Подстрочный перевод для книги:

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Joe Martin
Craig Libuse

Tabletop Machining

a basic approach to making small parts on miniature machine tools

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`https://github.com/ponyatov/tabletop`

Настольные станки

основные приемы изготовления мелких деталей на миниатюрных станках

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Joe Martin

фотографии и иллюстрации Craig Libuse

- модели
- приемы и техники
- прототипы
- измерения
- наладка станков

... Это то, что каждый инженер должен знать о станках, механической обработке и производстве

Оглавление

Глава 1

A special note to engineers reading this book... Специальное примечание для инженеров, читающих эту книгу...

1.1 Machining for engineers and engineering for machinists Мехобработка для инженеров и инжиниринг для станочников

At first glance the subtitle on the cover of this book could be a bit deceiving. What does tabletop machining have do with engineering you may ask? Compare it to a book that has been written about the ocean. The seas could be described from the perspective of a young man who has just sailed around the world in a twenty-five foot sailboat or by a merchant seaman who has spent his career aboard a giant ocean liner. Each would have an entirely different view of what the ocean was all about. In a storm, the chap in the small boat would write about surviving broken masts and mountainous seas while the merchant seaman might write about seasick passengers.

I believe you would learn more about the ocean from the young man in the small boat, because in a sense he was more involved in his subject. He was not just on it, he was *in* it.

На первый взгляд подзаголовок на обложке этой книги может быть немного обманчив. Вы можете спросить, как настольная обработка связана с инжинирингом? Сравним с книгой, написанной об океане. Моря могли бы быть описаны с точки зрения молодого человека, который только что ходил по всему миру на парусной лодке длиной двадцать пять футов, или моряком торгового флота, который провёл свою карьеру на гигантском океанском лайнере. Каждый из них будет иметь совершенно разную точку зрения об океане. В шторм парень на небольшой лодке написал бы о выживании со сломанными мачтами и волнах размером в гору, в то время как моряк торгового флота мог бы написать о морской болезни пассажиров. Я думаю, что вы бы узнали об океане больше от молодого человека на небольшой лодке, потому что некоторым образом ему было сложнее в своём путешествии. Он был не просто в путешествии, он был *внутри* него.

1.2 Navigating the seas of machining
Навигация по морям механической обработки

The ocean in this case is the world of machining. The craftsman using tabletop machine tools is like the sailor in a small boat, while the professional machinist with his big CNC shop tools is like the world-traveling seaman. The process of producing complex, accurate parts cannot be described by looking in the window of a quarter million dollar CNC machine. It would be like a merchant seaman working in the engine room trying to describe a storm in the Atlantic Ocean by telling you how much extra fuel the ship used. The professional's view of the subject may be so cluttered with details that it is difficult to sort the things you really need to know to sail in rough seas or make good parts. It is the craftsman working with small tools, turning the cranks by hand, who will have the most to tell you about the real world of working with metal.

Океан в нашем случае — мир механической обработки. Мастер использующий настольные станки, как матрос на маленькой лодке, в то время как профессиональный станочник с его большим магазином ин-

струментом на станке с ЧПУ, как моряк несколько раз совершивший кругосветку. Процесс производства сложных, точных деталей не может быть описан описан, глядя в окно ЧПУ станка за четверть миллиона долларов. Это было бы похоже на моряка торгового судна, работающего в машинном отделении, который пытается описать бурю в Атлантическом океане, рассказывая вам, сколько дополнительного топлива использовал корабль. Представления специалиста о предмете разговора может быть так наполнено тонкостями, что трудно отсортировать вещи, которые вам действительно нужно знать, чтобы плавать в бурных морях, или делать хорошие детали. Если этот мастер работает с мелкими инструментами, вытачивает шатуны вручную, у него больше возможностей рассказать вам о реальном мире работы с металлом.

1.3 Looking ot engineering from the craftsman's perspective Инжиниринг с точки зрения мастера

With the aid of computers, parts can easily be drawn that can't be built. CAD programs allow a designer to put a perfect .0001" radius on the inside comer of a pocket cut in tool steel. Hopefully after reading this book you will not ask a toolmaker to do it, but if you do, you'll at least know it is going to cost a great deal of money to try. Working with metal is far more difficult than one would imagine. A false impression is gained by looking at the beautiful yet inexpensive machined parts that we deal with daily. They have been produced in very large quantities, and that five-dollar part you may consider a "rip-off could easily cost five hundred dollars if you had to manufacture just one. New engineers will often think a toolmaker is a failure when the seemingly simple part they design ends up costing a thousand dollars to make. Most engineers will eventually have to deal with the craftsman who turn their ideas into reality, and in reading this book I would hope you come away with a new perspective of what is really involved in producing a machined part or a product. An alternate subtitle for the book might have been "Things they should have taught you in engineering school but didn't". This book might be considered your textbook for a course called "Reality 101".

Используя компьютер, очень легко смоделировать детали, которые не могут быть изготовлены. САПР программы позволяют проектировщику поставить идеальный радиус с точностью 0,0001 мм на внутреннем

ребре кармана, отфрезерованного в инструментальной стали. Надеюсь после прочтения этой книги вы не будете просить инструментальщика сделать такой элемент, но если вы это сделаете, вы по крайней мере будете знать, что это будет стоить много много денег, даже только чтобы попробовать это сделать. Работа с металлом является гораздо более трудной, чем можно себе представить. Это ложное впечатление сложилось, глядя на красивые, но все же недорогие детали, сделанные на станках, с которыми мы имеем дело ежедневно. Они были сделаны серийно в очень больших количествах, и цена в 5 долларов за деталь, которую вы можете почитать надувательством, легко может взлететь до 500 долларов, если вам нужно сделать одну такую деталь. Начинающие инженеры часто думают что для инструментальщик плох, когда казалось бы простая деталь в итоге оказывается с ценой в тысячи долларов. Большинству инженеров в конечном итоге придется иметь дело с мастером, который может превратить их идеи в реальность, и вы читаете эту книгу, я надеюсь, чтобы сформировать новую точку зрения на то, что на самом деле происходит при обработки детали или продукта. Альтернативным названием для книги могло бы быть "Вещи, которым вас должны были научить в ВУЗе". Эта книга может считаться вашим учебником по курсу с названием "Реальность 101".

