ELASTIC BALLISTICS

M.I.T. 'STROBE LAB' FINAL PROJECT REPORT

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Purpose

The purpose of this project was to investigate the characteristics of two elastic (rubber band) firing pistols through the use of high speed photographic techniques, and hopefully to make improvements on the design to increase the accuracy of the pistols.

Equipment

Most of the project revolved around the use of an Edgerton high-speed camera (GR type 651-AG) combined with an EG&G type 501 high-speed stroboscope controlled by a GR 1309A oscillator. This system was used to take high-speed movies of the elastic pistols' mechanism in operation, and of the elastic in flight just after leaving the muzzle of the pistol. This system was chosen because it could easily cover the speed ranges required, and the operation of the system was relatively simple and reliable. The film used in this camera was Eastman type 5375 fine grain sound recording movie film, primarily because it was available. Development was done with Dektol 1:1 to "push" the speed of the film (AS A 10) up a bit. The film is orthochromatic, and the developing was done "in a bucket" under safelight until the image appeared acceptable (usually about five minutes).

The remainder of the photographs were taken on Tri-X with a Yashica 35mm camera. Velocity measurements were done using a pair of EG&G type 553 multi-flash strobe units, and some stills were taken of the pistols in their final form.

The pistols were hand made; one small one of wood, the Mark 1, and a larger one with an aluminum barrel and trigger assembly, the Mark 2 (see photos 1 and 2 in appendix). The trigger mechanism in both pistols is the same. The actual release is a semicircular piece, ordinarily held upright against the tension of the elastic by a small "catch bar" which rested on the trigger (see Fig. 1). the nose of the Mark 1 was a simple ramp (see Fig. 2), while the nose of the Mark 2 was an elastic activated retracting post designed to drop before the back end of the elastic could run in to it (see Fig. 3).

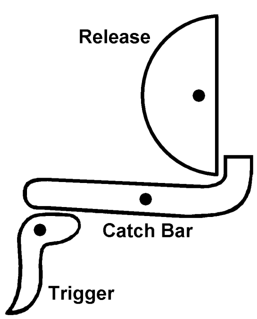


Fig. 1

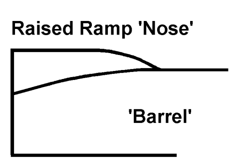


Fig. 2

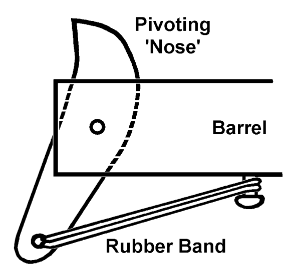


Fig. 3

The elastics used were Plymouth Rubber Company Pure Rubber Bands; type 62 which are about 2 3/8 in. long (unstretched), and type 64 which are about 3 1/2 in. long. Both types are 1/32 by 1/4 in. in cross section. For some experiments, "ballistic" elastics were made by wrapping a folded 1 in. piece of Mystik type 7431 lead tape around a regular elastic.

The Experiments

The first series of experiments were done to gain some basic understanding of the contortions an elastic goes through in the process of being fired. High-speed movies were taken of the release mechanism of the Mark 1 pistol at 100, 500, and 1,000 frames per second, and then of the nose of both the Mark 1 and the Mark 2 at 1,000 frames per second.

After briefly examining the results of these runs, the nose of the Mark 1 was modified by cutting the ramp down flush with the top of the barrel, and the Mark 2 was modified in a similar fashion. Three more movies were then made at 1,000 frames per second of the effects of these changes, and variations in the loading technique.

In order to get some idea of the velocities involved, and how the velocity falls off with time, the 553 multi-flash units were used with the Yashica. The strobes were set up at a fairly shallow angle with respect to the path of the elastic, and the camera was placed about eight feet back from the subject to give a reasonable flight length. Four different types of elastics were fired from each pistol; a regular type 62 and 64, and a “ballistic” type 62 and 64.

