Professional Jewelry Making

A Contemporary Guide to
Traditional Jewelry Techniques

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ACKNOWLEDGEMENTS

Many generous people have helped in the preparation of this book. During my practice and education I have met and shared information with countless craftspeople and other experts, each offering a unique point of view based on their own personal experiences. In 1972, in search of training that I could not find in the United States, I traveled to Pforzheim, Germany, a town known throughout the world as the “Gold City.” Pforzheim is located in the Black Forest region, and for nearly two hundred years it has served as a major international center of goldsmithing and jewelry manufacturing. For two years I had the good fortune to study at Pforzheim’s world-renowned Fachhochshule für Gestaltung, formerly the Kunst und Werkschule, with students from jewelry communities around the world. Indeed, the school has trained leaders in the jewelry industry for well over a hundred years. Jewelry historian Ralph Turner noted that the Pforzheim school “has probably produced more creative jewelers than any equivalent anywhere else in the world.”

Professor Reinhold Bothner was most responsible for my training as a goldsmith. At the time that I worked with him, he was the senior master goldsmith in Pforzheim, having spent half a century creating treasures. I studied design with Professor Reinhold Reiling, a master goldsmith and internationally acclaimed jewelry designer. Professors Föll and Zeiss trained me in the skills of hand engraving and stonesetting, respectively. In addition to my classes and studio work, I was employed in several workshops, including that of Klaus Ullrich, a renowned designer, master goldsmith, and master silversmith. It was while working for Professor Ullrich that I learned how to use precious metals.

Many other dedicated craftspeople helped me gather the information presented in this book. We all share a love of fine metal work and together are carrying our craft into the next millennium. Some are senior members of the jewelry community, and some are newcomers whose enthusiasm has helped keep the torch lit. Among these fine craftspeople are George McLean, Evert DeGraeve, Edward Friedman, Michael Good, Yas Tanaka, Jon T. Dixon, Karen Sprague, Paul Christiansen, Harold O’Connor, Steven Kretchmer, Jaime Pelissier, Doug Zaruba, Frank Trozzo, George Sawyer, Joannie Mar, Wellington Dong, Julie Harrington, Holly Beye, Emmy McKenzie, Neal Pollack, Irene Hogan, Irving Gold, Enrique Lopéz Larrea, David Clarkson, Keith Bartel, Abrasha, Michael Smorra, and Gregory Steerman. In addition, I wish to thank the many students at the Revere Academy of Jewelry Arts who helped me prepare the material for this book including: John Sliwa, Bruce Morrison, Catherine Glew, Jay Vullings, Keith Saslaw, Eric Baltzley, Vinnie DiPadova, Terry Cook, Jeff Gray, and Kristin Baker.

Two modern masters, Tim McCreight and Charles Lewton-Brain, contributed significantly to this project through their service as technical editors. I would like to thank George Holmes, the editor of Jewelers’ Circular-Keystone where much of this material first appeared, as well as Lilly Kaufman of Van Nostrand Reinhold for her support; Anna M. Miller for putting me in touch with VNR; and jewelry writer and critic Ettagale Blauer for her encouragement.

I would like to thank Bill Nigreen and Max Yasgur who colluded to save me from law school, as well as Andrew Wilner who showed me that crafts could be a way of life. I acknowledge Carolyn Chaiken Rosenberg who introduced me to art and craftsmanship at an early age. In addition to the photographs, Barry Blau has given this project many years of his tireless perfectionism and humor, both in the original and now revised edition.

The reworking of Professional Goldsmithing into Professional Jewelry Making was possible thanks to the tireless hours by my assistant, Christine Dhein, and book designer Kathleen Cunningham. Also thanks to Yas Tanaka and James Binnion for technical assistance, to emiko oye for her work on the illustrations, and to Robert Graham for his eye in proofing the text.

Finally, I wish to thank Sherli and my father George for their support, patience, and encouragement during my journey, as well as my children Dustin and Alexis, who inspired me to prepare this material for future generations.

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In the early 1700s a French philosopher, art critic, and writer named Denis Diderot began the monumental work of creating the largest encyclopedia of his time, *L'Encyclopédie, ou dictionnaire raisonné des sciences, des arts et des métiers* (The Encyclopedia or Rational Dictionary of the Sciences and Trades). Through twenty-eight volumes of highly detailed engravings, Diderot documented the technology of pre-industrial Europe. The original 1751 edition, which was later revised, covered hundreds of subjects in great detail, from the art of gardening to the art of war, from belt making to barrel making, and from blacksmithing to goldsmithing.

Nearly three centuries have passed since Diderot's encyclopedia first appeared, and in that time, most of the trades he described and illustrated have either disappeared or have been mechanized by modern technology. Interestingly enough however, the art of jewelry making has remained virtually unchanged. Jewelry makers today still fabricate rings and bracelets in much the same way as did the artisans of Diderot's time, and moreover, the tools they use have remained nearly identical to those that Diderot documented. And despite the passage of nearly three centuries, the finest jewelry is still made the old fashioned way, by hand.

This book follows the spirit of Denis Diderot, documenting the practice of making jewelry using precision photography along with detailed technical instructions. The material in this book was compiled in the workshop of the Revere Academy of Jewelry Arts in San Francisco, California, and is based on classical goldsmithing education as handed down for generations. It describes a series of practical projects including rings, chains, bracelets, earrings, and clasps. The work was executed by Alan Revere, a modern master jeweler, and is presented in a graduated format. Each project has been successfully completed by student jewelers following the instructions presented in this book.