1.4 Seeing production from the point of view of both the engineer and machinist
Производство с точки зрения инженера и станочника

My perspective on machining could be considered unique because, in order to survive, I have had to deal with every aspect of product design from engineering to prototyping to tooling to manufacturing to sales. In this book I have tried to pass along the logic I used to solve the associated problems. Understanding how a craftsman thinks and works is an essential part of getting projects done. Unless you are willing to build your designs yourself, you are going to have to learn how to deal with the craftsman who will actually build them. The more you know about their methods, personalities and unique problems, the better your chances are for

success. Smooth sailing.

Мой взгляд на мехобработку можно считать уникальным потому что, для того чтобы выжить на рынке, я имел дело с каждым аспектом дизайна продукта от проектирования и прототипирования до производства и продаж. В этой книге я попытался объяснить логику моих решений, связанных с этим проблемами. Понимание того, как мастер думает и работает, является неотъемлемой частью получения готовых проектов. Если вы не готовы изготавливать свои проекты самостоятельно, вы все равно сможете узнать, как общаться с мастером, который будет на самом деле их делать. Чем больше вы знаете о его методах, личных и уникальных особенностях, тем выше ваши шансы на успех. Счастливого плавания.

— Joe Martin
— Джо Мартин

Глава 2

About the Author

Joe Martin worked in the construction trades after graduating from high school, but his real love was always building and flying radio controlled model airplanes. When he decided to turn his hobby into a business and start his own company making components for the radio control industry, he had to learn about machining and toolmaking on his own. He simply couldn't afford to hire anyone else to set up the tools and make the molds. He has designed and taken to market numerous products and owned several companies over the years. He began his association with Sherline Products as an importer of Australian-built lathes in the early 1970's. Since then, Joe's company has grown to become the sole manufacturer and worldwide distributor of Sherline machine tools.

Joe was one of the founders of the sport of Formula One model aircraft competition as well as one of its early champions. His competitive nature seems to find its way into whatever form of fun he pursues. He has been a winner in sports from model airplane competition to ocean sailboat racing and, most recently, automobile racing.

Never one to be a spectator in life, he has tried and mastered many skills. In this book, he passes on to you some of his hard-won knowledge about machining. His down-to-earth style is not highly polished. In fact, if you could say that life has put a finish on him, it would probably be described as ground or honed... very accurate

but not slick. I think his heartfelt love of good tools and miniature machining will be apparent to all who read this book. Working with him these past 25 years is certainly an experience 1 would not have wanted to miss.

— Craig Libuse

Joe at speed in a 1974 vintage IndyCar at Phoenix International Raceway.

Глава 3

Dedication

Carl Hammons — 1936–1997

Carl Hammons, my friend and business partner for thirty years, died September 11, 1997 as I was writing this book. We shared thousands of lunches and coffee breaks over the years we worked together, and much of the knowledge I have passed on in this book came from Carl. Carl and 1 shared the rare distinction of having been partners not just once, but twice. We both played different roles in putting together the product line, and without him it just isn't going to be as much fun.

When we joined forces for the second time, we had an agreement that eliminated any need to financially justify the purchase of a new piece of equipment. We would buy machines that interested us and find a job for them later. The laser engraver was a perfect example of this, but now we couldn't get along without it. It may seem contrary to smart business practice, but that's the way we did it. I have no regrets, for we were always the happiest when we were confronted with a new set of technical problems. Therefore, I dedicate this book to Carl Hammons; my business partner, my friend.

I should also credit the English teachers in the Cranston, Rhode Island school system for forcing a not-so-

willing student enrolled in the "boys general class"to learn enough about our language to dare to take on the task of expressing difficult concepts in simple words. I graduated in 1953. You, the reader, will be the ultimate judge of their (and my) success in this undertaking.

— Joe Martin

The photo composition above is a joint effort. The photo of Cart was taken by his wife Barbara. The photo of Swan Lake, Montana, a favorite spot of Carl's, was taken by friend Wayne Armstrong. The two images were composed in PhotoShop by artist Elaine Collins

Глава 4

Modeling Miniature Machine Tools

You will probably not be surprised to find that people who are interested in miniature machine tools often find it fun to make miniature models of full-size tools. This page shows beautiful examples of a lathe and a mill from two expert craftsmen.

Barry Jordan built a 2"diameter rotary table and then needed a machine to use it on. The result was this 1/5 scale Bridgeport® mill. The project was started in 1997 and completed just in time for Bridgeport's 60th anniversary in 1998. What started as a model turned into a real machine in miniature, capable of actually cutting small parts in mild steel.

The parts are all machined from aluminum and billet cast iron. No castings were used. The polished pulley cover is made from Dural. More of Barry Jordan's miniature tools can be seen on page 246.

This small but fully functional 1/6 scale Hardinge lathe was modeled by Wilhelm Huxhold of Ontario, Canada. A lifelong machinist, he shows his love for machine tools by modeling them in miniature. Unlike Barry Jordan's

Bridgeport, this project took many years to complete. More of Mr. Huxhold's work can be seen on pages 22 and 217. A profile of his career is presented on page 330.

