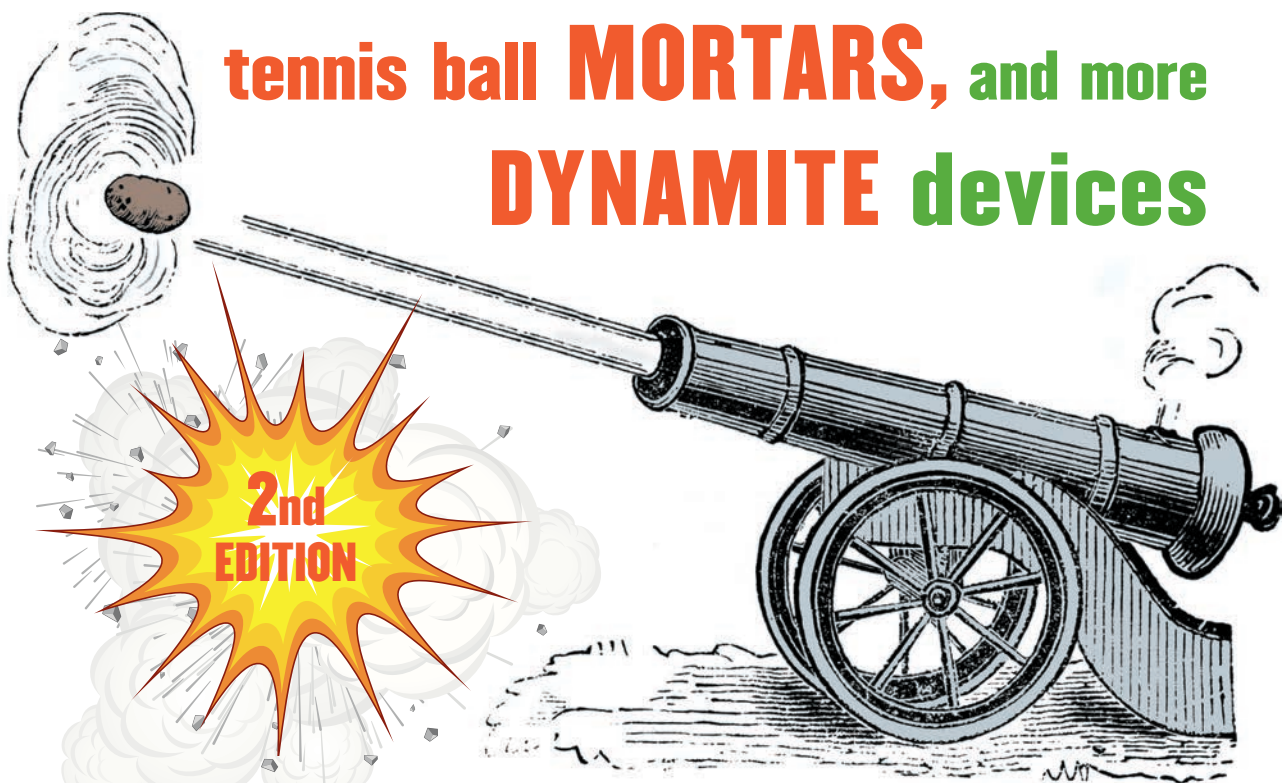


EXPANDED and **EVEN MORE** **EXPLOSIVE**

BUILD potato **CANNONS**, paper match
ROCKETS, Cincinnati **FIRE KITES**,
tennis ball **MORTARS**, and more
DYNAMITE devices



BACKYARD BALLISTICS

WILLIAM GURSTELLE



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This book is dedicated to my father,
Harold H. Gurstelle,
and my brother,
Steven M. Gurstelle

At other times, but especially when my uncle Toby was so unfortunate as to say a syllable about cannons, bombs, or petards—my father would exhaust all the stores of his eloquence (which indeed were very great) in a panegyric upon the Battering-Rams of the ancients—the Vinea which Alexander made use of at the siege of Troy.

