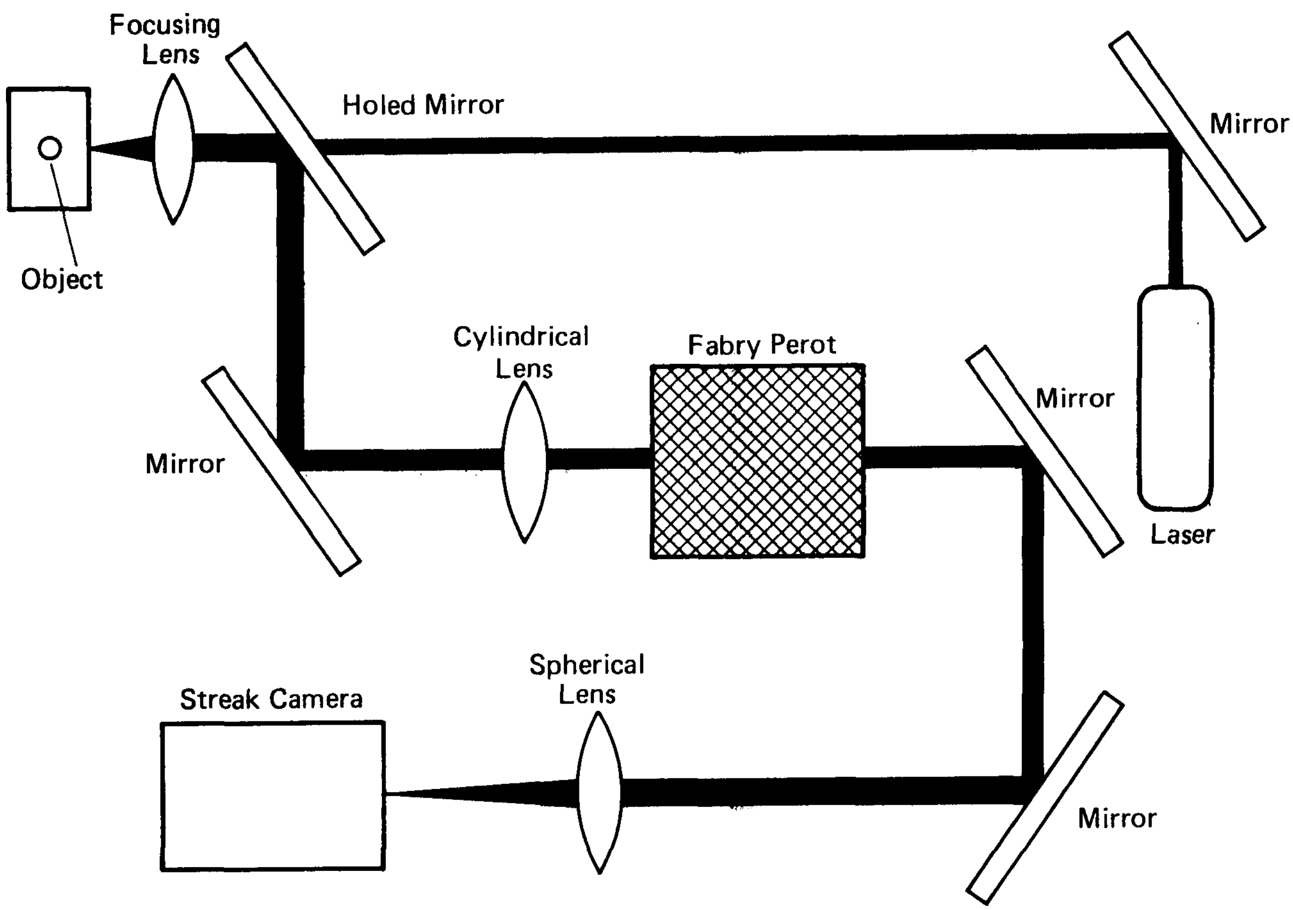


FIGURE 1 - Fabry interferometer system setup.

beam back through the lens and off the holed mirror. From this point the laser light travels through a cylindrical lens, which converges the light in the horizontal plane at some focal distance from the lens. The quasicolumnar laser light travels into the Fabry Perot. The fringe pattern is then focused down by a spherical lens onto the slit in the streak camera to create a time record of the fringes.