Tabletop Machining

. . . A basic approach to making small parts on miniature machine tools

Joe Martin

Design, typesetting, illustration and photography by Craig Libuse

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To order additional copies of this book call:
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or write to: Joe Martin. 3235 Executive Ridge, Vista. California 92081

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4.1 Machining is not a "paint-by-numbers" process

If you are looking for a book that will give you complete, step-by-step instructions on how to build your particular machining project, this is not it. In fact, that book probably does not exist. What this book will give you is all the basic knowledge you need to start machining metal. Your imagination plus the information in this book will allow you to make just about anything. The many photos showing what others have done are here to spark your imagination. None of the projects shown in the photos in this book came with detailed instructions. Most came with none at all. They are, for the most part, not beginner projects. I'd suggest you start with a relatively simple project and apply what you learn from this book. As your skill and experience increase, you'll be ready to tackle anything you see here. Read the parts about tools and materials. Read the parts about speeds and feed rates. Study the photos of setups carefully. Everything you need is right there, but you have to use some brainpower to apply it to your projects. The level of satisfaction you achieve will be directly related to the amount of effort you are willing to put forth.

The book is now in its fourth printing, and some have commented that it doesn't contain enough project plans. I have avoided adding a lot of "how to"plans in order to concentrate on the general skills, craftsmanship and techniques needed to create a good part. These will never be found in a set of plans. For those looking to take what they've learned here and apply it to a specific project, there are many sources of kits and plans on Sherline's web site at `www.sherline.com`. Several magazines like *The Home Shop Machinist* and *Machinist's Workshop* offer new plans in every issue.

4.2 Thanks to those who helped

Joe Martin and Craig Libuse would like to thank all of those who took the time to read this book word for word and sent in suggestions for corrections in the previous printings. Our thanks go to Marc Cimolino, Jim Clark, Glenn Ferguson Jr., Mort Goldberg, Alan Koski and especially Huntly Millar for their extremely diligent, voluntary efforts. Among other things, this book addresses the issue of quality and the quest for perfection,

so we have made every attempt to eliminate any typographical errors. We welcome your input in a continuing effort to improve the quality of this book. Though rarely achieved, perfection is a goal always worth pursuing.

Часть I

Safety rules for power tools

A patternmaker's interview for employment

One of the best patternmakers I ever knew apprenticed in the trade for many years with his father. When he went to work for U.S. Steel in their pattern shop, the foreman who was interviewing him for the job asked him to hold out his hands. When the foreman could see that the applicant still had all ten fingers, he was hired. The foreman could see from his work that the patternmaker was a good craftsman, but he figured that if he had been working in the trade that long and still had all his fingers he must be a good, safe worker too, and that was just as important.

Spinning tools that are powerful enough and sharp enough to remove metal can also remove just about anything else that gets in their way. Though less dangerous than their larger full size shop counterparts, small power tools can still cause serious injury to those who don't show them the proper respect. Even hand tools used improperly can cause injury. Talking about safety is not nearly as fun as talking about the beautiful miniature machining projects in this book, but working safely is part of the skill of a good craftsman.

Working safely is simply a series of habits that you develop. Once they become habits, it takes no longer and is no less enjoyable to work that way than to work with unsafe habits. Injuries definitely take the fun out of working with tools, and fun is what miniature machining is all about. Please read these rules and apply them until they become habits so that you can enjoy your hobby to the fullest.

1. KNOW YOUR POWER TOOL — Read the owner's manual carefully. Learn the tool's application and limitations as well as the specific potential hazards peculiar to this tool.

2. GROUND ALL TOOLS — If a tool is equipped with a three-prong plug, it should be plugged into a three-hole receptacle. If an adapter is used to accommodate a two-prong receptacle, the adapter wire must be attached to a KNOWN GROUND. Never remove the third prong. (See drawing on next page.)

3. KEEP GUARDS IN PLACE — and in working order.

4. REMOVE ADJUSTING KEYS AND WRENCHES — Form a habit of checking to see that keys and adjusting wrenches are removed from the tool before turning on your machine.

5. KEEP WORK AREA CLEAN — Cluttered areas and benches invite accidents.
6. AVOID DANGEROUS ENVIRONMENT — Do not use power tools in damp or wet locations. Keep your work area well illuminated.
7. KEEP CHILDREN AWAY — All visitors should be kept a safe distance from the work area.
8. MAKE WORKSHOP KID PROOF — with padlocks, master switches or by removing starter keys.
9. DO NOT FORCE TOOL — Do not force a tool or attachment to do a job for which it was not designed. Use the proper tool for the job.
10. WEAR PROPER APPAREL — Avoid loose clothing. neckties, gloves or jewelry that could become caught in moving parts. Wear protective head gear to keep long hair styles away from moving parts.
11. USE SAFETYGLASSES — Also use a face or dust mask if cutting operation is dusty.
12. SECURE WORK — Use clamps or a vise to hold work when practicable. It is safer than using your hand and frees both hands to operate the tool.
13. DO NOT OVERREACH — Keep your proper footing and balance at all times.
14. MAINTAIN TOOLS IN TOP CONDITION — Keep tools sharp and clean for best and safest performance. Follow instructions for lubrication and changing accessories.
15. DISCONNECT TOOLS — Unplug the tool before servicing and when changing accessories such as blades, bits or cutters.
16. AVOID ACCIDENTAL STARTING — Make sure the switch is "OFF"before plugging in power cord.

17. USE RECOMMENDED ACCESSORIES – Consult the owner's manual. Use of improper accessories may be hazardous.

18. TURN SPINDLE BY HAND BEFORE SWITCHING ON MOTOR — This ensures that the workpiece or chuck jaws will not hit the lathe bed, saddle or crosslide. and also ensures that they clear the cutting tool.

19. CHECK THAT ALL HOLDING, LOCKING AND DRIVING DEVICES ARE TIGHTENED — At the same time, be careful not to overtighten these adjustments. They should be just tight enough to do the job. Overtightening may damage threads or warp parts, thereby reducing accuracy and effectiveness.

20. WHEN WORKING THROUGH THE SPINDLE, DO NOT LET LONG, THIN STOCK PROTRUDE FROM THE BACK END OF THE SPINDLE SHAFT — The end of unsupported stock turned at high RPM can suddenly bend and whip around.

21. It is not recommended that the lathe be used for grinding. The fine dust that results from the grinding operation is extremely hard on bearings and other moving parts of your tool. For the same reason, if the lathe or any other precision tool is kept near an operating grinder, it should be kept covered when not in use.