*Professional Jewelry Making* is a revised and expanded version of *Professional Goldsmithing*, by Alan Revere, originally published in 1991. This edition includes larger photographs that have been refined and corrected to show the greatest level of detail. *Professional Jewelry Making* includes five new chapters as well as a totally new look and layout.

The projects in this book are generally arranged in order of difficulty; that is, the first few are the easiest and they become more challenging as the book progresses. Later projects may include techniques introduced earlier. Because skills are presented as they are needed and some procedures are used in several projects, we presume that the reader will be familiar with those techniques already discussed in earlier chapters. In many cases, several different techniques can be used to achieve the same results, and so different solutions to the same type of problem are demonstrated in different projects.

Before embarking on a project, it is best to read through the procedures and study the illustrations. Try to understand and visualize what is happening. Try to imagine how
the metal is being transformed, how the tools affect it, and what it should look like when completed. While you are making a new piece, keep a journal in which you can take notes and make sketches. You could even place the finished piece of jewelry on a copy machine and paste the image into your journal.

Above all, enjoy yourself. The purpose of undertaking these projects is to build and improve your skills. Take the time required, without distraction, to do your best. While the purpose is to challenge yourself and learn new skills, do not attempt a project that is too far beyond your current level. It is more rewarding to complete a simpler project well than to struggle and meet frustration at every turn in a more advanced one.

This book is intended for anyone interested in making jewelry and doing fine metal work. For beginners it provides a graduated course of study in the art of making jewelry, with an emphasis on hand skills. For experienced jewelry bench workers, the projects provide a chance to increase technical versatility. And for the jewelry collector, historian, and merchant, this book demystifies one of humankind’s oldest and most refined art forms.

The projects are presented clearly and concisely, with step-by-step instructions for replication in a small jewelry workshop, with photographs and text to show how to hold each tool and fabricate the components of each project. Instructions reveal trade secrets and tricks that are rarely taught in schools and seldom shared in today’s jewelry industry.

An old master once said, “The art of jewelry making is really very simple and can be summarized by ten techniques. However,” he said with a smile, “there are ten thousand tricks.”

Begin counting.
Part 1

Getting Started
Chapter 1

Precious Metals
Throughout history, precious metals have been highly valued and sought after. Precious metals are extremely durable because they are highly resistant to attack from the environment, most acids, and tarnish. The title noble metals refers to the high value and enduring quality that sets these metals apart from all other elements found in nature.

Gold was probably the first metal discovered, and it has been used to fashion objects of special value and adornment for thousands of years. Gold is the king of metals in several regards. It is the only yellow metal and it is more visually striking and workable than all others. Silver has also been widely used and appreciated since antiquity for its high degree of workability and for its white lustrous appearance. Platinum, although found in pre-Columbian artifacts, was not significant in jewelry until the nineteenth century.

There is a total of eight elements under the collective grouping of precious metals; they are gold, silver, and platinum, and the five other metals in the platinum family: iridium, osmium, palladium, rhodium, and ruthenium (Table 1.1).

Their durability, appearance, and malleability make all of the precious metals (except osmium) ideal for use in jewelry. A metal is an element characterized by a distinctive luster, malleability, ductility, and thermal and electrical conductivity, or is an alloy of such metals. In turn, an alloy is a mixture or combination formed by the fusion of two or more metals. Pure metals are elements and cannot be separated or purified further. Of the 79 metals among the 103 naturally occurring elements, only 4—gold, silver, platinum, and copper—are found in metallic form in nature. Native metals, as these are called, are rarely pure but are usually found in natural alloys with other metals. Native gold, for instance, is generally combined with varying proportions of silver; when it contains approximately 50 percent silver, it is called electrum. The six platinum metals are found together in nature and share similar characteristics, in fact, the six were not completely distinguished until the nineteenth century.

**GOLD**

Gold has been used in jewelry for over seven thousand years! The beauty of pure gold is incomparable. As the only yellow metal, its rich, deep yellow color and its substantial weight are universally appealing. Ancient people associated gold with the sun and gold has always stood for wealth and power. Throughout the ages, most of the gold that has been mined has been used to make articles of jewelry and ornamentation. Even today, approximately 56 percent of the world’s output of gold is used to make jewelry. Another 13 percent is consumed by electronics, industrial, and dental uses, and 31 percent winds up as gold coins, bars, and other investments (World Gold Council 2009). Gold has often been the standard on which paper currency is based. Until 1939, the paper money of the United States was backed by gold, meaning that upon demand at a bank anyone could redeem gold for their paper money.

Gold is the most malleable (i.e., “softest”) of all metals, which means that it requires the least effort to bend and shape. It is also the most ductile, making it easiest of all metals to draw into a long wire without breaking. In fact, 1 ounce of gold can be drawn into a fine thread several miles long. Pure, or fine, gold is exceptionally well-suited

<table>
<thead>
<tr>
<th>Metal</th>
<th>Symbol</th>
<th>Atomic Number</th>
<th>Jewelry uses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gold</td>
<td>Au</td>
<td>79</td>
<td>Usually alloyed with other metals for jewelry</td>
</tr>
<tr>
<td>Silver</td>
<td>Ag</td>
<td>47</td>
<td>Usually alloyed with 7.5 percent copper to make sterling</td>
</tr>
<tr>
<td>Platinum</td>
<td>Pt</td>
<td>78</td>
<td>Usually alloyed with other metals for jewelry</td>
</tr>
<tr>
<td>Iridium</td>
<td>Ir</td>
<td>77</td>
<td>Traditionally added to platinum to increase hardness</td>
</tr>
<tr>
<td>Palladium</td>
<td>Pd</td>
<td>46</td>
<td>Used to make setter’s white gold. Contemporary use on its own</td>
</tr>
<tr>
<td>Rhodium</td>
<td>Rh</td>
<td>45</td>
<td>Electroplated over white metals for durable finish</td>
</tr>
<tr>
<td>Ruthenium</td>
<td>Ru</td>
<td>44</td>
<td>Sometimes added to platinum and gold for hardness</td>
</tr>
<tr>
<td>Osmium</td>
<td>Os</td>
<td>76</td>
<td>Too hard for jewelry uses</td>
</tr>
</tbody>
</table>

