

Acknowledgments

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About the Author

Mario Igréc was born in Zagreb, Croatia. He studied composition with Stanko Horvat and piano performance with Pavica Gvozdić at the Zagreb Academy of Music, where he received his Bachelor of Music degree in piano performance and pedagogy in 1984. He continued his studies with Martin Canin at the State University of New York at Stony Brook, and received his Masters Degree in piano performance in 1986. He received a special prize from *Jeu-nesse Musicale* at the 1982 International Piano Competition “Rina Sala Gallo” in Monza, Italy, and he won the Sunwood Piano Competition in Old Field, New York, in 1985.

Mario’s interest in piano technology was sparked at an early age by his grandmother’s Trautwein upright, which was too intriguing not to be explored in depth. He received his first training a few years later, after acquiring an old Petrof grand—a local technician, fed up with frequent string-replacement visits to the Igréc household, decided to teach Mario how to replace the strings himself. Mario armed himself with books and trained with other technicians to learn how to make the piano support, not limit his pianism. This book is part of that journey.

Mario’s understanding of piano making and servicing was deepened by his visits to and informal training at the Bösendorfer factories in Vienna and Wiener Neustadt. This is where he experienced the standards of workmanship that he has strived to reach ever since.

Mario continued learning as an assistant piano technician during his graduate studies in music at Stony Brook, after which he became a full-time piano technician at Loui-

siana State University in Baton Rouge. During his tenure at LSU School of Music he taught piano design, construction, and the theory of tuning and temperament, and maintained over 120 of the school’s pianos, harpsichords, and celestas. As a concert technician for the LSU Union Theater, First Baptist Church of Baton Rouge, and the Baton Rouge Riverside Centroplex Theater, he worked for many renowned artists, including Philippe Bianconi, Constance Carroll, Richard Goode, Gilbert Kalish, Jon Kimura Parker, Garrick Ohlsson, and Santiago Rodriguez. He rebuilt numerous pianos during this period, including those used in the aforementioned concert venues.

In the 1990s, Mario’s career took a turn toward information technology. He became a Certified Expert for Adobe FrameMaker and a Microsoft Most Valued Professional, and has written on technology, managed long document projects, designed books, and built database applications. He partnered with Brian Gardner to form Selltis, LLC in 2000. The company develops Selltis Sales, a hosted, cloud-based, customer-relationship management software solution. Mario is the creator of HyperLinking™ technology for data contextualization. At Selltis, he heads the development group as software architect and Chief Technology Officer.

When he is not at Selltis, Mario restores pianos, focusing on tone and touch, and studies historical keyboard instruments and performance practices. He welcomes comments and suggestions. Please send them via the Contact link at <http://www.pianosinsideout.com>.

Introduction

“*The pianoforte is the most important of all musical instruments; its invention was to music what the invention of the printing press was to poetry.*”
—George Bernard Shaw

Musical instruments have been involved in music making since the dawn of mankind. While some have evolved modestly, others have been transformed into new instruments that dwarfed and eventually replaced their predecessors. No musical instrument better illustrates this process than the piano. From the frail and delicate harpsichord and clavichord, in only 170 years the piano metamorphosed into a means of conveying a tremendous range of musical expression. By the 1870s, the piano had become so powerful that it could hold its own against a large orchestra, while allowing the most nuanced articulation in solo or chamber music. With an ever-improving sustain, in skilled hands it could even emulate the human voice.

But, as George Bernard Shaw astutely observed, the real significance of the piano transcends its musical qualities. By the late 19th century, public performance was no longer the only way “big” music could be consumed—the piano was ubiquitous, and almost everyone could enjoy his or her favorite operas, symphonies, songs, marches, or hymns in the privacy of the home. Soon, the need to learn to play the piano was obviated by the introduction of the reproducing or player mechanism. Although the phonograph and radio eventually took over, it was the piano that ushered in a new model of *personal* consumption of entertainment, democratizing access to music and changing the entertainment industry forever.

Unlike electronic instruments, the acoustic piano rewards us with a sound that’s alive, never the same, never completely predictable. But the prize is not without a price. Built from living materials, the piano is in a constant state of flux and requires care and attention. This has been the province of professional tuners, technicians, and re-

builders who have dedicated their lives to perfecting their craft through lengthy apprenticeships, training courses, and membership in professional organizations. Although the piano technician is without doubt the most qualified person to work on the piano, there is no reason for pianists and piano owners to remain in the dark. While owners of other musical instruments replace strings, make their own reeds, change pads, and tune their instruments, most pianists leave all aspects of piano maintenance to the piano technician. As a result, they never learn about their instruments and don’t know how to communicate their needs. This should change. At the very least, pianists should know how the piano works and what they can expect from it. A pianist who understands his or her instrument is a more flexible performer and a better-informed consumer. For those who have some mechanical aptitude and sufficient physical strength, there is no reason not to regulate the action, adjust the pedals, replace a broken string, or even tune the piano. Yes, all this work requires a lot of practice, but isn’t this what you are already so good at?