22. WEAR YOUR SAFETY GLASSES — Foresight is better than NO SIGHT! The operation of any power tool can result in foreign objects being thrown into the eyes, which can result in severe eye damage. Always wear safety glasses or eye shields before commencing power tool operation. We recommend a Wide Vision Safety Mask for use over spectacles or standard safety glasses.

4.3 ELECTRICAL CONNECTIONS

The power cord used is equipped with a 3-prong grounding plug which should be connected only to a properly grounded receptacle for your safety. Should an electrical failure occur in the motor, the grounded plug and receptacle will protect the user from electrical shock. If a properly grounded receptacle is not available, use a grounding adapter to adapt the 3-prong plug to a properly grounded receptacle by attaching the grounding lead from the adapter to the receptacle cover screw.

NOTE: Electrical circuits designed into the speed control of the Sherline lathe or mill read incoming current and automatically adapt to supply the correct 90 volts DC to the motor. As long as you have a properly wired, grounded connector cord for your source, the machine will operate on any current from 100 to 240 volts AC and 50 or 60 Hz. without a transformer [1]. This should include just about any country in the world. Prior to 1994, an AC/DC motor was used. Use the AC/DC motor ONLY with the power source for which it was intended. It will not automatically adapt to any other current and using it with an improper power source will bum out the motor or speed control.

GROUNDING TYPE 3-PRONG PLUG
PROPERLY GROUNDED TYPE OUTLET
USE PROPERLY GROUNDED RECEPTACLE AS SHOWN
PLUG ADAPTER
GROUND WIRE

Proper grounding of electrical connections.

[1] The first DC units built in early 1994 did not include the circuits to adapt to other currents. The capability to include that feature was not available to Sherline at that time. As soon as it was, it was included. If you think you may have an early DC model, remove the plastic speed control housing and look. for a label on the aluminum speed control frame. If it has a small metallic label on top of the frame that lists input voltage as 120 VAC, DO NOT ATTEMPT TO CONVERT THIS UNIT TO OTHER CURRENTS. Models that can be used with any current have a paper label on the end of the speed control frame which lists the model number as KBLC-240DS.

Older AC/DC motors available from Grainger

Sherline's supply of older AC/DC motors is slowly being depleted. A very large run must be custom ordered to get more, and this is not economically feasible. However, the Grainger catalog stocks a 1/5 horsepower motor identical to the one used on early Sherline tools. The catalog number is 2M139. They have locations in every state and can be found in the Yellow Pages under "Electric Motors". Their web address is `www.grainger.com`. Your other option would be to upgrade your motor and speed control to the newer, more powerful DC version.

"Common sense is instinct, and enough of it is genius."
— Josh Billings

Часть II

FOREWORD

4.4 What is "tabletop machining"?

Tabletop machining is about operating miniature machine tools. These are machines that can be picked up and set on a small bench or, if need be, a kitchen table, and used to build precise metal parts. They are inexpensive compared to their full-size shop equivalents, but are just as versatile and accurate as long as the size of the part is appropriate for the machine. The "Unimat"was the first miniature lathe mass produced and well known. Thousands of Unimats were sold, and today many are still in use. It had a wide variety of accessories manufactured for it and a price that was affordable. A number of other miniature machine tools have been manufactured since the Unimat, and the company I own, Sherline Products Inc., has become today's leader for this class of machine. I believe the fact 1 am both a hobbyist and toolmaker gave me more insight into what our customers needed when it comes to both accessories and instructions.

The original Unimat lathe was the first miniature machine tool to achieve international popularity. It came in a professional looking wood box and offered a versatile design and many accessories at a reasonable price. Its two-rail bed design made it too flexible for jobs requiring a high degree of accuracy, but it introduced many people to the fun of machining in miniature.

4.5 Beating the system

For me there has always been something special about projects that have been built on these small machines. The machinist who works with miniature machine tools will have beaten the system by not spending thousands of dollars on tools. These craftsmen build beautiful projects for enjoyment, not wages. These are special people who may suddenly have an urge to accurately build that model they have dreamed of for years. The machinists who are successful will realize there is a learning curve involved in accomplishing this. This book is about shortening that learning curve and giving you a new sense of what craftsmanship is all about.

4.6 Not just the “how”, but also the “why”

The tables and charts can be found in *Machinery's Handbook*, and I don't plan to duplicate them in this book. Library shelves are full of books of this nature. The information in this book won't be found in charts and graphs. I'm going to attempt to give you the information to actually start making "parts". Instructions that tell you "how"to do a job too often skip the most basic information, and that is "why"you would want to do a job this way or that way. I believe the customers who purchase miniature machines are intelligent enough to find the specific information they need at a library. These customers just don't happen to know much about machining. However, I also believe this book contains enough general rules to get a job done. Get started on a project as soon as you have your tools set up and working. Read a little, machine a little. Never cut metal without a plan that includes dimensions. "Making chips"without a plan can develop terrible work habits. This trade has few choices when it comes to parts fitting together. To work in unison they must be accurate, and your first task should be to make parts "to size".

4.7 How to read this book

A book like this doesn't need to be read from front to back like a novel. You will probably skip around reading first the sections that interest you the most. Therefore, this book may seem at times to be redundant. I have attempted to make each chapter relatively complete in and of itself, and some rules apply to more than one machining operation. Some of the more important ones may be repeated wherever they apply. To keep you interested and make the book more fun. we have included many pictures of actual projects and the people who made them. The examples of what has actually been done using tabletop machine tools speak more eloquently about their capabilities than anything I could say.