Fabry Perot Testing

Exploding Bridgewire Tests

In order to become more familiar with Fabry Perot testing techniques for gathering data, EBW devices with large flyers attached were used. They were chosen for four reasons. First, they are large enough to allow the beam to be easily focused on them. Second, the flyers do not travel faster than 10 mm/μs. Third, the detonators were abundant. Fourth, the flyers were easily made and offered a uniform diffuse surface. SE-1 detonators with copper flyers (20 mm x 5 mm) epoxied onto the detonator face were used in the first studies. However, fragmentation of the copper prevented velocity measurements beyond the initial jump out. Additional testing continued, with stainless steel flyers (5 mm round x 5 mm) replacing the copper flyers. Several shots were fired in this configuration with success. During these tests, the Fabry Perot mirror plates were varied along with the sweep durations on the streak camera to determine what effect this would have on the resulting data. Appendix A contains copies of the films from the actual streak records. Appendix B contains the velocity as a function of time profiles as well as the distance as a function of time profiles taken from these films.

Test 3.0 and shot 3.1 were tested on a streak record 10 μs in length (5 mm/μs). The mirror plates were 25 mm apart in shot 3.0, but were spread out to be 119.7 mm apart in shot 3.1. As the delays were determined through the fireset, camera, and explosive train, the sweep time was decreased in order to get the maximum resolution of the flyer acceleration. Shot 3.2 had a streak duration of 10 mm/μs and a mirror spacing of 50 mm. After gaining confidence from a success at this sweep rate, the sweep was raised to 25 mm/μs. The first shot at this rate was unsuccessful (see shot 3.3). This was because the camera trigger was delayed too long, which caused the streak camera to capture only the deceleration of the flyer. After adjusting the camera trigger delay time, shots 3.4 and 3.5 were produced. The sweep rate on these shots was again 25 mm/μs with mirror spacings of 50 mm. As can be seen in Apppendix A, the velocity profiles look similar in shape and amplitude. Each of the shots showed that the flyers accelerate quickly to reach a maximum velocity of approximately 0.45 mm/μs. Any increase in the velocity before that point may be caused by a shock wave traveling down the sleeving that holds the high explosive. After the velocity reaches its peak value, it begins to decelerate almost immediately. The flyer continues to decelerate gradually for several microseconds. In order to more fully characterize the rapid acceleration portion of the flyer movement, streak speeds in excess of 25 mm/μs will be needed.

Slapper Testing

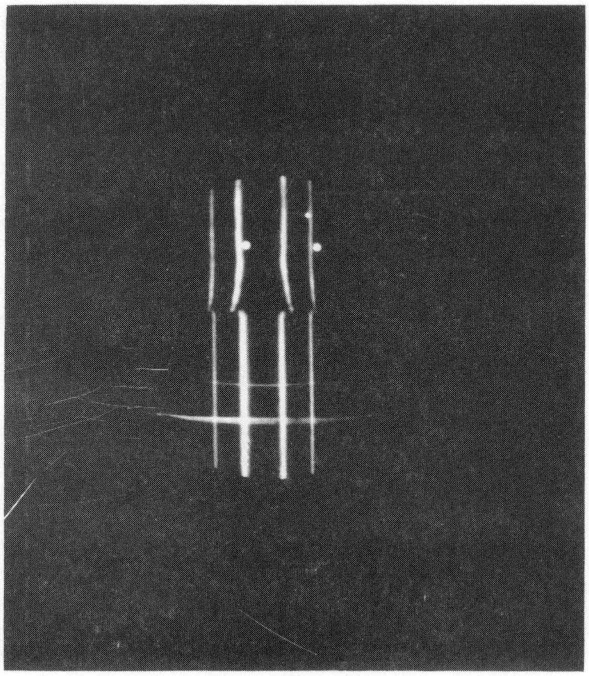
Obtaining velocity profiles of slapper detonators was a goal for 1986. Preliminary efforts involved trying to characterize velocity profiles of MAD devices with a 40-mil barrel. No data were obtained from the initial tests. (See the figure in Appendix A with no aluminum covering.) This was a result of bridge light interference, in the same spectral range as the laser light, covering the data. In an effort to correct this problem, the slapper was slightly modified by depositing 100 Å of aluminum on the slapper material. This created a highly mirrored surface on the slapper. Shots fired using this method yielded data, and an example can be seen in Appendix A. However, as the slapper began to move, intensity appeared to decay rapidly until the data could no longer be read. Actually, the flyer was observed only halfway down the barrel. This problem was a result of the angle of reflection off the slapper surface changing during dynamic conditions. The solution for this was to cause the surface to become more diffuse. Sandblasting slappers had been done on the velocity interferometry system for any reflector (VISAR) with success. Several parts were sandblasted in preparation for development testing. At this point recurring problems with the streak camera halted the testing. A velocity profile of the one successful nonsandblasted slapper shot can be seen in shot 1 in Appendix B. This profile indicates that the slapper was still accelerating at the time the intensity of the light on the film became unreadable. VISAR tests showed a terminal velocity of 4 mm/μs in 350 ns for this device.