Table 1.1 The precious metals.
Professional Jewelry Making

to chasing and forging, but like pure silver and pure platinum, it is generally considered too soft for jewelry due to its vulnerability to scratching, denting, and wear. Some Asian (mainly Chinese) jewelry is made with pure gold, but in the West, pure gold is rarely used in jewelry, except in certain cases. For instance, fine gold and fine silver are used in enameling, and occasionally a bezel is made of pure metal to facilitate the setting of very fragile gemstones. Most often though, pure gold is alloyed with copper and silver in varying proportions to produce the wide range of karat gold alloys used in jewelry (Illustration 1.1). The proportions of these three metals determine the color and working characteristics of the alloy.

Gold and other precious metals are weighed and traded internationally in troy ounces. In this ancient system, 1 troy ounce equals 20 pennyweight (dwt), each of which contains 24 grains. In the metric system, 1 troy ounce equals 31.103 grams.

**KARAT GOLDS**

The purity or fineness of gold alloys is based on the proportion of pure gold to other metals. The measure of gold’s purity is expressed as its karat, abbreviated K, Kt, k, or kt in the United States. In Great Britain the spelling is carat, abbreviated c or ct. The term carat also refers to a completely separate system used to weigh precious gems. One carat equals 0.2 grams. This usage has ancient roots, derived from the consistent weight of a carob seed.

In the karat system, gold’s purity is measured in twenty-four parts, and so fine gold (100 percent pure) contains twenty-four/twenty-fourths gold, which is stated as 24k. An alloy that contains 75 percent, or eighteen/twenty-fourths gold is 18k. The fineness of precious metals can also be expressed in parts per thousand, which is the international system used in most other countries, making pure gold 1000 fine, and 18k equal to 750 fine. Pure gold thus can be stamped either 24k or 1000. Gold suppliers offer a wide variety of alloys, or karat golds, to meet specific needs such as casting, fabrication, or pinstems for brooches (Table 1.2).

**18K GOLD**

Eighteen-karat gold is the international standard for the finest gold jewelry. This alloy is 75 percent pure and highly workable. It is composed of 18 parts gold by weight and 6 parts other metals, making it a nearly perfect compromise between pure gold’s rich yellow color and feel, and the increased hardness and durability made possible through alloying. The exact composition and proportion of the non-gold components depends on the color and working characteristics that are sought (see Physical and Mechanical Properties of 18k Gold Alloys in the Appendix).

Silver and copper are the primary metals added to make 18k alloys. When there is a greater proportion of silver, the result is a softer gold alloy with a greenish tint. Red-gold alloys contain a greater proportion of copper, which raises the hardness. An 18k alloy with an equal amount of silver and copper is a deep yellow color. It is very workable and ideal for most jewelry applications. Small amounts of zinc are sometimes added to karat golds in order to lower the melting point.

In England, 18k gold became legal for jewelry during the fifteenth century, and it has been used for jewelry ever since. In the United States, 18k gold is used for the finest gold jewelry, with the majority of commercial jewelry being produced in 14k gold.

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Illustration 1.1 Diagram of the Au–Ag–Cu ternary system.
In the United States, most gold jewelry is 14k, or $\frac{14}{24}$, gold. Fourteen karat gold is 58.333 percent pure gold. Convention has converted this number to the more manageable and slightly finer 58½ percent gold, which can also be expressed as .585, or 585/1000 pure. This quality is stamped 14k in the United States, and often 585 in Europe. The remaining 41½ percent is usually composed of silver and copper. Fourteen karat gold is harder than 18k and more durable for jewelry use, although it is paler in color. The more copper there is in 14k alloys, the redder the color will be (see Physical and Mechanical Properties of 14k Gold Alloys in the Appendix). Likewise, the greater the proportion of silver is in the alloys, the greener the color and generally the softer the material will be. Rings, chains, and settings made of 14k gold will outlast similar items made of 18k, because of the increased hardness. Most 14k gold alloys need to be annealed more frequently than do 18k alloys, and most 14k gold alloys are less resistant to tarnish than higher karat alloys. In addition, 14k gold is considerably less expensive than 18k gold because it contains approximately 20 percent less pure gold. It is also less dense, further lowering the cost compared to that of 18k gold.

**White Gold**

White gold alloys were developed in the twentieth century as a substitute for platinum. White gold can be produced in several finenesses, including 14k and 18k. Two types of
white gold are most often used in jewelry manufacture: alloys that contain nickel and alloys that use palladium. Nickel white golds employ nickel as the bleaching agent, and produces the least expensive white-gold alloy. The addition of nickel hardens gold alloys, making them more durable and able to take a higher polish. Its hardness makes nickel white gold less desirable for forging, forming, and especially for bright-cut or bead setting.

Palladium white-gold alloys are called setter's gold. They are grayer in color and better suited for gem setting, especially bright-cut or bead setting. Palladium white-gold alloys are more costly than nickel white-gold alloys, because palladium itself is a precious metal. Other metals that can be found in white-gold alloys include platinum, silver, copper, zinc, and manganese.