He would tell my uncle Toby of the Catapultae of the Syrians, which threw such monstrous stones so many hundred feet, and shook the strongest bulwarks from their very foundation—he would go on and describe the wonderful mechanism of the Ballista which Marcellinus makes so much rout about; the terrible effects of the Pyraboli, which cast fire; the danger of the Terebra and Scorpio, which cast javelins...

But what are these, would he say, to the destructive machinery of Corporal Trim? Believe me, brother Toby, no bridge, or bastion, or sally-port, that ever was constructed in this world, can hold out against such artillery.

—Laurence Sterne,
*The Life and Opinions of
Tristram Shandy, Gentleman*



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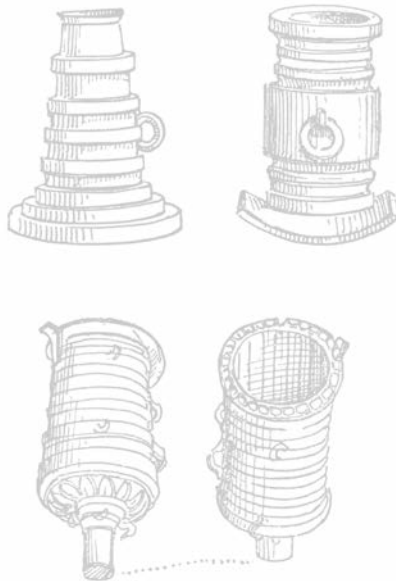
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Preface to the Second Edition

Even as I invested nearly all my spare time writing *Backyard Ballistics* in 1998 and 1999, I wasn't terribly optimistic that I would find a publisher. At the time, projects and experiments like these were considered too edgy, too dangerous to describe in a book that just anybody could buy. There were a few publisher rejection letters telling me, more or less, that I was crazy to attempt publishing such material.

But I got some help from some wonderful and influential colleagues, caught a break or two, and basically, just kept at it. *Backyard Ballistics* was published and has since sold hundreds of thousands of copies.

In the ten or so years since the book first hit bookstore shelves, I have received countless e-mails and letters from people all over the world telling me how much they enjoyed the book. In some cases, letter writers told me that the book made a profound impression on them, so much so that it contributed significantly to their choice of science as a career. Nothing could make me so glad.

A lot has changed since the book was first published. There is a wider selection of project materials to choose from and more places than ever to obtain them. The Internet has made it much easier for experimenters to procure all sorts of raw materials and tools that were once hard to find. Best of

all, there's a new interest in DIY science, and lively communities of enthusiastic builders, both real and virtual, have taken hold. This is due in no small part to media like *Make* and *Popular Mechanics*, magazines where I am proud to be listed as a contributing editor.

This newly revised second edition of *Backyard Ballistics* includes all the great projects from the original edition, but updates them to make them even better. The original spark igniter Potato Cannon is still here of course, plus you'll find a new model using a different ignition system as well.

Pnewton's Petard, a.k.a. the compressed air cannon, has been thoroughly reworked. It's easier to build and far more accurate than before.

The Cincinnati Fire Kite remains the same and seems to be one of the most popular projects in the book. The Hydro Pump Rocket has been reworked, and it is supplemented with a deeper and more thorough scientific explanation.

In fact, nearly every chapter has something new, something improved, or something different. Over time, many readers have been kind enough to contact me with their thoughts regarding improvements or changes they have developed. Many of those excellent suggestions have been incorporated for the benefit of Backyard Ballisticians everywhere.

I believe the highlights of this new edition are the brand new projects: the sublimator, the powder keg, and the electromagnetic pipe gun. These projects are just great—edgy, exciting, and grounded in scientific exploration. They are perfect “whoosh-boom-splat” additions to the existing contents. All of them are quintessentially ballistic in nature—something shoots into the air, explodes (mildly, one hopes), or ignites.

PREFACE TO THE SECOND EDITION

A word of warning, now. These three new projects involve electricity, fire, and dry ice—three dangerous things. So, pay attention to the directions and safety instructions. (Of course that goes for everything in the book, but it can't hurt mentioning it one more time.)

Thanks to everyone who purchased and enjoyed the original *Backyard Ballistics*. I hope you find this new edition fun, educational, and perhaps even a bit inspiring. As always, I value the opinions and contributions of readers. If you have something you'd like to share, visit me at www.backyard-ballistics.com.