Future Fabry Perot Objectives

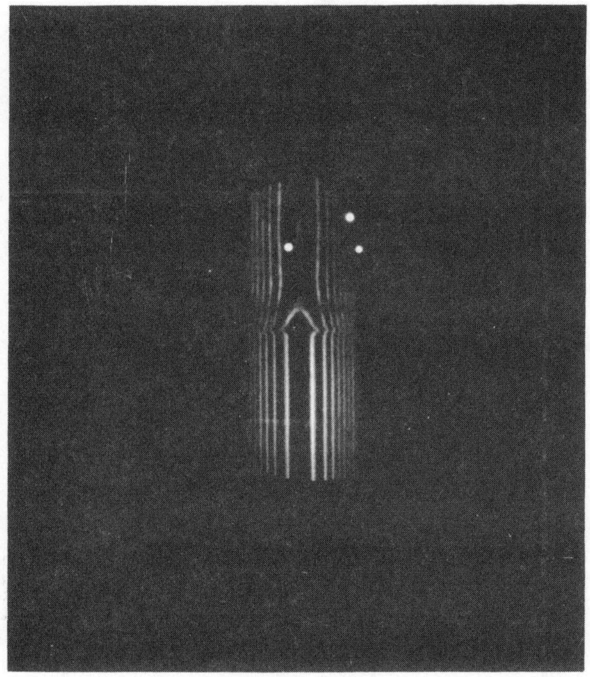
To increase measurement accuracy and automate the Fabry Perot test system, an effort is being made to replace the existing streak camera. Advances in the electronic streak camera industry find several companies offering fast streak cameras with electronic readout systems. The advantage these systems have is the ability to read in the streak camera data using digital arrays, then transfer the data to a host computer for analysis, effectively giving immediate results of the test conducted. With this change, Fabry Perot testing could be used as an effective tool in a development or a production environment. Also being added to the Fabry Perot system is a calibrated optical fiducial generator. Any nonlinearities in time measurements on the streak camera will be compensated for by this equipment. One future test objective is to complete Fabry Perot and VISAR tests and compare the data. If the resulting data prove that both methods produce similar data, the Fabry Perot system will be utililized to a much greater degree.