Two experiments of a non-photographic nature were also done. A simple accuracy test of the final version of the Mark 2 was done at a distance of ten feet. Using a dusty chalkboard as a target, group sizes were measured for both a regular and a "ballistic" elastic. Also, some measurements were made of the force produced by the elastics at the draw lengths of the two different pistols to determine the uniformity of the elastics under firing conditions.

Results and Conclusions

The Pistols: When the pistols were originally built, their performance was rather disappointing. Both pistols fired considerably higher than where they were pointed, and the Mark 2 with its retracting post was considerably worse than the Mark 1. The first series of high-speed movies were taken to determine exactly why they behaved in this manner.

The first question that needed to be answered was whether or not the tilting forward action of the release piece was contributing significantly to the elevation problem or not. The movies taken of the Mark 1 release at 500 and 1,000 flashes per second (see prints 3 and 4 in Appendix) show that instead of producing a lifting effect on the elastic directly, what little lifting there is appears to be the result of the elastic just in front of the release being bent down onto the top of the barrel (print 3), and then rebounding off of the barrel (print 4). Although this effect is not severe, it probably contributes a significant amount to the elevation inaccuracy problem.

The next place to look for trouble was the operation of the noses of the two pistols. Movies of both the Mark 1 and the Mark 2 were taken at 1,000 frames per second (see prints 5 and 6 in appendix). The photo of the Mark 1 (print 5) shows the back end of the elastic elevated slightly (presumably from the release bounce effect), and then the entire elastic appears to lift off of the front of the gun before tangling up, without even touching the front ramp. This would seem to indicate that the biggest effect is the elevation error is from the release bounce, at least as far as the Mark 1 was concerned. The photo of the Mark 2 nose with the retracting post (print 6) gives a rather clear indication of what the problem with the Mark 2 was. The retracting post only barely begins to move by the time the elastic has cleared the pistol, probably due to its inertia.

After these movies had been examined, it was obvious that the retracting post would have to go, but the problem then was what to replace it with. The Mark 1 nose would have been an improvement, but modifying the release to eliminate the bounce problem would be even better. It was decided to attempt to raise the point of aim of the Mark 1 (lower the impact point) by cutting the front post down flush with the surface of the top of the barrels. This seemed to help, so the Mark 2 was also modified in this fashion. The next step will be to redesign the release, but time constraints prevented it from being done for this project.

The Elastics: The biggest difficulty in constructing an accurate elastic pistol of any sort is the basic inaccuracies of the average elastic. Elastics do not follow a linear force relationship for anything but very short displacements. This means that any actual variations in the elastic get worse the farther they are stretched. Spreads of up to three pounds of tension out of a maximum of eight pounds tension were measured for several type 62 elastics stretched 13 5/8 in. (the draw length of the Mark 2) compared with a spread of one pound out of four for a type 62 at 8 1/4 in. (the draw length for the Mark 1).

Another source of variations, and therefore inaccuracies, is the way the elastic is loaded onto the pistol. Almost anyone that has ever used one knows that if the elastic is loaded with uneven tension in the two sides, it will tend to shoot sideways in one direction or the other. One simple method of reducing this error is to mark the elastics before they are stretched so that the length of elastic on either side is equal. Another variable is the orientation of the elastic as it is loaded. When an elastic is fired, it wants to collapse to its original form, which is usually a long oval. If the elastic is loaded “sideways", it will want to fly "sideways".

High-speed movies were made of the Mark 2 Mod 1 (with the new nose) with both sideways and lengthwise loaded elastics at 1,000 frames per second (see prints 7 and 8 in Appendix). The sideways loaded shot (print 7) shows the elastic attempting to regain its normal shape even while still on the gun. A close look at the picture shows where the end of the elastic starts to fold up before anything else. The lengthwise loaded elastic (print,8) merely accordions up before leaving the pistol. Although it is difficult to tell, it seems likely that the sideways loading technique results in more drag, and should probably be avoided.