SILVER
Silver is an important precious metal and is used in jewelry all over the world. It has been prized throughout history for its unique whiteness, high degree of reflectivity and excellent working characteristics. As a pure metal, silver is second only to gold in malleability and in ductility. Aside from its use as a component in most gold alloys, silver is the principal component of sterling silver. Pure silver is generally considered too soft for use in jewelry and other objects and is usually alloyed into the universally standard sterling quality. Sterling silver contains 92½ percent silver and 7½ percent copper; it is easy to work yet durable enough to stand up to extended wear.

FIRESCALE ON STERLING SILVER
After silver alloys are heated, a characteristic stain frequently appears on the surface. This stain is called firescale and is a result of the oxygen combining with copper, where it forms a subsurface copper oxide.

The risk of firescale is increased by exposing the metal to high temperatures for extended periods during both annealing and soldering. Firescale is not immediately noticeable because it is hidden by the effects of a process called depletion plating. During the pickling process, surface oxidation and nonprecious metals in the alloy are removed, raising the fine metal content on the surface, thereby concealing the stain. Firescale then usually appears during sanding and polishing, which breaks through the surface layer of metal, revealing the purplish stain below.

The two approaches to dealing with firescale are prevention and remedy. If the metal is sealed from oxygen, the chances of firescale occurring are diminished. This can be accomplished by heating the metal in a controlled atmosphere without free oxygen to combine with the copper in the silver alloy. Unfortunately it is not possible to control the atmosphere in the ordinary jewelry workshop, and so the jeweler’s most effective firescale preventative is to coat the metal with a thin layer of flux before heating it. When it is heated, the flux glazes the surface, like a clear enamel, and blocks the penetration of oxygen. Several formulas, all of which include borax, are at least partially effective for preventing firescale. The most common formula for fire coat protection is an equal amount of powdered boric acid mixed with alcohol. Before being heated, the metal can be immersed in the mixture or it can be painted with the solution. Then, when the alcohol is ignited, the boric acid is released to coat the surface. Use caution when doing this, as it can start a fire.

Prip’s flux, another solution that is applied in a similar manner for this purpose has the benefit of not being flammable. Note, however, that no formula works all of the time. Thus when using with silver, it is best to minimize its exposure by heating it quickly. This prevents prolonged exposure to oxidation and reduces the effects of firescale.

After firescale has appeared, it can be removed mechanically, chemically, or electrolytically. Mechanical methods such as filing, sanding, and grinding remove the surface layer containing firescale, but this is often not practical because it is very time-consuming and distorts the dimensions and surface of the work. Mechanical methods used to dissolve the discolored oxidation also usually result in a finely textured surface. The electrolytical method for removing the surface is called electrostripping and is virtually the reverse of electroplating. In electrostripping, the surface metal is pulled off and deposited on the cathode in an electrolytic bath. But, this too is not a perfect remedy, as it also leaves the surface with a characteristic texture. An additional treatment of firescaled surfaces is to electroplate over the area. Unfortunately this is merely a cosmetic
remedy that will only temporarily mask the firescale. The best approach is to prevent the buildup of firescale by using an anti-firescale “fire coat” and reducing the metal’s exposure time during heating.

THE PLATINUM FAMILY

Platinum has been used since the sixteenth century, when it was discovered in South America. Initially it was associated with silver (plata in Spanish). Platinum is the most common and most widely used of the six metals in its family. Three of the metals—rhodium, ruthenium, and palladium—are light, having a specific gravity around 12. The other three—osmium, iridium, and platinum—are heavy, with a specific gravity nearly twice as high, around 21 or 22 (see Table 1.4). Grouped in another way, three of the metals—palladium, platinum, and rhodium—have even higher melting temperatures, between 1550 and 1970°C. The other three—ruthenium, iridium, and osmium—have very high melting temperatures, over 2200°C (see Table 1.5). All of these metals are highly resistant to corrosion, and aside from osmium, which has no jewelry application, they are used by jewelers. Osmium, even annealed, is so hard that it is virtually unworkable and so it is used where extreme durability is required, such as for the tips of fountain pen nibs.

Platinum is used in jewelry because of its high degree of workability and its white tarnish-free color. Most commonly, platinum is alloyed with iridium, palladium, or ruthenium to increase its hardness. Platinum and its jewelry alloys behave similarly to gold in such areas as sawing, filing, drilling, rolling, drawing, forming, and forging. Noteworthy differences occur when soldering and polishing platinum alloys. During soldering, the melting temperature of the solders is so high that the metal is heated to a cherry red (which requires the use of very dark welder’s goggles).

It is good practice to work platinum in a clean station. Many jewelers have a dedicated workbench and soldering station just for platinum work. If you cannot have a dedicated workstation for this purpose, you should do a thorough cleaning of your workbench and soldering station because residues of other metals can contaminate the platinum work. For example, it is important to clean all files so that metal stuck in the teeth of your files will not be embedded in the platinum and contaminate the piece.

With the advent of new technologies in the jewelry field, platinum work has become easier, or at least less time consuming. There are new filing tools (Valtitan files are excellent for platinum work); new sanding media (micron graded sheets, film, and strips); new polishing technologies (rubber, silicone, and ceramic polishing wheels); new platinum polishing compounds, and radial bristle disks; and new soldering technologies as well (platinum soldering goggles, tungsten soldering picks, and tungsten or ceramic-tipped tweezers for soldering). These new technologies have made it easier for jewelers to work in platinum with confidence.