Appendix A

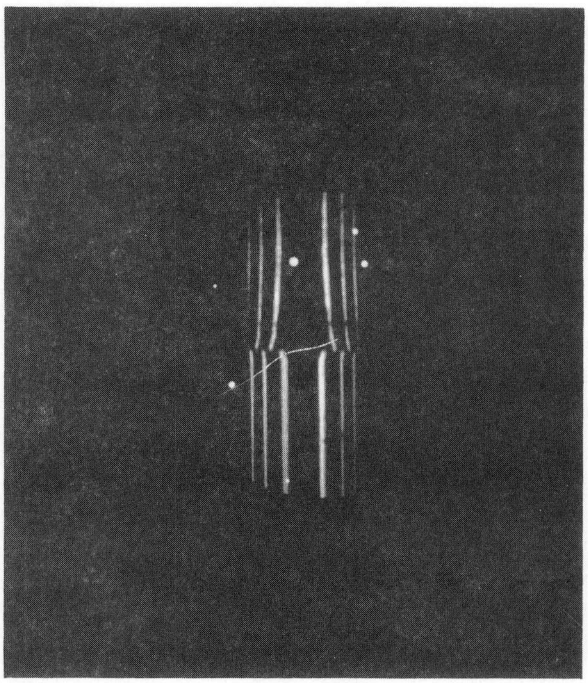
Velocity Profiles



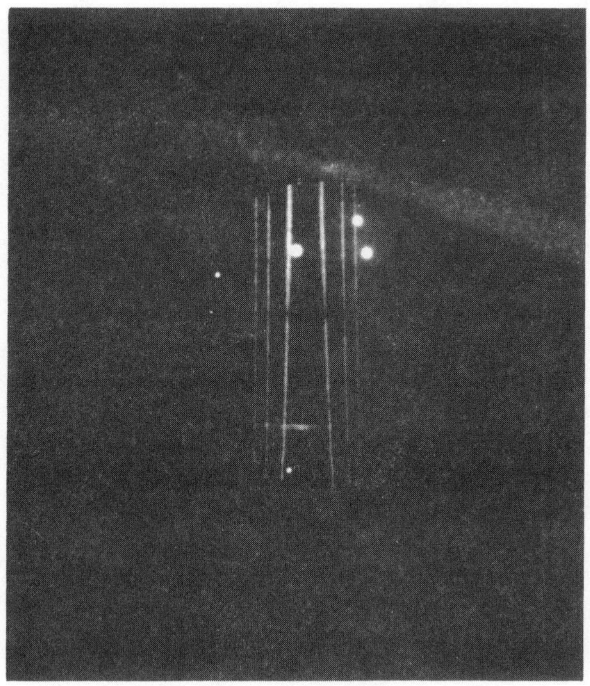
Shot 3.0



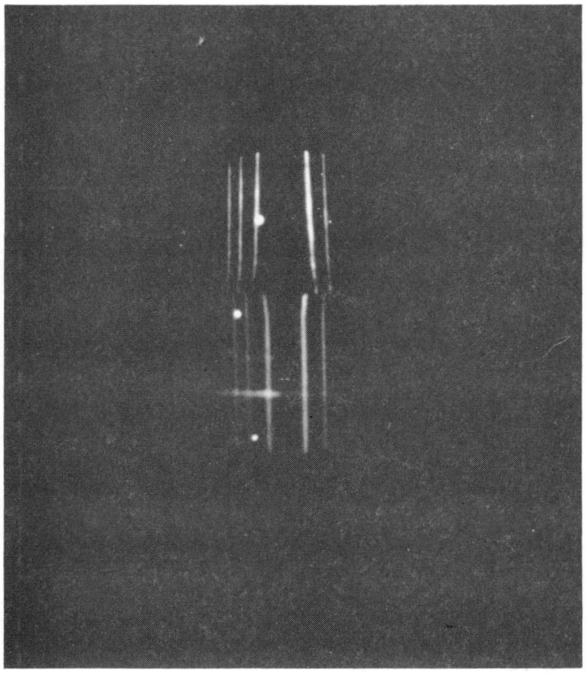
Shot 3.1



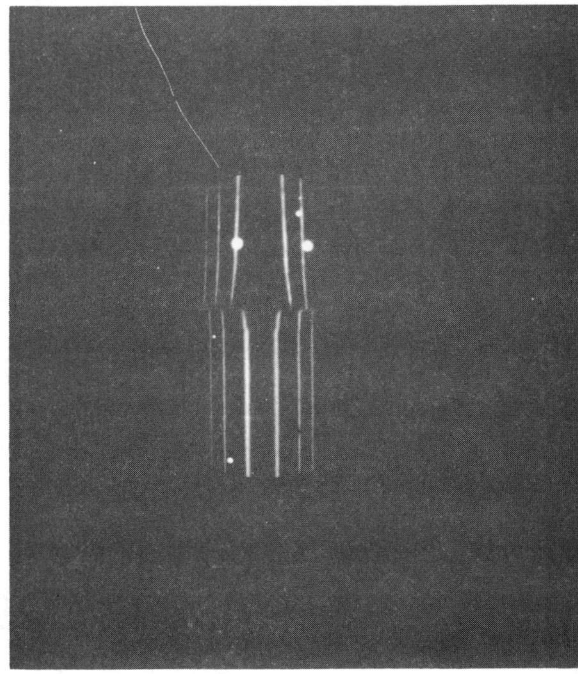
Shot 3.2



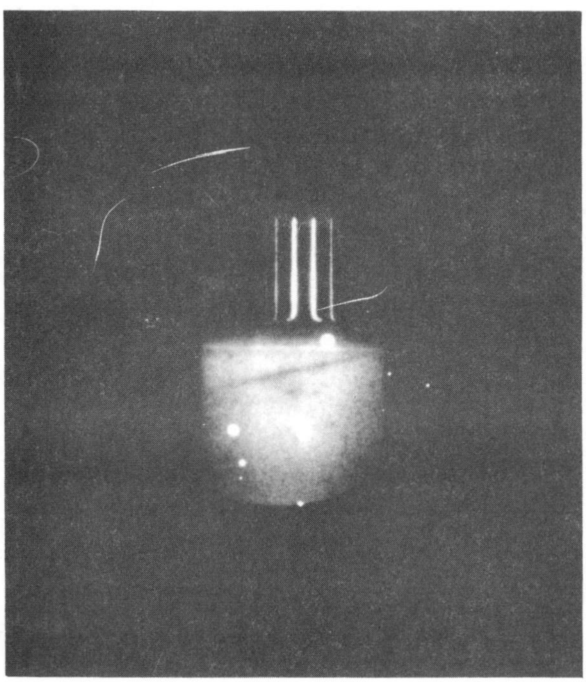
Shot 3.3



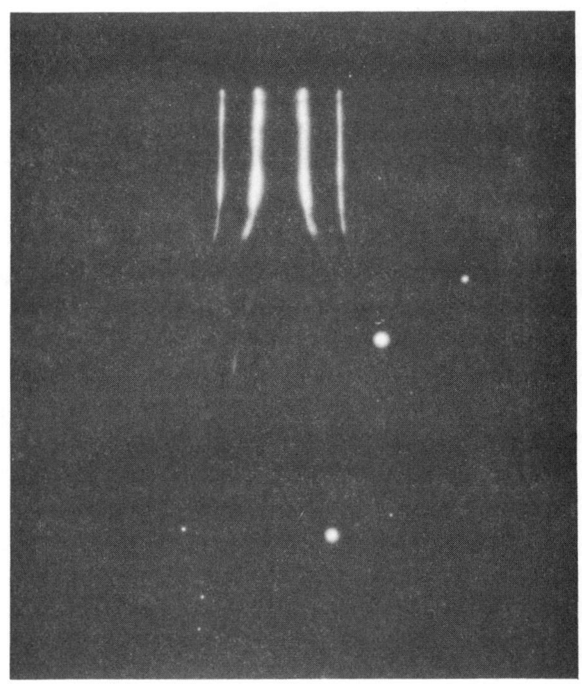
Shot 3.4



Shot 3.5