4.8 Why Sherline tools are used in the examples

I must say up front that Sherline tools will be used in the examples throughout this book. It is not my intention to use this book as a tool to sell Sherline tools, but rather to use these tools to demonstrate the techniques I am discussing. The reason should be obvious; that is, they are what I have available and what I know the most about. The principles involved in using these tools are pretty much typical of all machine tools, even larger full size shop tools, so what you learn through these examples should be able to be applied to whatever brand of tools you are using. Also, we have sold many thousands of these tools over the past twenty-five years, so the knowledge specific to Sherline tools will be of additional benefit to those of you who are using them as you work with this book. In addition, I hope the information I've included about how this tool line was developed and how our business is run might inspire some of you to follow your dreams and start a business of your own, whether it is in the area of machining or in any area that interests you.

Craig Libuse is seen at the drawing board with author Joe Martin. Craig has been doing all of Sherline's illustrations, instruction sheets, magazine advertisements and catalogs since shortly after Joe started the company in the mid-1970's. He ran his own graphic design studio for 22 years doing Sherline's work on contract before coming on board full time as Marketing Director in 1995.

According to builder Edward J. Young of Mobile, Alabama, this model Stuart 10H steam engine runs "smooth as silk" when powered by compressed air. The inset photo shows the plexiglass cover he made to replace the plate over the valve so its action can be viewed as the engine runs.

Глава 5

INTRODUCTION

5.1 The essence of “craftsmanship”

I wrote the introduction to this book last. That’s because when I started writing, I didn’t quite know where I was headed. I knew that over the years I had written many instructions for our products which contained enough knowledge and advice to be valuable. I also figured I could start writing answers to questions that had been asked of me over the years. I could fill the remainder of the book with pictures and charts and end up with a book that wouldn’t be any different or better than what was already out there. For me, therefore, the most important part was to try and instill in a potential machinist the value of good craftsmanship. Great craftsmen not only get the job done, they add a certain "look" to parts they build. It is almost a signature. I have seen the same part made by two different craftsmen using the same drawing. They were both highly skilled toolmakers. Both parts met the specifications perfectly, yet I could easily tell who built each part. Machining should be considered a form of art.

5.2 Some pretty good advice

Professional photographer, Tim Schroeder of Michigan built these five identical Stirling hot air engines to polish his skill as a new machinist. By making each part five times, he was able to get in more machining time with each setup and learn more in a shorter period... a pretty good way to learn.

On the wall of my Uncle's shop when I was a boy was a sign which I still remember. I'm not sure who said it. but I think it expresses what I'm trying to say pretty well. It said:

"A man who works with his hands is a laborer.

A man who works with his hands and his brain is a craftsman.

A man who works with his hands, his brain and his heart is an artist."

When I was building model aircraft, my friends and I had an interesting way of judging the quality of a model. We would set the model aircraft on the ground and start backing away from it until it looked good. A three-foot model would be considered superb and a fifty-foot model was one that was pretty crude. There were also models that wouldn't look good no matter what the distance was or the viewing angle. In those cases, the failure was in the design, and the best craftsman in the world can't make a bad design look good.

5.3 The best design is usually not your first design

The home machinist usually has more control over a design he is working with than a professional does. Don't use the first idea that comes into your head without proving to yourself that it's the *best* way. When a product has been designed properly, no one would even consider building it in a different way.

It is the way it is supposed to look because it's obvious. Unfortunately, these are the designs that are the hardest to come up with. They are also the designs you will get the least credit for even though they are your best. The assumption is that the obvious solution is also the easy solution, but this is usually not the case. The home craftsman also doesn't have to work within the constraints of commercial products where costs limit your choices. For us, time is not money, it's fun!

This is what craftsmanship is all about. Too few citizens really appreciate what good craftsmen do, Because their work doesn't fail it is taken for granted. A good craftsman can tell at a glance when someone's work is better than his, and he can start improving his work to be Number One, It is almost a form of competition between craftsmen where time and quality are considered at the same lime. Do you think Michaelangelo would be considered a great artist if he had only carved one statue and painted one picture? He produced so much good work in his lifetime that he set a standard that is still sought after today. One good part doesn't make you a craftsman. You are judged on the body of your work.

Author Joe Martin is shown with some of the miniature machine tools produced by Sherline Products. The small size of miniature machine tools makes them easy to use and not too intimidating for new machinists.

I not only wanted my writings to be useful to the hobbyist/machinist who builds parts for pleasure. but also to those future craftsman who want to build parts that have that "look". Please realize the parts being referred to in this book are not production parts. Machinists who produce these kinds of parts have the training and skill to make automatic machines build good parts. The only thing an automatic machine will manufacture automatically is scrap. It stilt takes that craftsman's touch to make machines run perfectly. The parts being discussed in this book will be parts built one at a time... "one off. These parts are usually part of another assembly that would be considered the final product.

5.4 You don't become a machinist by buying a machine

You should strive from the beginning to make better and more accurate parts than you think you need. Work to closer tolerances than the job demands. Be on the lookout for ways to make a job easier or better. I hope you will enjoy the process of creating accurate parts from raw metal. Buying a machine won't make you a machinist, but using it along with the skill and knowledge you acquire along the way eventually will.

5.5 What new machinists like most and least

If you are new to machining, you may find it to be either one of the most rewarding skills one can learn or the most frustrating thing you have ever attempted. What makes machining fun for some is the complexity and challenge. The same thing will drive others up the wall. One person may be overjoyed because he can now make parts that were not available for purchase. Another may wonder why he just spent all day making a part that is similar to one he could have purchased for two dollars. (The difference, of course, is that it is not the same as the two dollar part — it is *exactly* the part needed.)

Jewel-like projects like this miniature marine winch are a showcase for the kind of craftsmanship machinists strive for. Being able to display your work on a desk or coffee table or even carry it with you in your pocket is an advantage of working on small projects.