<table>
<thead>
<tr>
<th>Metal</th>
<th>Density (g/cm³)</th>
<th>Hardness annealed</th>
<th>Hardness cold worked</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gold</td>
<td>19.32</td>
<td>20</td>
<td>58</td>
</tr>
<tr>
<td>Silver</td>
<td>10.49</td>
<td>22</td>
<td>100</td>
</tr>
<tr>
<td>Platinum</td>
<td>21.45</td>
<td>37</td>
<td>108</td>
</tr>
<tr>
<td>Palladium</td>
<td>12.02</td>
<td>37</td>
<td>106</td>
</tr>
<tr>
<td>Rhodium</td>
<td>12.41</td>
<td>123</td>
<td>260</td>
</tr>
<tr>
<td>Iridium</td>
<td>22.65</td>
<td>220</td>
<td></td>
</tr>
<tr>
<td>Osmium</td>
<td>22.61</td>
<td>400</td>
<td></td>
</tr>
<tr>
<td>Ruthenium</td>
<td>12.45</td>
<td>220</td>
<td>360/750</td>
</tr>
</tbody>
</table>

Source: Grimwade 2009.

Table 1.4 Density and hardness values for the precious metals at 20°C.

<table>
<thead>
<tr>
<th>Metal</th>
<th>Melting Point °C</th>
<th>Melting Point °F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silver</td>
<td>961</td>
<td>1762</td>
</tr>
<tr>
<td>Gold</td>
<td>1064</td>
<td>1947</td>
</tr>
<tr>
<td>Palladium</td>
<td>1772</td>
<td>3222</td>
</tr>
<tr>
<td>Platinum</td>
<td>1552</td>
<td>2826</td>
</tr>
<tr>
<td>Rhodium</td>
<td>1966</td>
<td>3571</td>
</tr>
<tr>
<td>Ruthenium</td>
<td>2250</td>
<td>4082</td>
</tr>
<tr>
<td>Iridium</td>
<td>2410</td>
<td>4370</td>
</tr>
<tr>
<td>Osmium</td>
<td>3045</td>
<td>5513</td>
</tr>
</tbody>
</table>

Source: Adapted from Grimwade 2009.

Table 1.5 Melting points of precious metals.
WORKING WITH PLATINUM

In most ways platinum behaves in a manner similar to gold and silver. Alloys of all three metals are highly malleable, ductile, and workable. Platinum and its jewelry alloys are filed, sawed, drilled, rolled, drawn and formed in an identical manner to gold and silver. Because of its hardness, however, platinum requires greater force during most mechanical processes and several extra steps when finishing.

A major difference is encountered when soldering platinum. Aside from its hardness, platinum is extremely resistant to oxidation and attack by the environment. It has a very high temperature range for soldering and is a very poor conductor of heat. For these reasons, procedures for soldering platinum are quite different from working with karat golds.

Platinum items to be joined must fit together perfectly before soldering, even to a higher standard than for gold. When polishing platinum, components must be sanded to a higher degree than for gold. It is helpful to prepolish all platinum components prior to assembly, a procedure that is frequently carried out in gold jewelry fabrication as well.

PLATINUM ALLOYS FOR JEWELRY

Pure platinum, like pure gold and silver, is too soft for use as jewelry. It is generally alloyed with other metals to increase its hardness. The most common platinum alloys are composed of 5 to 10 percent iridium, as well as other alloys that include 5 percent ruthenium or 7.5 percent palladium. Its high density and cost make platinum jewelry considerably more expensive than an identical item in karat gold. Offsetting this increased cost is the fact that platinum’s durability permits components to be thinner and more delicate than those possible in gold fabrication.

FLAME

Because of platinum’s high temperatures and resistance to heat conduction, a bright oxidizing flame is used when soldering, welding, and melting platinum. Any oxygen-fuel system will work for soldering platinum: hydrogen-oxygen is ideal and oxygen-natural gas, and oxygen-propane work well. Oxygen-acetylene is the least desirable. When heating—during melting, soldering, or fusing—try to work quickly, minimizing the metal’s exposure to heat.

WELDING

Because of its very low thermal conductivity, platinum can be welded or fused. The advantages of welding are that an additional level is added above the usual grades of solder while creating a joint that is clean and invisible. To close a ring shank by welding, roll out a small piece of the same platinum alloy to about 0.2 mm thick. Cut a small flat snippet slightly larger than the cross section of the ring. Use tension to hold it in place between the two sides of the shank. Heat the snippet directly, unlike working with gold, where heat must reach solder by conduction from warmer nearby areas. Heat intensely until the metal flows forming an invisible joint of solid metal. File to clean up excess metal. A second level of welding can be carried out using pure platinum (which has a slightly lower melting temperature than a 10 percent iridium alloy) as the filler material.

SOLDERING

After welding, many levels of solder are available for use with platinum. These begin at about 1700°C and drop in approximately 100° intervals down to as low as 900°C. Therefore complex pieces can be assembled in several soldering stages with decreasing melting temperatures. In addition, due again to the low heat transfer of platinum, it is possible to use the same level of solder very close to prior seams without disturbing them.

In all soldering operations involving platinum, extra care should be taken to make sure that components fit together perfectly. Platinum solder will not fill in gaps. Avoid using ordinary steel or iron tools such as tweezers, soldering picks, and binding wire that will contaminate the metal if heated together. Tungsten carbide works well for a soldering pick and soldering tweezers.

EYE PROTECTION

Due to platinum’s very high annealing, melting, and soldering temperatures, it is absolutely essential to wear dark welding goggles with a #5 filter to protect the eyes from the blinding white light emitted. Even darker filters can be used when melting platinum. An alternative to wearing goggles is to hang a rectangular filter of the appropriate obscurity in front of the work area during heating. Warning: Even the darkest sunglasses are not acceptable as protection when heating platinum.
Platinum does not oxidize or tarnish at all, and therefore does not require flux. Neither fire coat nor pickling is needed.