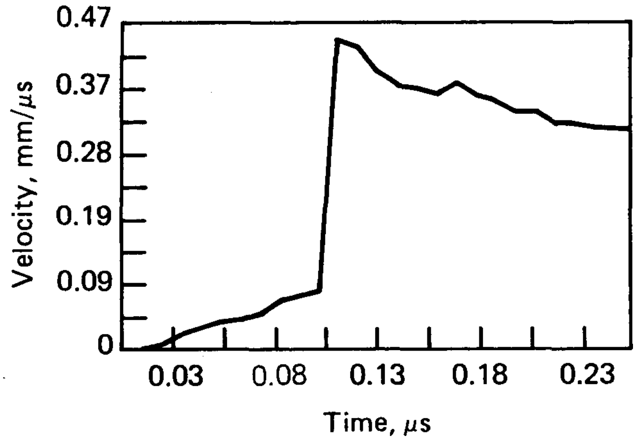


No aluminum coating



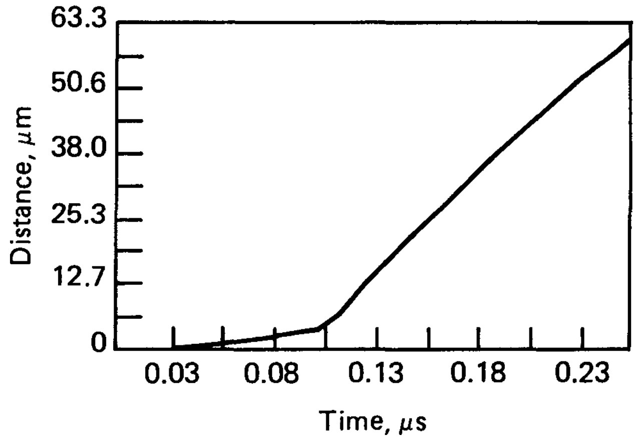
Aluminum coating

Appendix B
Velocity as a Function of Time and Distance as a Function of Time Profiles



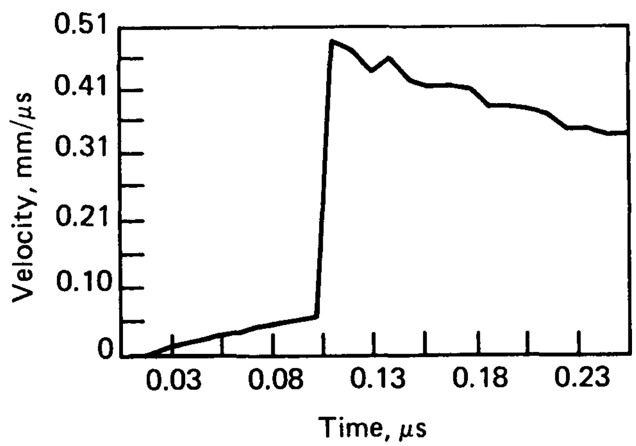
Shot No. 3.0

Innermost static fringe distance = 4.428 mm
Second static fringe distance = 12.365 mm
Fabry Perot mirror spacing = 25 mm