As much as a pianist can learn from this book, it is the technician and student of piano technology who will benefit the most from it. The skills required for piano restoration are exceedingly diverse, and few people can afford a complete, systematic training and apprenticeship. *Pianos Inside Out* aims to satisfy that need by offering comprehensive and concise instructions for practical work. It provides an overview of piano history, and in-depth discussion of all aspects of piano construction, design, and maintenance, followed by step-by-step instructions on tuning, regulation, voicing, repair, and rebuilding.

The book was written with the novice in mind; no previous knowledge or experience is expected. It will be easier for you to follow tuning instructions if you can play the piano and have an elementary understanding of mathematics, acoustics, and music theory, but that's not required. For repair and rebuilding, prior experience in working with wood, metal, and glues will be helpful, although, again, this is not a prerequisite.

You can learn to tune, regulate, and voice pianos with a minimal toolkit, but for complex repairs and rebuilding procedures you will need an appropriate, climate-controlled shop space and a number of tools and machines. Do not underestimate the cost and the time needed to set up such a shop.

As complete as this book may be, it is only a book. I encourage you to learn from an experienced piano technician or a rebuilding shop. Unless you can afford to attend a school such as North Bennett Street School, in Boston, or the Chicago School for Piano Technology, explore the opportunities for learning in your community—from apprenticing at a local piano shop, to individual training, to seminars or workshops at a local college. Consider a correspondence school such as the Randy Potter School of Piano Technology. Become a member of an association of piano technicians, such as the Piano Technicians Guild (PTG) or *Europiano* (see Appendix E, “Technicians’ Organizations,” on page 523), and learn from classes at your local chapter and at regional and national conferences. This way, you will also gain access to a vast array of resources and publications. Attend manufacturers’ training seminars. Participate in online forums such as pianoworld.com and those available through the Piano Technicians Guild. Attend conferences and visit music trade shows, such as NAMM (<http://www.namm.org>) and Musikmesse Frankfurt (<http://musik.messefrankfurt.com>).

An inherent danger with a book such as this is that it can be viewed as a substitute for systematic training, either self-instruction or training in a shop or school. The truth, of course, is that although this book will give you guidance, becoming competent in piano work will depend on how committed you are to learning each skill. *Pianos Inside Out* is not intended to encourage a casual attitude toward piano work. I hope that the book will increase your awareness not only of how to do things, but also of how *not* to do them. Toward that end, you will be constantly reminded of the ramifications of not performing the work completely or up to certain standards. Ultimately, though, *you* are the one responsible for your own standards; whether the book will empower you or make you dangerous depends on you alone.

How to Use This Book

Pianos Inside Out is organized in ten chapters. The first chapter, “History,” provides an introduction to the development of the piano. It is followed by “Construction and Design,” which discusses all the elements of the piano, in-

cluding their design and manufacture, and lays the foundation for understanding the rest of the book.

Chapter 3, “Maintenance,” covers various aspects of piano maintenance and provides solutions for climate control, piano cleaning, and servicing. Although written with the piano owner in mind, this chapter should interest all readers: proper maintenance and climate control are prerequisites for the successful long-term upkeep of every piano. Climate control is of critical importance in piano rebuilding and should be used in every piano shop.

Chapters 4 through 10 are intended for those who want to tune, regulate, voice, repair, and rebuild pianos. These chapters have many cross references and shared illustrations, reflecting the fact that all piano work is highly inter-related. To avoid inadvertently damaging one thing while fixing another, I recommend at least skimming all of them before proceeding with *any* work. Chapter 9, “Touch, Geometry, Playability,” is of special importance because it discusses, from theoretical and practical standpoints, the key aspects of action design and how they affect playability. Here you will learn how to improve playability, and how to avoid perpetuating or compounding previously made mistakes.

As a printed book, *Pianos Inside Out* is just the beginning. Much more awaits you at www.pianosinsideout.com, including search, downloads, updates, expanded coverage, and additional materials.

Online Resources

Web links (URLs) and e-mail addresses change. You will find a complete, up-to-date list of all Internet resources mentioned in this book at:

<http://www.pianosinsideout.com/Links>.

If a link on that page is invalid, please send us a note from:

<http://www.pianosinsideout.com/Contact.html>.

Patent Search

U.S. patents can be searched and downloaded from <http://www.google.com/patents> and from the U.S. Patent and Trademark Office at <http://www.uspto.gov/patents/process/search/>.