WILLIAM GURSTELLE
Minneapolis, Minnesota

Introduction

THE BOY MECHANIC

I have a special shelf in my library with about half a dozen books of science projects. In these books, from the 1892 *All-American Boy's Handy Book* through the 1939 *Fun for Boys*, there are hundreds of complicated projects that modern kids could hardly fathom. Most kids today will not be able to turn parts on a lathe or practice their taxidermy skills on a raccoon. But I love these books for the ideas they contain: how to build wooden street racers, how to build “superhet” radios, and how to construct and wind electric motors.

One of the best books I own is the 1913 edition of *The Boy Mechanic: 700 Things for Boys to Do*. *Popular Mechanics* magazine published it when electricity and aviation were young, when most people didn't even own cars. The cover shows a boy stepping off a cliff in a glider (built according to instructions on page 171). The image would make publishers and parents nervous today, but there were far fewer lawsuits in 1913. Back then it was your own carelessness, not *Popular Mechanics'*, if you didn't make your glider's joints fast and strong.

Paging through the book, several things become apparent. Electrical projects are prominent. You can build an “electric

bed warmer,” an electric toaster, or a wireless telegraph. Magic and illusions are also featured—you can build an “electric illusion box” with a secret compartment that magically transforms a full red apple into a half-eaten one before your eyes, or you can learn a whole bunch of coin tricks.

The Boy Mechanic is also long on things that shoot or explode. For instance, the gunpowder-driven “Fourth-of-July Catapult” flings a full-sized mannequin a hundred feet into the sky! The excitement goes on for 460 pages: how to build a working cannon, how to fashion a crossbow, and how to set a smoke screen.

The book contains safer but less exciting ideas, too—for example, how to make a lamp or a belt hanger. But that’s not why boys and girls used to read such books. They read them to channel their excitement and take risks in a productive way. They read them because, for yesterday’s young people, this sort of experimentation was a normal and expected part of growing up. *Backyard Ballistics* is the direct descendant of those books. Obviously, the time for making needle-tipped blowguns or mixing a homemade batch of mercury fulminate has passed. *Backyard Ballistics* proudly wears the mantle of those books and fits the needs of the present time. No cerebral computer simulations here, just plenty of real fun with a good purpose.

BE AN AMATEUR, PROUDLY

Around 1700, the Italian composer and music teacher Arcangelo Corelli published his sonatas for violin. The sonatas were bound in a stunningly beautiful book, printed on the finest quality paper of the day. The music was beautiful, too, despite its simplicity; the sonatas contained simple melodies without ornamentation or embellishment.

This simple music was fundamentally important to a generation of violinists—perhaps the finest generation ever to work a bow. You see, Corelli made the music simple for a reason: he expected his violin students to be amateur composers as well. The students themselves completed the music in his sonatas; they were supposed to improve his lines with trills and musical runs of their own. They interpreted the dynamics and phrasing of individual passages, added their counterpoint harmonies, and so on.

This was the age of the amateur, an era that produced tremendous creativity and genius. An amateur is literally someone who loves what he or she does. An amateur does something because he or she wants to, not because he or she is paid to. Professionalism, in the modern sense of the word, was almost unknown. And that's what drove eighteenth-century genius. Whether you played music or created inventions, if you were great, your work evidenced your passion.

A different way of thinking changed the nineteenth century. The improvisation and individualism so important to virtuosos of the day were eclipsed by rigid adherence to rules and uniformity. A new breed of professional musician came to the forefront in the late nineteenth century. The composer carefully detailed all the dynamics, accents, and tempos for musicians as musical improvisation and interpretation took a back seat to technique and cold precision.

Like music, inventing and engineering metamorphosed into professions of intellectualism, methodology, and procedure during the 1830s and '40s. Of course, they had to. Prior to the 1800s, every tool and fixture was handwrought by craftsmen using techniques honed by years of apprenticeship and experience. The Industrial Revolution changed this. Mass-produced goods created in the steam-driven factories and mills of the industrial Northeast required the coordinated efforts of many