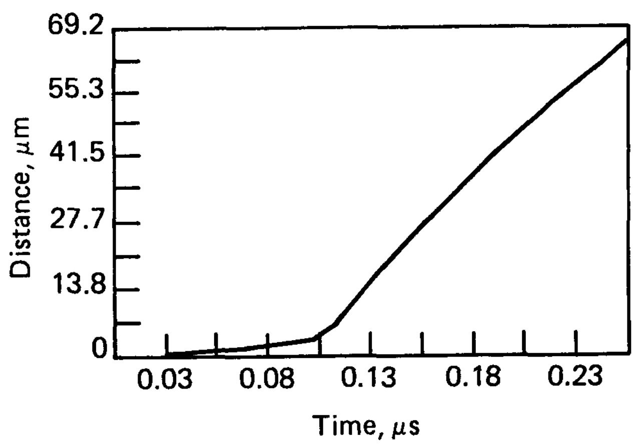
Shot No. 3.0

Innermost static fringe distance = 4.428 mm
Second static fringe distance = 12.365 mm
Fabry Perot mirror spacing = 25 mm



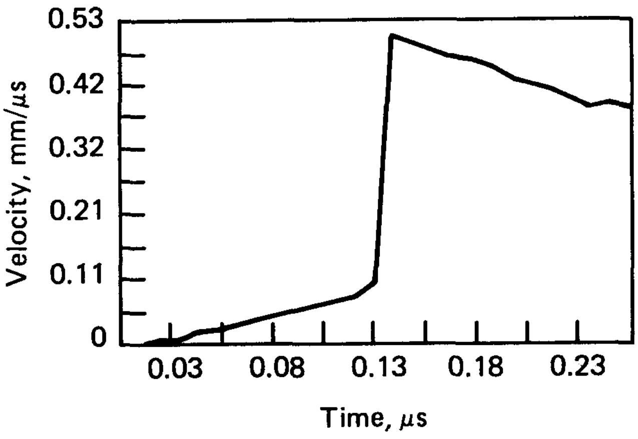
Shot No. 3.1

Innermost static fringe distance = 2.935 mm
Second static fringe distance = 6.272 mm
Fabry Perot mirror spacing = 119.7 mm