Whenever possible, hold the work in the air, not on a soldering pad or charcoal block. The bottom of an alumina crucible works well if a flat soldering surface is needed. Rings and other small objects should be held in a third-hand (mounted soldering tweezers) or other insulated cross-locking tweezers. Tweezers should hold the work at a point distant from the area to be heated, to prevent contamination. Either fine-nose tweezers or a wet brush can be used to pick up and transport the solder to its destination. Use many very small pieces of solder placed carefully along the seam, rather than a few large pieces.

Because the low thermal conductivity prevents the spread of heat over a large area, heat is directed to only a small area. There is no need to preheat or warm nearby areas. When soldering small items such as ring shanks, use a small, very hot flame directed at the seam. Platinum solder cannot be pulled along a seam as is possible when working with gold. Because of the slow heat transfer, the back of a platinum ring can usually be soldered without fear of overheating a gem set on top of the ring. Heat the solder directly until it flows, a distinct difference from gold procedure. When joining platinum to gold, use the appropriate gold solders.

**SOLDERING PAD**
Charcoal burns away quickly at the high temperatures needed for platinum. For this reason, use an alumina or ceramic soldering pad intended for this purpose.

**ANNEALING**
Platinum should be annealed when rolled or drawn to two-thirds of its original thickness. Platinum must be absolutely clean prior to heating. The metal should be placed on a clean ceramic block used only for this purpose. Use a bright oxidizing flame to heat small objects such as rings, and hold them at a bright orange color for thirty seconds. Large items require longer times for annealing. After heating, the metal can be air cooled or quenched in water.

**MELTING**
When recycling platinum scrap, only the very cleanest, solder-free metal can be melted without refining because platinum is easily contaminated by trace amounts of other metals. Melt small quantities at a time, and weld them together if larger pieces are needed. Do not attempt to melt large ingots. Place the metal in an alumina crucible, and heat with a very hot oxidizing flame until it melts and congeals into a button. Allow the metal to air cool or quench it in water after the red glow is gone. The round button can be hammered, rolled, sheared, and drawn to the size and shape desired.

**SETTING**
The strength and permanent brilliant white luster of polished platinum make platinum the perfect choice for areas that are to be pavé set with diamonds. Again its hardness enables the metal to be extremely thin while retaining its strength. Prior to setting, the metal should be annealed evenly to avoid hard and soft spots. Normal stone setting burs can be used effectively on platinum. Platinum responds well to engraving.

**FINISHING**
Platinum is more difficult to polish than gold because of its hardness and high density. Since the metal does not oxidize during soldering, pieces should be prepolished whenever possible before assembly. This is advantageous because small pieces are often easier to polish before they are joined to others. Platinum must be finished with more steps and more exacting craftsmanship than required for gold or silver. After rough filing or sawing, use fine #4 or #6 files to achieve a finer finish. Sand with a sequence of abrasive papers starting with 240 and going through 400 and 600 paper. Buff with bobbing compound and then tripoli. Polish with a hard platinum rouge such as white or yellow.

**HALLMARKING**
In Egypt as early as 2000 B.C., items of gold were tested and marked to indicate their purity. The term hallmarking derives from Goldsmith’s Hall in London, which has overseen the marking of gold in England since 1300 CE. Most countries base their system of hallmarking at least in part on
the English system. Each country sets its own standards for gold alloys and is responsible for enforcing them. Underkarating is the fraudulent stamping of precious metals, indicating a higher quality than an alloy really is. Underkarating is both a moral and a criminal offense punishable under the law. In fact, until 1815, hallmarking violations in England could result in a sentence of death.

Four systems of enforcement are currently used around the world:

**COMPULSORY HALLMARKING**
In England and France, jewelers must submit every item manufactured of precious metal to a regional office for testing and stamping. Items that do not meet the standards for which they are submitted may be destroyed by the testing facility.

**VOLUNTARY HALLMARKING WITH PERIODIC GOVERNMENT AUDITS**
In countries such as the United States, hallmarking and quality standards for items made of precious metals are also regulated by law. Individual makers are accountable for adhering to them, yet they are rarely checked by government audits. In the United States, The National Gold and Silver Marking Act dictates the standards and requirements for marking precious metals. Originally enacted in 1906 and revised several times since, this law requires the maker and seller of precious metal objects to indicate the quality and maker’s (or another’s) registered trademark, indicating who is responsible for ensuring that quality. The maker’s mark must be the same size as the quality mark, and be placed as close as possible to it. As of October 1, 1981, gold items without solder that are imported, exported, or transported through the United States must be of a fineness not lower than 3/1000ths parts of that indicated. Those items that contain solder have a greater tolerance and may be 7/1000ths lower than the indicated quality. Items that combine two identifiable metals should bear the quality mark of both, for example, “14k and Sterling.”

The Federal Trade Commission has published a booklet entitled *Guides for the Jewelry Industry* that defines jewelry-related terms and describes deceptive or misleading practices and other misrepresentations of products and processes involved in jewelry manufacture and sale. Violations of these laws can result in fines or imprisonment or both.

**VOLUNTARY HALLMARKING**
Voluntary hallmarking leaves the quality and hallmarking up to the manufacturer without governmental supervision.

**SPONSOR’S MARKING**
Some countries, such as Germany, do not require an official assay. Instead, quality standards and hallmarking are supervised by credentialed master goldsmiths whose licenses entitle them to mark items of precious metals.

Items of gold jewelry for import into many countries are tested as they pass through customs. A small sample, often scraped at a solder seam, is tested for quality. In order to be imported and sold in that country, the quality must be equal or superior to that indicated on the hallmark, or else the items can be refused entry.