Precautions

There are three important precautions you should take, especially if you will be working on pianos without the supervision of an experienced technician: with grands, be sure the legs are sturdy and are firmly in place. With verticals, be careful not to tip the piano over! Many repair and rebuilding procedures, as well as the tuning itself, require

physical strength. Do not overestimate your physical capabilities—*always* get help when lifting a piano or its plate, when stringing a piano, or even when removing and carrying an action and keyboard.

Stay Healthy

As you work on pianos, you will be exposed to dust, mold, and mildew, as well as toxic substances, from oxidized key leads and verdigris (page 246) to chemicals used for rodent and insect control. There are biological dangers as well (see “Rodents and Diseases” on page 136). The best way to protect yourself is to wear a dust mask for fine particulate. A pair of cotton gloves won’t protect you from chemicals (wear nitrile or similar gloves in those cases), but will reduce exposure and protect you from splinters, scrapes, and small wounds that could lead to exposure.

Other sources of toxicity are the chemicals you will use—lubricants, glues, solvents, and finishes. Breathing toxic fumes and clogging up your lungs with dust, wool fibers, and lubricant powders will undermine your long-term health and your ability to do this work.

Chemicals enter your body not only through the lungs, but also through the skin. Just consider how quickly an analgesic cream works—that’s how quickly your body will absorb a glue or solvent. It may take years for your liver to recover from careless exposure to such chemicals.

Tuning and rebuilding involve repeatedly using certain groups of muscles, which can lead to injury and chronic pain. I can’t overemphasize the importance of rest and frequent breaks. Regular stretching and exercise are just as important. If you do develop pain, a self-applied trigger-point massage may help.¹

Protect Your Hearing

Working on pianos can be very loud. Just as you protect your eyes or hands when using power tools, you should protect your ears from damaging noises. Particularly tough on your hearing are tuning, hammering tuning pins during restringing, and working with loud power tools and machines.

Use earplugs with 30 decibel protection when you work with power tools or when you hammer tuning pins. You will find disposable foam earplugs in pharmacies (Figure 1) and corded ones in hardware stores.

See “Protecting Your Hearing and Health” on page 112 for recommendations that apply to tuning.

Protect the Environment

As you work on pianos, you will accumulate chemicals and generate waste, some of which will be flammable and toxic. Be careful how you store these substances. Dispose

¹ Clair Davies, NCTMB, a former piano rebuilder, explains his method for treating pain with self-applied massage in *The Trigger Point Therapy Workbook*. Self-massage tools such as the Body Back Buddy and Thera Cane® massager are widely available.



Figure 1 Foam earplugs. Tapered plugs are easier to insert.

of toxic wastes responsibly. In the United States, toxic-waste disposal is regulated by the Environmental Protection Agency (<http://www.epa.gov/osw/hazard/tsd>), but individual states may impose even stricter standards.

Some communities organize hazardous waste collections a few times a year. Many stores and private organizations will take paints and other chemicals. Contact your local authorities to learn what is available.

Materials and Products

I don’t endorse any products mentioned in this book—competing products may be just as good or better. I received no compensation from any of the vendors or manufacturers mentioned.

I encourage you to try as many different products and materials as practical, especially those that represent promising new technologies. Be careful, though, and test a new product *extensively* before using it for an important repair or rebuilding procedure. Make testing conditions (materials, environment, methods of application, etc.) as similar as possible to the actual application. Keep in mind that certain products vary from batch to batch, and can be affected by transportation and storage.

Terminology

The terms used in this book are based on those currently in use in the U.S. See pages 22–23 for a cross-section diagram and a list of parts in the grand piano, and Figures 162 and 163 on page 64 for the names of parts in grand and vertical actions.

Terms used in the UK are listed in the Glossary. They are based on input from UK technicians, on the definitions in Herbert A. Shead’s *The Anatomy of the Piano*, and on interactive nomenclature diagrams in H.J. Fletcher & Newman’s online catalog.²

² Go to <http://www.fletcher-newman.co.uk/frameset.html> and click “Piano Parts Catalogue,” then “Visual Product Identifier.” Grand and vertical action diagrams are available.

Conventions

Units of Measurement

All measurements are expressed in standard U.S. units, with metric measurements appearing in square brackets. For example, four feet is written as 4' [1.2 m], one inch as 1" [25 mm], and thirty-two thousandths of an inch as 0.032" [800 μm or 0.8 mm].

Bibliographical References

Throughout the book, bibliographical references are given in an abbreviated format; complete references are in the Selected Bibliography on page 509, and online at <http://www.pianosinsideout.com>.