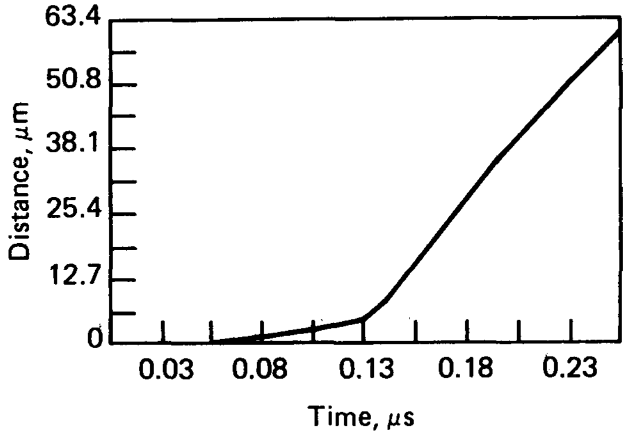
Shot No. 3.1

Innermost static fringe distance = 2.935 mm
Second static fringe distance = 6.272 mm
Fabry Perot mirror spacing = 119.7 mm



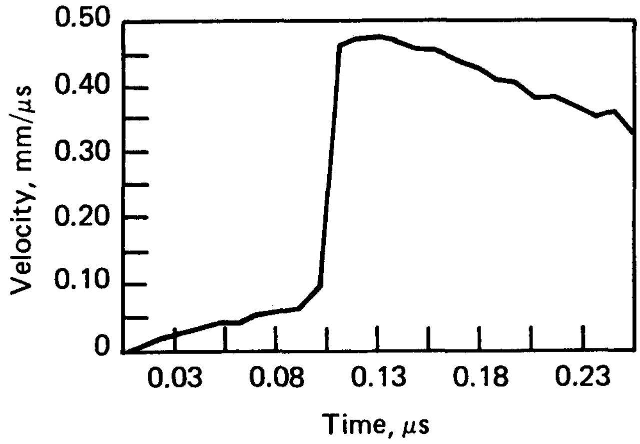
Shot No. 3.2

Innermost static fringe distance = 4.009 mm
Second static fringe distance = 9.553 mm
Fabry Perot mirror spacing = 50 mm



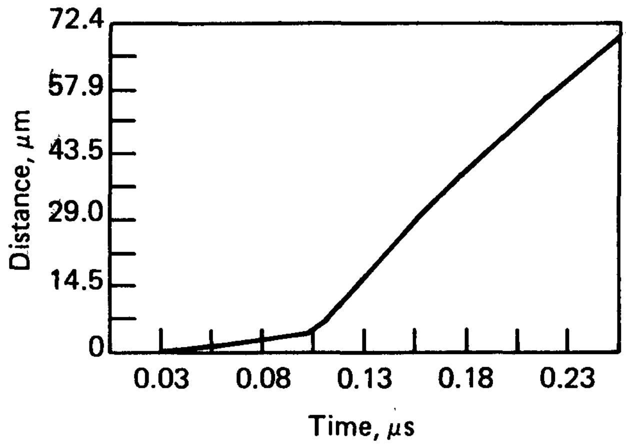
Shot No. 3.2

Innermost static fringe distance = 4.009 mm
Second static fringe distance = 9.553 mm
Fabry Perot mirror spacing = 50 mm



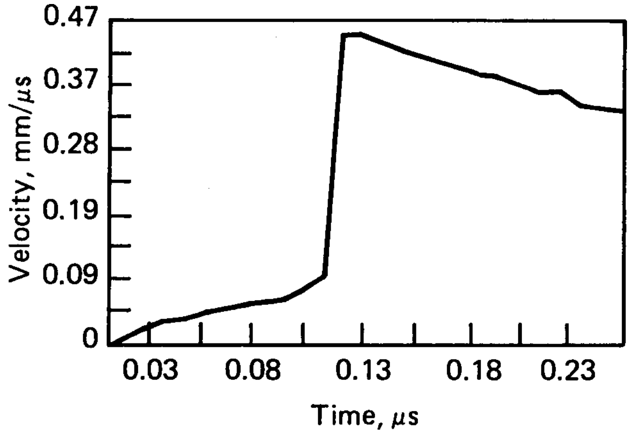
Shot No. 3.4

Innermost static fringe distance = 4.08 mm
Second static fringe distance = 9.53 mm
Fabry Perot mirror spacing = 50 mm