5.6 There are no shortcuts

Machining is a slow process because parts are made one at a time. The interesting thing is, a skilled machinist may take almost as long to make the same part as a novice. Shortcuts usually end in failure. Unlike some other trades, mistakes cannot be covered up. There are no erasers, white-out or "putting-on tools"for machinists. You

simply start over. Do a lot of thinking before you start cutting. To expand a little on an old rule: "*Think three times, measure twice and cut once!*"

5.7 Anticipation of a tool's limitations is the crafts man's strength

The skill in machining isn't just "moving the dials". It is a combination of engineering and craftsmanship. A file is just as useful a tool to a machinist as a multi-thousand dollar machine tool. Tools "deflect" or bend under load, and anticipating this bend is what it is all about. Sharp tools deflect less than dull tools, but with each pass the tool dulls a little and the deflection becomes greater. If you try to machine a long shaft with a small diameter, the center will always have a slightly larger diameter than the ends because the part deflects away from the tool where it has less support. You can go crazy trying to machine it straight, or you can simply pick up a good, flat mill file and file it straight in a few moments. Machine tools will never replace the "craftsman's touch and machining is a combination of both good tools and good technique.

5.8 The great parts about running a business like this

I'm a hobbyist who has been lucky enough to make a living at a hobby I enjoy. I own and manage Sherline Products Inc. and enjoy coming up with new products. After working at if for over twenty-five years, this has become more of a hobby to me than a business. I still work the same number of hours, but it's more fun now that I don't have to worry about making payroll. I have a good staff to take care of the day-to-day business, and I get to spend most of the day thinking about better ways of doing things and deciding which new products to make. I appreciate it all the more because it wasn't always that way. At first I had to do it all; buying and maintaining machines, making parts, assembling, packaging and shipping them, doing the bookkeeping and paying the taxes. I realized I had reached a real benchmark in business when I found that a product had gone from raw material to delivery and 1 didn't know one thing about it.

Here's a miniature machine tool you won't often see. The ManSon lathe is a fully functional miniature machine tool made in the 1940's by a Los Angeles company. It had a number of accessories available, but its extremely small size limited the projects you could actually make on it. It is one of a number of miniature machine tools collected for display by the author. (Sherline chuck and toolpost are for size comparison.)

5.9 The satisfaction of watching others progress

Another thing I enjoy is determining how a particular part will be run through the shop. Designing new products has become easier for me now because of the wide assortment of tools we own — about a million dollars worth. In 1985, I could set up and operate every machine I owned, but that time has passed. I don't operate my own machines now because they are too complex to casually start pushing buttons. I have to rely on my employees, and I get a lot of enjoyment out of watching employees progress as they become accomplished craftsmen in their chosen trade. However, I still don't believe anyone in the shop knows more about making good parts than I do. I may not know what button to push any more but I'm still the best at solving problems in the shop. I've learned a lot about machining over the last 30 years and I'm going to try to pass on some of that knowledge. Because of my experience 1 can compare methods used by a hobbyist and a professional machinist. I've have also added information that I hope you will find interesting about machining. It will give me a lot of satisfaction if I inspire readers to strike out on their own and start a new business with a product that has been "prototyped"on Sherline machines.

5.10 The Inspection Department only finds mistakes after it's too late

Most of this knowledge I've gathered has been learned the hard way because money was too tight to hire experts. At Sherline we make all of our own parts and only contract out the plating, heat treating, and powder

coating. In the past, we have also done a lot of contract machining and I've learned the problems one can get into by finding errors in the inspection department. It's just too late. Parts must be inspected as they are built, not after. Errors found after the parts are made mean you start over. Design errors found after the parts are made will always result in scrap. The only difference is who pays for the scrap.

5.11 Work extra hard to eliminate errors when "the chips are down"

I've never met a good craftsman who wants to do a job over, even when he is getting paid for it. It goes against his nature. I have also never met a good craftsman who has never had to do a job over because of his own mistakes. This is a good time to stay away from him, because he is mad at himself. The fact is, you can't work with this many types of tools, dimensions, and materials without making an occasional error. The trick is not to make errors when it counts. Good toolmakers will work with an entirely different attitude when they are making an inexpensive fixture than they will when working on apart that has thousands of dollars worth of material and labor in it.

5.12 Inattention can lead to more than just scrapped parts

You can't have a couple of beers and machine good parts. The job is too demanding. Machining is a serious business. Inattention can result in scrap or, worse yet, injury. You can always make another part but you can't grow a new hand. Even a machine as small as a Sherline lathe or mill can give you a nasty cut. Machinists may have to work for days at a time with their hands in close proximity to moving cutters and parts, yet there are few injuries. They pay attention to what they are doing.

5.13 The credit for a good part goes to the craftsman

Good craftsmen know when they have made an exceptional part and get much satisfaction from it. They also have the ability to produce good work on machines that should be in a junkyard. It just takes them longer. I have a great respect for good craftsmen, because they have to work without excuses or erasers. I try to keep reminding you of this fact in this book, because it is the craftsman, not the machine, who builds the beautiful things we see daily in this world. Modem machines have given this talented group of people a way to produce more and better work, but it will always be their "touch" that makes those parts beautiful. In my eyes they just don't seem to get enough respect.

5.14 An open invitation

If you ever travel to San Diego, California, the Sherline factory is less than an hour away to the North. It's also about two hours South of Los Angeles. I always offer an open invitation for anyone to stop by to see how modern production machines produce parts used in Sherline tools.

"You've achieved success in your field when you don't know whether what you're doing is work or play."

— Warren Beatty

Sherline's facility has a showroom where you can see the entire line of tools and accessories as well as some sample projects built on the tools. Factory tours are available for anyone who would like to see how miniature machine tools are manufactured.

Часть III

PROJECTS... A gallery of miniature craftsmanship

This section is devoted to showing you some of the great projects made on tabletop machine tools tike those discussed in this book. After all, it isn't really the tools you are interested in so much as what can be made with them. A column of figures about the size and accuracy of a machine will tell you how big it is and how well it is built, but it still won't tell you what can be built with it. These photos are some of the most important in the book because they show what these tools in the hands of craftsmen have actually done. And yet, as impressive as some of these projects are, they still only represent the best of what has been done to date, not the best that will ever be done. That is up to you.