The velocity of an elastic as it leaves the pistol is primarily a function of the individual elastic, and the draw of the pistol. However, their ability to maintain that velocity is largely a matter of drag, and their initial momentum. Elastics are relatively light, and therefore have a low momentum and loose their velocity quickly. By building a "ballistic" elastic out of a regular elastic and some lead tape, it seemed reasonable that as long as the tape was not so massive as to appreciably slow the elastic down, that its velocity characteristics would be improved. The increased mass would also be less likely to be affected by variations in elastics and loading as far as accuracy is concerned. Multi-flash photos were taken of both pistols firing different types of elastics (both regular and ballistic) using the EG&G 553 strobe units at 120 flashes per second (see prints 9 through 12 in Appendix). Prints 9 and 10 show a comparison between the Mark 1 and the Mark 2 with a type 64 elastic (note the open loop flight of the Mark 1 shot). Print 11 and 12 show a comparison of the Mark 2 firing a regular and a ballistic elastic. A graph of the velocities measured from the photos for several different elastics is also in the Appendix. It clearly shows the improvement made by the use of the lead tape, as well as several other general characteristics. The velocity starts out relatively constant, but very quickly starts a steady decay. The actual rate of this decay appears to be proportional to the starting velocity, although the data is hardly sufficient to make any less general statements.

The end result of this project, aside from a large amount of useful background information for further studies, was a relatively accurate elastic pistol. Group dimensions for 10 shot strings fired at ten feet were as follows:

Elastic	Max. Spread (WxH)
62	9″ x 9″
64	7″ x 6″
62 ballistic	2″ x 2″
64 ballistic	2″ x 2″

Acknowledgements

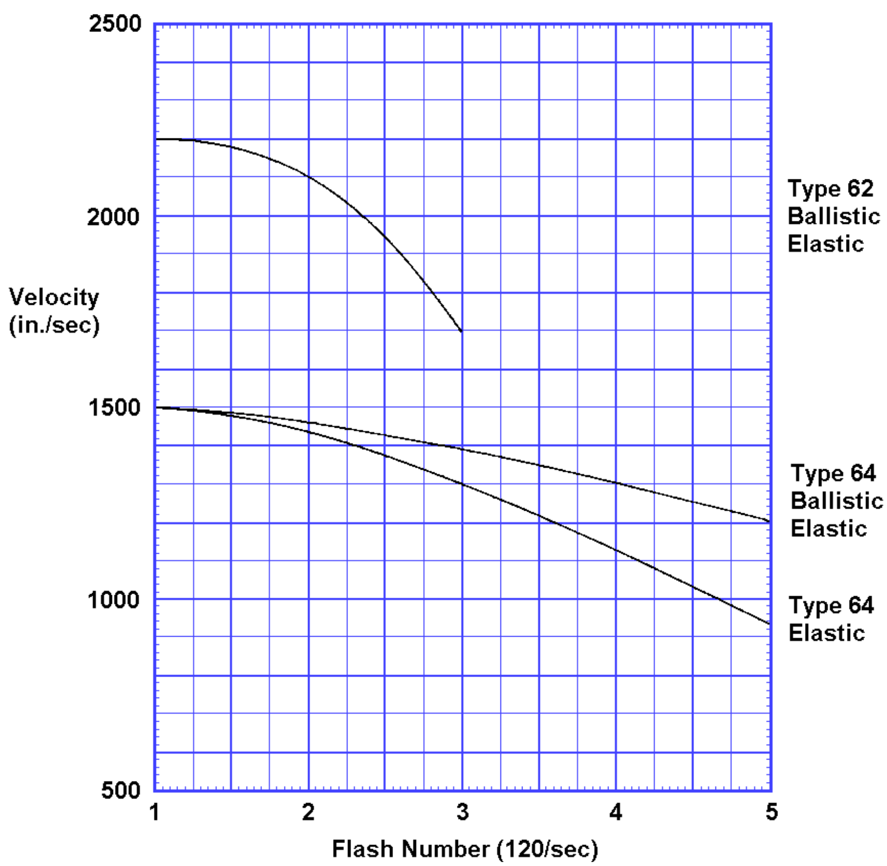
My thanks to Charlie Miller and Dave Breuer for their technical assistance and for not laughing too hard when I came up with this idea, and special thanks to Shannon Hill for the help he gave with everything.