**PHYSICAL PROPERTIES OF PRECIOUS METALS**

The physical properties of precious metals come into play when they are worked. Each alloy has a characteristic response to the forces exerted on it during forming, forging, bending, rolling, and drawing. Alloys are selected for specific applications because of these properties.

A metal’s hardness refers to its resistance to denting. The hardness of metals is measured scientifically by pressing a very hard object of a known size with a known force into samples of different metals and measuring the results. Factors affecting the hardness of metals include the composition of the alloy and the degree to which it has been worked. The three different testing and measuring systems for hardness are Brinnel (HB), Rockwell (HR) and Vickers (HV). (Values from one system can be compared to values from a different system using an appropriate conversion table. Brinell and Vickers values below 300 are very close.)

The metal’s hardness indicates its relative response to the forces exerted while working it. (Table 1.4)

When metals are hammered or rolled, they respond differently. Malleability (literally meaning “hammer ability”) refers to the capacity of a metal to be altered by such forces. Gold is the most malleable metal, followed by silver and aluminum. Gold can be rolled thinner without annealing than can any other metal. In fact, gold can be rolled or
beaten so thin that light passes through it with a greenish tint. The comparative malleability of metals in descending order is:

<table>
<thead>
<tr>
<th>Malleability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gold</td>
</tr>
<tr>
<td>Silver</td>
</tr>
<tr>
<td>Aluminum</td>
</tr>
<tr>
<td>Copper</td>
</tr>
<tr>
<td>Tin</td>
</tr>
<tr>
<td>Platinum</td>
</tr>
<tr>
<td>Lead</td>
</tr>
<tr>
<td>Zinc</td>
</tr>
<tr>
<td>Iron</td>
</tr>
</tbody>
</table>

Strength is the property of a metal to resist permanent deformation.

Tensile strength is a measurement of the maximum load that can be applied to metal without the occurrence of necking (localized reduction in diameter) or fracture.

Ultimate strength or UTS is the maximum stress a material can withstand, the point at which any further stress will result in necking and weakening.

When stress is applied to metal, it deforms. When the stress is below a certain threshold the metal will return to its original shape when the stress is removed. This is called elastic deformation. The range of this temporary deformation is called the elastic zone.

Plastic deformation is what happens when a metal is deformed beyond its elastic deformation point. It is not possible to accurately measure the exact transition between elastic and plastic deformation. To provide a useable reference, a permanent deformation of 0.2% was chosen to represent the stress needed to cause plastic deformation.

Yield strength is the aspect of tensile strength that indicates the amount of force or stress required to permanently deform a metal by 0.2 percent.

Malleability indicates the ability of a metal to be formed by compression (such as by being struck with a hammer) without breaking.

Ductility refers to the ability of a metal to be elongated or drawn into a fine wire without breaking. Again, gold is the most ductile metal, permitting it to be drawn finer than any other metal can without breaking. Second is silver, followed by platinum. The comparative ductility of metals in descending order is:

<table>
<thead>
<tr>
<th>Ductility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gold</td>
</tr>
<tr>
<td>Silver</td>
</tr>
<tr>
<td>Platinum</td>
</tr>
<tr>
<td>Iron</td>
</tr>
<tr>
<td>Copper</td>
</tr>
<tr>
<td>Aluminum</td>
</tr>
<tr>
<td>Nickel</td>
</tr>
<tr>
<td>Zinc</td>
</tr>
<tr>
<td>Tin</td>
</tr>
</tbody>
</table>

One measure of ductility is elongation to break, or the length to which metal can be stretched before it will break, expressed as a percentage.

Malleability is related to ductility but not all malleable metals are ductile. Gold is both malleable and ductile; lead is malleable but not ductile.

A sugar cube weighs less than a cube of gold the same size, the reason being that gold is denser, or weighs more for the same volume. Density is measured as weight per unit of volume, or specific gravity. It is expressed as grams per cubic centimeter (g/cm³) as compared with water, which has a specific gravity of 1 g/cm³. Gold is very dense. With a specific gravity of 19.32, its weight is almost twenty times greater than the same volume of water. The density of gold explains why prospectors find gold when panning. Because of its high specific gravity (density) gold sinks to the bottom of any stream.

When comparing the relative cost of making an item in 14k or 18k gold, one must consider that 18k will weigh more for the same volume because of its higher specific gravity.

Melting point is defined as the point below which a metal is solid and above which it is liquid. Pure metals have a specific melting point, but most alloys have a temperature range where they are neither completely solid nor completely liquid (Table 1.5). When an alloy is heated, it reaches a point at which it is no longer a solid but is not yet fully liquid. This is called its solidus point.
As the metal is heated further it reaches its liquidus point, the point at which the metal is totally liquid. In this range between solidus and liquidus, the metal has a slushy consistency. Pure metals do not exhibit such a range.

The exceptions are alloys that transition from liquid to solid at a specific melting point. These are called eutectic alloys and can be defined as the mixture with the lowest melting temperature alloy. Not all alloy systems have a eutectic, but a very important one for jewelers is in the silver-copper system where the eutectic alloy is 71.9% silver and 28.1% copper with a melting point of 1435°F (779°C). The presence of the silver/copper eutectic is felt not only in sterling silver melting and solidification behavior but also in silver solders and even in gold alloys that contain a significant amount of silver and copper such as 14k yellow with its relatively low melting point.

As an electric current passes through different materials, it meets a resistance characteristic for that material. In general, metals are good conductors of electricity. Silver has the best electrical conductivity, because it presents the least electrical resistance. Copper is the second best electrical conductor with gold being third. This high conductivity, combined with its superior resistance to tarnishing, makes gold ideal for use in solid state circuitry (Table 1.6). Like electricity, heat passes through materials in differing ways. Silver is the best thermal-conductive material, again with copper being second and gold the third-best thermal conductor (Table 1.7).