Hundreds of years ago, craftsmen made timepieces and mechanical calendars that required tremendous precision. Modelmakers made tiny ships in bottles and detailed display models of ships. In fact, before naval architects began drawing plans of ships and shipwrights knew how to read them, ship designers built models and the builders used that as a guide. Despite the quality, accuracy and detail of these old projects, the tools they had to work with were crude by today's standards. As tools and materials have improved, it has become easier and more fun to make very precise parts. Almost all of the projects shown here were made by hobbyists, not professional machinists. If you have patience, some skill with your hands and a desire to make projects like these, today's tools will bring you a lot of satisfaction and enjoyment. There is not a project here that couldn't have been built on a tabletop in your own kitchen, den or home shop.

An American quarter and dime are used for size reference in many photos in this book. For those outside the United States who might not be familiar with these coins, they are shown here at actual size. A quarter ($.25) is .950" or 24.1 mm in diameter, while a dime ($.10) is .705" or 17.9 mm in diameter.

Steam tractor, Dennis Franz, Newton, Kansas

A lot of detail is packed into a very tiny package. This model won 2nd prize at the 1995 Sherline Machinist's Challenge contest in Michigan.

Stover "hit'n miss" gas engine George Luhrs, Shoreham, New York

Paint and pinstripes add a nice finish to this model which finished 4th in 1995. It has a 7/16" bore and 5/8" stroke. The speed control is quite detailed and complicated.

1/12 Ferrari V-12 F1 Engine Bob Breslauer Ft. Lauderdale, Florida

Approximately 1500 hand made pieces went into this display model engine and transmission. More photos of it can be seen in the profile on Bob on page 311 at the beginning of Section 5.

Single action steam engine Chris Thompson Colorado Springs, Colorado

At the extreme small end of the size scale is this tiny steam engine with a 1/8" (3.2mm) bore and stroke.

Gattling gun, George Britnell, Strongsville, Ohio

This walnut and brass gun took 3rd place in the 1995 Sherline Machinist's Challenge contest. The barrels rotate and the elevation mechanism also works. The quality of finish on every part is superb.

Miniature micrometer, Dennis Scherf, Cedarburg, Wisconsin

Miniature tools are a popular subject for modelers. This tool and felt-lined box can easily be carried in a pocket and is a great "conversation starter."

Air Compressor, steam engine and miniature tools Kurt Schulz, Harper

Woods, Michigan Not just a steam engine, but the air compressor to drive it too, this handsome model is an interesting combination of round and hard edged parts, satin and shiny surfaces. At the bottom are some other of Kurt's projects: a miniature height gage and two small mill vises sitting on a ground surface plate. The small vise would make an interesting tie tack!

Hot air engine, Scotty Hewitt, Van Nuys, California

This delicate engine is powered by the difference in temperature above and below it. Set it on a hot cup of coffee, give it a turn and it will spin like crazy for over 15 minutes. Scotty produced a short run of these to sell in toy stores.

Lunkenheimer oiler, Jerry Kieffer, Deforest, Wisconsin

Just like the full size prototype, this tiny oiler delivers measured amounts of oil to a bearing or cylinder. The "sight hole" through the base allows the engineer to check the drip rate visually.

.010 Diesel model aircraft engine

A simple design and nicely made aluminum parts make for an interesting little engine. Not much in material cost here!

1/30 Corliss steam engine Jerry Kieffer, DeForest, Wisconsin

(Below) This model represents Jerry Kieffer's determination to build to scale down to the smallest detail. Even 1/4-20 bolts are scaled to 1/30 size. Though modelers will often use hidden springs to return the valve gear, the "pots"at the bottom actually pull a vacuum just like the real ones. A portion of a quarter can be seen at the bottom for scale. (More on Jerry and this engine can be found on page 112.)

Above is a photo of the real 1909 Viltcr Corliss engine Jerry used as a prototype for his model. It can be seen in a steam engine display in Sussex, Wisconsin. It is said to produce about 200 horsepower at 90 RPM, had a 15" bore and 36" stroke and a 10-foot diameter flywheel. The Vilter company still exists in Milwaukee and now makes refrigeration equipment.

This masterfully built model runs flawlessly on air supplied from a tiny aquarium air pump. Though others told Jerry he would not be able to achieve good performance in a model this small if he insisted on scaling every part, he proved them wrong.

The photoengraved name plate is typical of Jerry's devotion to detail. Notice the hollow air line going into the large brass elbow. It has a functional compression fitting and is made from a hypodermic syringe needle.

U.S.S. Roosevelt Richard DeVynck U.S. Virgin Islands

This model is now on display at the Bowdoin College Museum in Maine. To the left is a detail of the ship's boiler. Below can be seen the stack and some of me deck details. The model is left unplanked so that all the interior details can be seen.

1 -Cylinder 4-cycle overhead valve model airplane engine Ron Colonna, McKeesport, Pennsylvania

(Above) Ron built this engine from a design by Eric Whittle of England. The highly polished pieces and wood base make it a good display as well as a nice piece of engineering.

3-Cylinder engine, Jesse Brumberger, Macedon, NY

(Above left) This radial model airplane engine was an entry in the 1996 Sherline Machinist's Challenge.

Assorted small projects, Robert Culpepper

(Left) A small shop can tum out plenty of nice work.

Robot Hand, Carl Hammons, Escondido, California

Joe's partner Carl was interested in robotics and motion control. He built this 4" hand to test a concept he had in mind for gripping.

Fantasy Gun, John Winters, Seattle, Washington

Lost wax castings and machined parts are combined in this air powered, B-B firing gun that looks as if it came straight from a Buck Rogers episode.

Custom silver key ring, Jim Grabner, Leucadia, California

The spiral and radial geometric pattern on this silver key ring helped it win a blue ribbon at the San Diego County Fair in Del Mar. Projects like these are not what comes to mind when most people think about "machine tools but in the hands of a creative person, a good tool makes many things possible. Jim used a rotary table on the mill to create the patterns.