Appendix

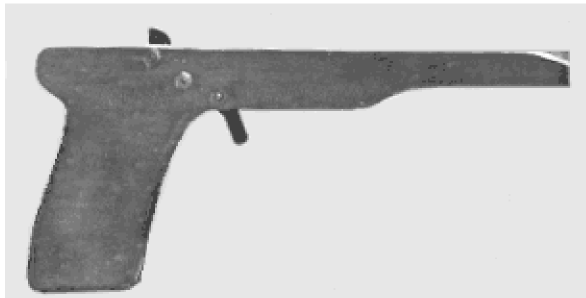
Photographic Data:

Print 1; f/2.8, 1/30 sec., Tri-X film
Print 2; same as 1
Print 3; f/2.5, 501 strobe, Eastman 5375 film
Prints 4 through 8, same as 3
Prints 9 through 12, f/15, 553 strobe, Tri-X film

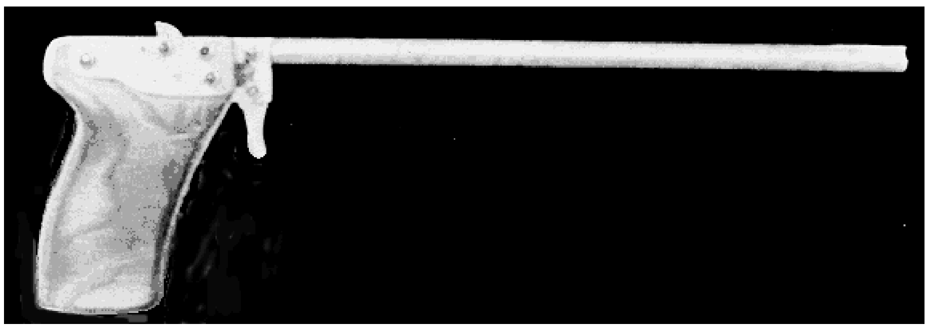
Approximate Velocity Curves for Mark 2