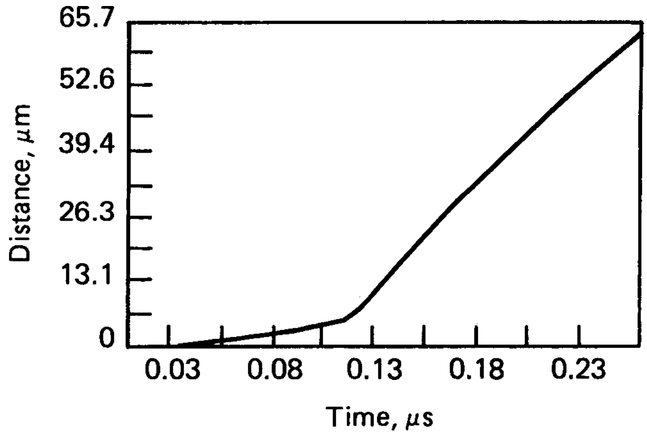
Shot No. 3.4

Innermost static fringe distance = 4.08 mm
Second static fringe distance = 9.53 mm
Fabry Perot mirror spacing = 50 mm



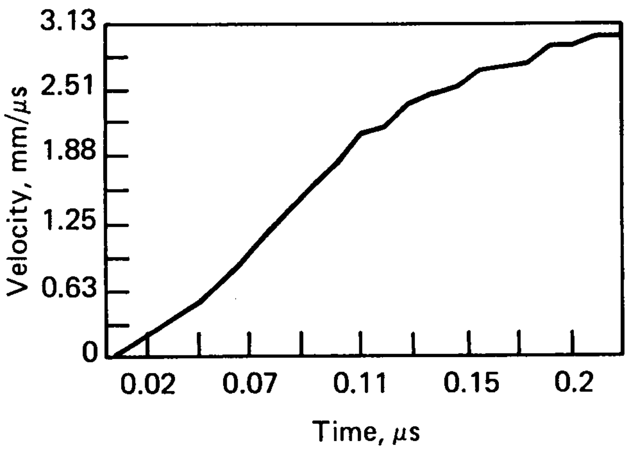
Shot No. 3.5

Innermost static fringe distance = 3.308 mm
Second static fringe distance = 9.522 mm
Fabry Perot mirror spacing = 50 mm



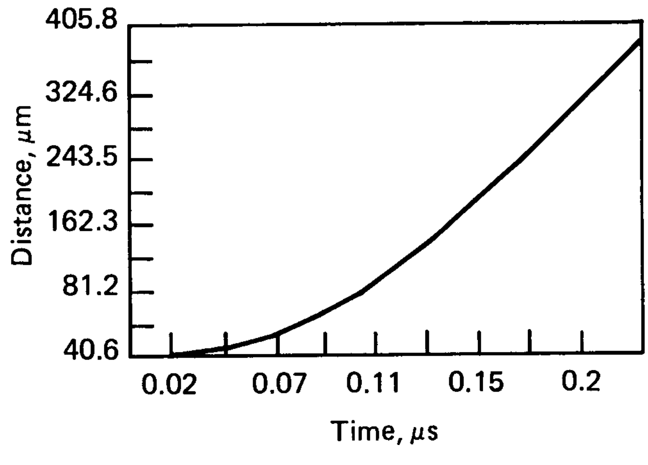
Shot No. 3.5

Innermost static fringe distance = 3.308 mm
Second static fringe distance = 9.522 mm
Fabry Perot mirror spacing = 50 mm



Shot No. 1

Innermost static fringe distance = 2.904 mm
Second static fringe distance = 7.412 mm
Fabry Perot mirror spacing = 20.3 mm



Shot No. 1

Innermost static fringe distance = 2.904 mm
Second static fringe distance = 7.412 mm
Fabry Perot mirror spacing = 20.3 mm

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