Hula-hula radial engine, Russell Kutz, Clinton, Wisconsin

(Left) This engine gets its name from the interesting action of the six oscillating radial cylinders.

1/6 Porsche piston and cylinder Pete Weiss, Escondido, California

(Above) As part of a project to build a running 1/6 scale Porsche flat 6-cylinder engine, Pete has so far built a number of the components. See page 120 for more photos.

Gap frame stamping press Glenn Busch, St. Clair Shores, Michigan

Here are two views of a solidly built and nicely finished model. The contrast of brass and aluminum parts give it a very rich look.

Gyroscope Tim Schroeder, St. Joseph, Michigan

(Right) This nicely finished gyroscope includes details like lightening holes in the support arms and chamfered holes and edges on the wheel. Tim is a professional photographer, so even the photos of his work are done with great attention to detail.

Marine engine and drill press/Water pump Scotty Hewitt, Van Nuys, California

Scotty's main project won 1st place in the 1995 Sherline Machinist's Challenge, but he also took 5th place with this one. To the right is another of Scotty's projects; an air powered water pump. Scotty's work always combines many materials, skills and a lot of imagination. Notice how the wood bases add a finishing touch like a good frame on a nice painting. For more photos and a profile on Scotty see page 24.

Radar study model Frank Libuse, Carlsbad, California

This waterline model was used to test radar targeting systems for antiship missiles. A number of small deck fittings had to be fabricated from metal. Simpler models were also made to see how much detail was needed for a missile to be able to recognize and target a particular ship.

Frank is a pilot and industrial designer who started his own design firm and industrial model shop after retiring from the Air Force. He is also Craig's father. and Craig worked with Frank for several years in the design and model business before starling his own design firm.

Miniature Stuart 10V steam engine Chris Dinardo Springfield, Illinois

The large hex bolt used as a display base really points out how small this engine is. Despite its small size, all the working details are still there, modeled in bronze, brass and steel.

2-Cylinder marine engine Raymond Hasbrouck, New Platz, New York

(Below) This model exhibits a nice combination of materials and finishes. Notice the engine-turned pattern on the base. The custom propeller is an interesting project all its own. (To learn how to make one, see page 56.)

Thimble steam engine Richard Long Wichita, Kansas

(Above) This tiny butane powered engine drives a stamping mill. Using the thimble as part of the design is a clever way to emphasize small size.

Model airplane display engines Edwin Teachworth, San Diego, California

This display model of a 1911 compressed air engine was built for an exhibition on the history of model aviation at the San Diego Aerospace Museum. Though it looks like metal, it is made from cut and machined styrene components and painted to look like metal. Styrene is easy to work with, glues together quickly and is popular for modeling.

This is another display model from the same exhibit and is a model of a Stringfellow steam model airplane engine. It is made from a combination of materials including styrene, wood and brass. The original engine won a prize for engine design in 1868 and developed about 1 horsepower. Display models need only look like the prototype, while function is less important than looks, cost and ease of building.

Stop motion animation dog, Tom Brierton, Illinois

With all the joint movements of a real dog, this framework is covered in clay and then photographed one frame at a time as it is moved in progressive steps.

Pre-lubricator for steam or air engine Salvatore Rubino, Naperville, Illinois

This device provides oil under pressure to lubricate bearings before an engine is started. This extends engine life substantially since most wear occurs when bearings are dry.

Scroll saw and die filer conversion Milo Bresley, Bloomington, Minnesota

Mr. Bresley designed and built a die filer and scroll saw powered by his Sherline lathe. The die filer is driven by the "Scotch yoke" principle. Many people find the chief source of enjoyment in their hobby is designing and making new accessories for their machines. It not only provides a fun and challenging project, but your machine shop is that much more complete when you are done.

Quick-change tool holders Roland F. Gaucher, Spencer Massachusetts

This working model of an Aloris toolholder is built 3/10 the size of the #1 size holder used for full size machines. These holders follow big machine practice, allowing tools to be quickly locked onto a special dovetailed holder. This is another good example of using the tools in your shop to build accessories to make your shop that much better equipped.

Model hot rod, Augie Histano, Miami, Florida

This 1/25 scale hot rod won the top national award for model cars. Shown here is just the engine and frame. Notice the scale Jaguar independent rear suspension made up of almost 100 separate parts.

Custom model boats and engines Don Martin, Sacramento, California

Don's small shop turns out some excellent R/C drag boats. ЛИ his tools are within easy reach and a vacuum cleaner rests under the

(Above left) High performance machined out-drive components and exhaust tips sparkle on Plum Nasty's transom.

(Left) A Connolley V-8 with supercharger sits on its test stand. The rig provides readings on temperature and RPM.

Shown above is the front part of the hot rod engine being machined from an aluminum block. Behind it is the photo of the actual Ford 427 engine Augie used for reference in detailing his model. More on Augie and his award winning models can be found in a profile on page 180.

Double Corliss steam engine Wilhelm Huxhold West Hill, Ontario, Canada

This beautiful and ambitious project demonstrates why retired machinist Wilhelm Huxhold's work is considered among the best being produced. The closer you look at every part, the better they look. Although Mr. Huxhold's shop is equipped with many full-size machines, his favorite projects are very small in size and are well within the capabilities of the tabletop machine tools discussed in this book. Now that he is retired, he still puts in a full day's work, but he gets to choose the projects.

Triple expansion steam engine (left) and machinist's vise (above)

This highly detailed steam engine won the 1997 Sherline Machinist's Challenge contest. The vise is only a few inches long and duplicates every detail of the original right down to the engraved angle scale. The handle is removable.

Naval cannon display (left) and steam engine (below) Timmy Perreira, Haiku, Maui, Hawaii

This 17th Century 24-pound naval cannon is set in its own diorama. The ship's deck setting adds a sense of purpose to the brass and oak cannon. Below is a Rudy Kouhoupt-designed steam engine Mr. Perreira built from brass, aluminum and cold rolled steel.