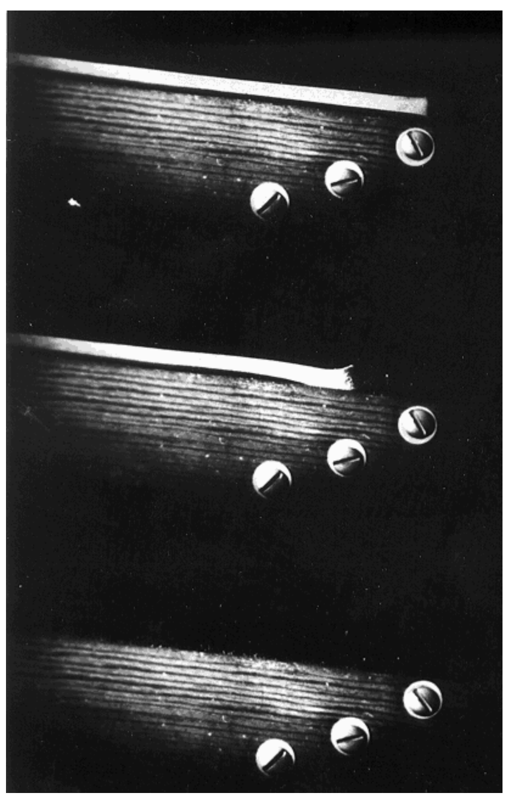
Print 1: Mark 1 Pistol



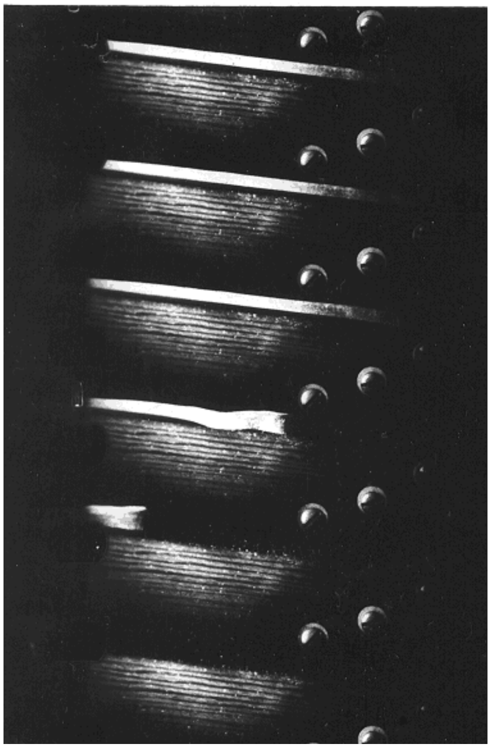
Print 2: Mark 2 Pistol



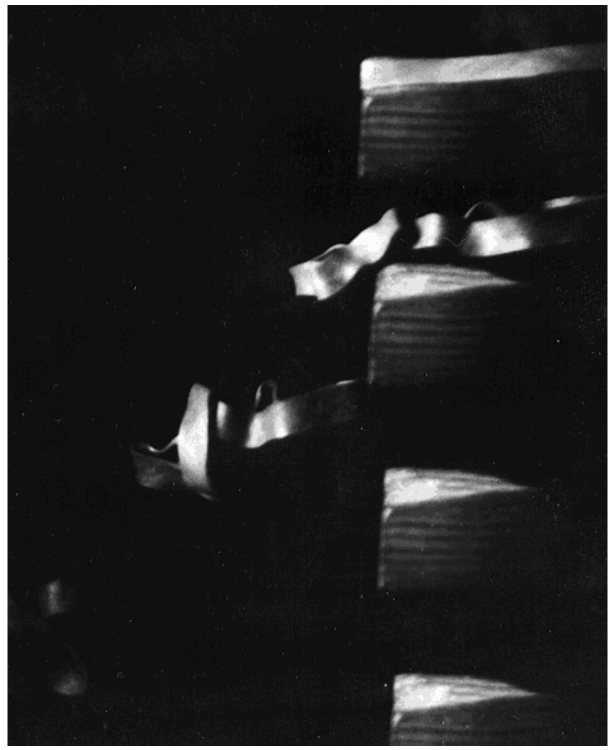
Print 3: Release of Mark 1, 500 Flashes per Second



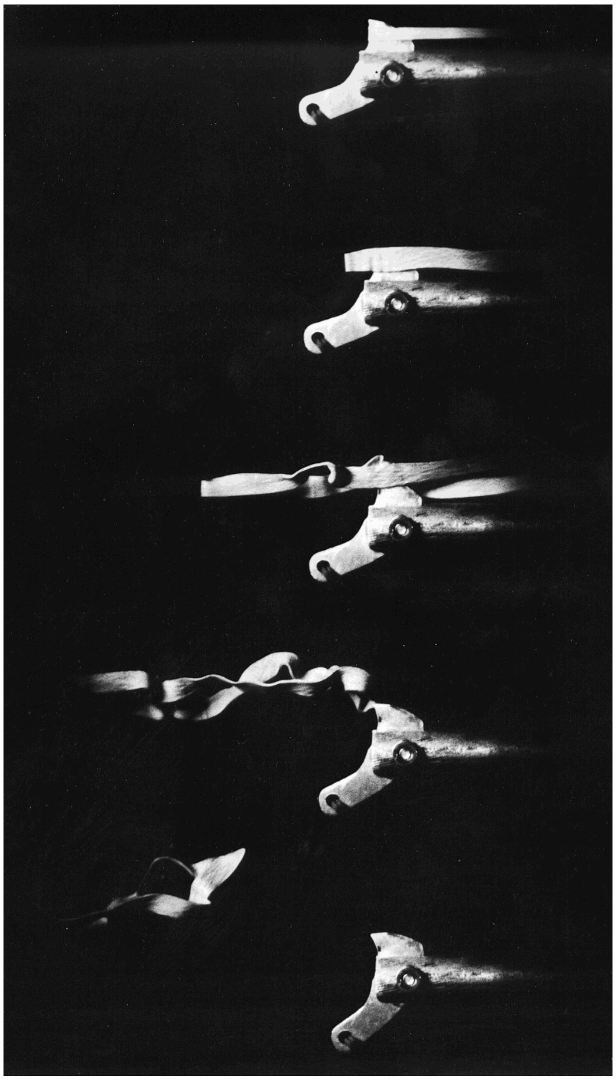
Print 4: Release of Mark 1
1000 Flashes per Second