Dynamic Markings

The force with which you strike keys in various diagnostic and regulation procedures is expressed in terms of its tonal effect, and is notated using the following dynamic markings:

<i>ppp</i>	<i>pianississimo</i>	Extremely soft
<i>pp</i>	<i>pianissimo</i>	Very soft
<i>p</i>	<i>piano</i>	Soft
<i>mp</i>	<i>mezzo piano</i>	Medium soft
<i>mf</i>	<i>mezzo forte</i>	Medium loud
<i>f</i>	<i>forte</i>	Loud
<i>ff</i>	<i>fortissimo</i>	Very loud
<i>fff</i>	<i>fortississimo</i>	Extremely loud

Articulation

The touch with which you strike keys is indicated with the following articulation phrases:

<i>legato</i>	tied	hold each note until sounding the next note
<i>staccato</i>	sharply detached	play and bounce off the key
<i>tenuto</i>	held but detached	press the key and release it at approximately half the duration between the notes

Musical Nomenclature

This book uses scientific pitch notation: the lowest note on the piano is A0, "middle C" is C4, and the highest note is C8. To convert the names to the notation commonly used in Europe and by musicians in the U.S., see Figure 2 below.

In European pitch notation, middle C is called "c¹". Each C above middle C is written in lowercase followed by a number in superscript ("c²", "c³", "c⁴", or "c⁵"), and is read as "C two," "C three," etc. The Cs descending from c¹ are: small C ("c"), great C ("C"), contra C ("C₁"), and sub-contra C ("C₂"). Helmholtz notation is similar, except that the numbers are substituted by prime symbols. For example, c³ is written as c''' and A₂ as A,,.

In all three notation systems, the chromatic notes (all white and black keys) within the major 7th up from any note C have the same number (or number of apostrophes) as that C. For example, E above C6 (c³) is E6 (e³).

Intervals are expressed as codes, such as "M3" or "m6," but are spoken in full, spelled-out form; e.g., "major third" or "minor sixth," not "em three" or "em six." See "Intervals" on page 95 for more on this.

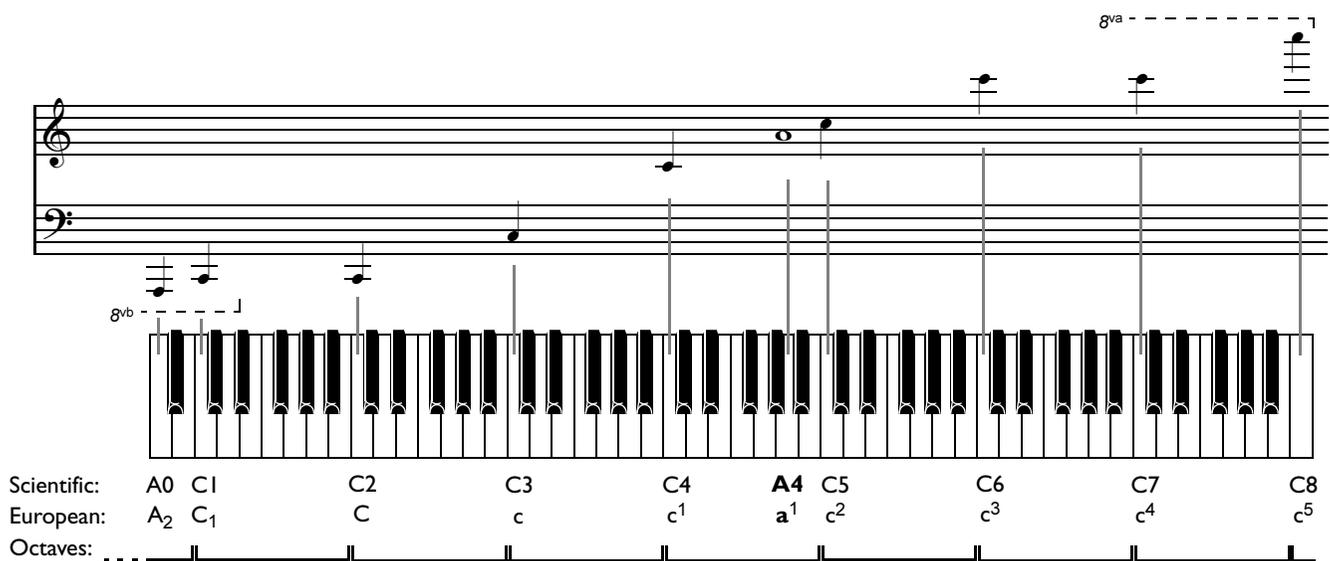


Figure 2 Names of notes and octave ranges. Notes under "8va" ("ottava") are played an octave higher, those under "8vb" ("ottava bassa") an octave lower.