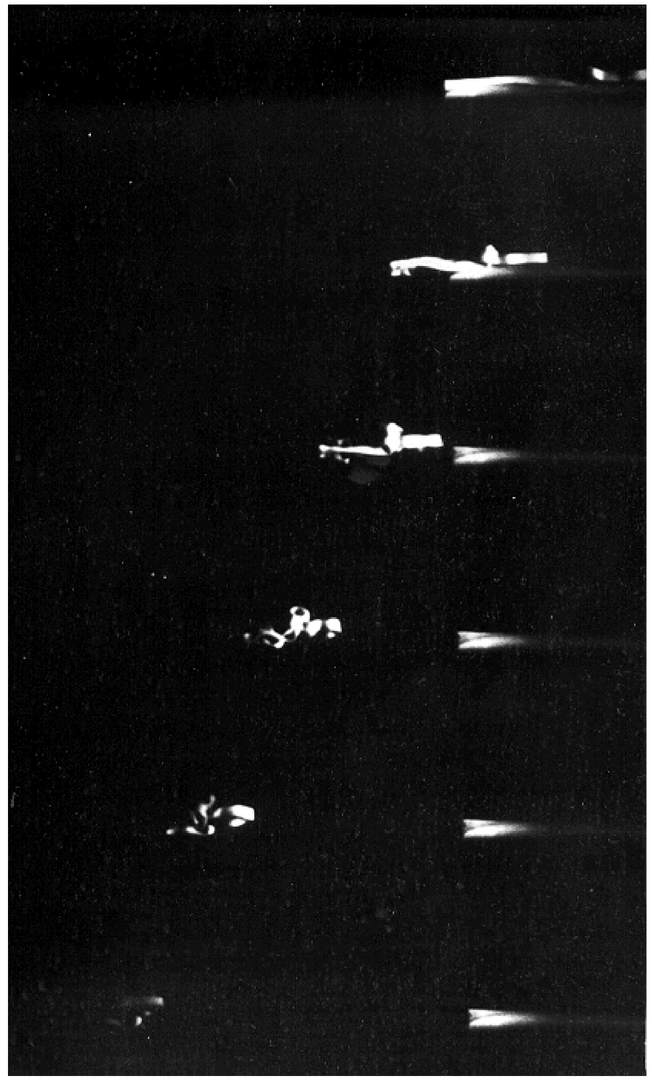
Print 5: Nose of Mark 1 Pistol
1000 Flashes per Second



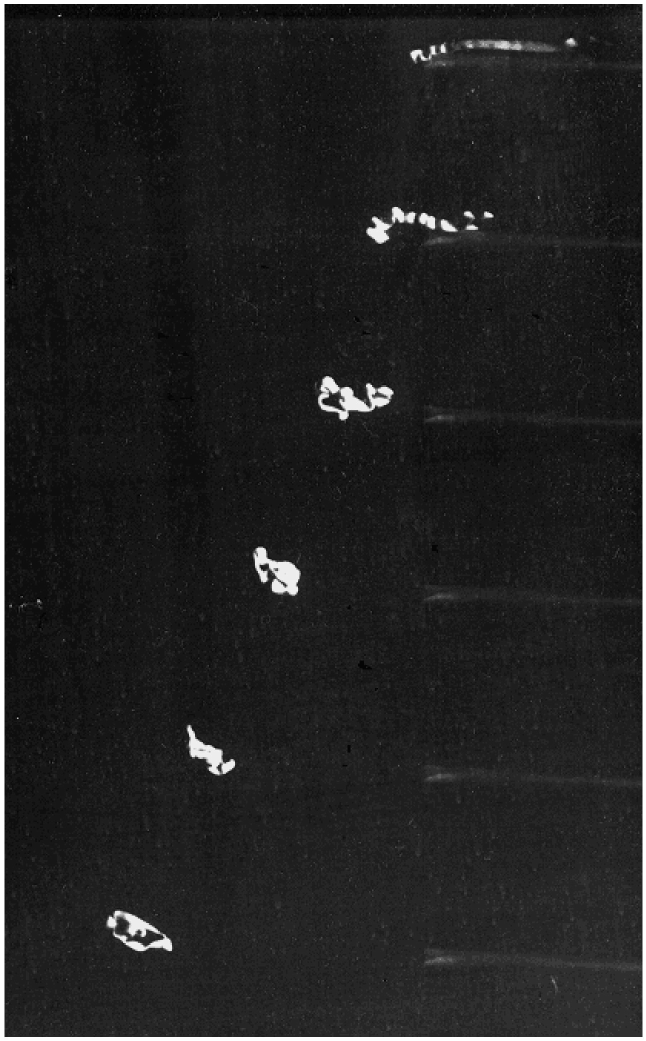
Print 6: Nose of Mark 2
1000 Flashes per Second



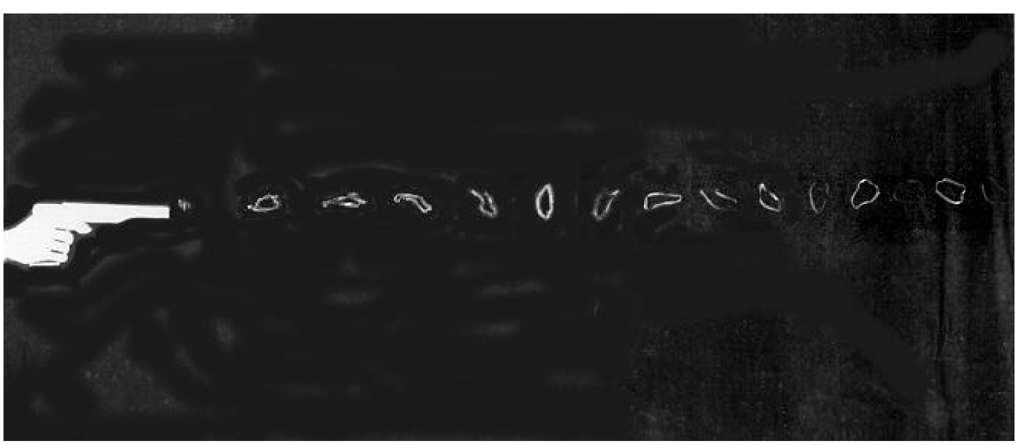
Print 7: Sideways Loaded Elastic
1000 Flashes per Second



Print 8: Lengthwise Loaded Elastic, 1000 Flashes per Second



Print 9: Mark 1 With Type 64 Elastic, 120 F.P.S.



Print 10: Mark 2 With Type 64 Elastic, 120 F.P.S.

Print 11: Mark 1 With Type 62 Elastic, 120 F.P.S.

Print 12: Mark 2 With Type 62 Elastic, 120 F.P.S.