<table>
<thead>
<tr>
<th>Metal</th>
<th>Resistivity at 0°C μΩ cm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silver</td>
<td>1.47</td>
</tr>
<tr>
<td>Gold</td>
<td>2.01</td>
</tr>
<tr>
<td>Rhodium</td>
<td>4.33</td>
</tr>
<tr>
<td>Iridium</td>
<td>4.71</td>
</tr>
<tr>
<td>Ruthenium</td>
<td>6.80</td>
</tr>
<tr>
<td>Osmium</td>
<td>8.12</td>
</tr>
<tr>
<td>Platinum</td>
<td>9.85</td>
</tr>
</tbody>
</table>

Source: Grimwade 2009.

Table 1.6 Electrical resistance of precious metals.

<table>
<thead>
<tr>
<th>Metal</th>
<th>Thermal Conductivity 0 to100°C W/m K</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silver</td>
<td>425.0</td>
</tr>
<tr>
<td>Gold</td>
<td>315.5</td>
</tr>
<tr>
<td>Rhodium</td>
<td>150</td>
</tr>
<tr>
<td>Iridium</td>
<td>148</td>
</tr>
<tr>
<td>Ruthenium</td>
<td>105</td>
</tr>
<tr>
<td>Osmium</td>
<td>87</td>
</tr>
<tr>
<td>Palladium</td>
<td>76</td>
</tr>
<tr>
<td>Platinum</td>
<td>73</td>
</tr>
</tbody>
</table>

Source: Grimwade 2009.

Table 1.7 Thermal conductivity of precious metals.

**GRAIN STRUCTURE AND WORK HARDENING**

Metals have a crystalline structure. These crystals, often referred to as grains, change in size and orientation as a result of external forces. Cold working precious metals increases their hardness and decreases their malleability and ductility. When metal is initially cast into an ingot or into a finished piece of jewelry, the grain structure is random, and the size of the grains is large. Such metal is soft and workable (Illustration 1.2). When working metals, the grains become packed together. Processes such as bending, forming, rolling, and twisting compress the grains and make the metal harder. The result, known as work hardening, may be desirable for components that require springiness or hardness, such as cuff bracelets, clasp elements, pinstems, and hinge pins (Illustration 1.3).

With continued working, the metal becomes even harder and more resistant to external forces because of the further compaction of the grains into an elongated and flatter configuration (Illustration 1.4). If the metal is pushed even further, it will eventually break along the boundaries of the grains. This phenomenon is exhibited when repeatedly bending a wire coat hanger back and forth to break it. To avoid overworking and consequent cracking, metal should be annealed when its thickness has been reduced to approximately 50 to 75 percent of the starting point. This can be measured when rolling, drawing, or forging a piece of metal but it is difficult to measure when bending, forming, or twisting. For this reason, be sensitive to an increase in hardness as a result of cold working.
Annealing

After a significant amount of cold work has hardened metal, a workable state can be restored through a process called annealing, which entails heating metal to an appropriate temperature. During this process, the stretched deformed grains recrystallize into larger sizes and more uniform shapes, restoring a metal’s workability. Although it is difficult to measure the temperature of a metal during this process, the color of both the metal and the flame are indicators. For maximum annealing and the corresponding increase in workability, heat the metal to the proper temperature (and color) (Table 1.8).

The effects of annealing are subject to both the variation in duration and the temperature of heating. Short annealing times and lower temperatures relieve residual stress in the metal with virtually no change in the size of the grains, whereas higher temperatures result in increased malleability and ductility, decreased hardness, and larger grain size. Overheating the metal will result in even larger grains that are visible to the naked eye, accompanied by a decrease in workability. It is important to anneal a piece of metal uniformly, to avoid creating differential grain sizes and consequent variations in hardness.

Although greater control during heating can be achieved in a kiln, most jewelers anneal metal by heating it on a charcoal block with a torch. Observe the color during heating by placing the work in a darkened area. Use a broad reducing flame over the entire object, or systematically heat the metal in sections. Bundle wire tightly to avoid accidental melting. During heating, watch the color to determine when annealing has occurred. Other visual indications of annealing are when flux becomes molten and when the tip of a torch flame turns yellow-orange as it is.

<table>
<thead>
<tr>
<th>Metal</th>
<th>Approximate Annealing Temperatures °C</th>
<th>°F</th>
<th>Color by Eye</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fine Gold</td>
<td>200</td>
<td>400</td>
<td>Black heat</td>
</tr>
<tr>
<td>Fine Silver</td>
<td>200</td>
<td>400</td>
<td>Black heat</td>
</tr>
<tr>
<td>22k Colored Golds</td>
<td>550</td>
<td>1000</td>
<td>Very dark red</td>
</tr>
<tr>
<td>18k Colored Golds</td>
<td>550–600</td>
<td>1000–1100</td>
<td>Very dark red</td>
</tr>
<tr>
<td>14, 10, &amp; 9k Colored Golds</td>
<td>650*</td>
<td>1200</td>
<td>Dark red</td>
</tr>
<tr>
<td>Palladium White Golds</td>
<td>650–700**</td>
<td>1200–1300</td>
<td>Cherry red</td>
</tr>
<tr>
<td>Nickel White Golds</td>
<td>700–750**</td>
<td>1300–1400</td>
<td>Cherry red</td>
</tr>
<tr>
<td>Sterling Silver</td>
<td>600–650</td>
<td>1100–1200</td>
<td>Dark red</td>
</tr>
<tr>
<td>Platinum</td>
<td>800</td>
<td>1500</td>
<td>Bright red</td>
</tr>
</tbody>
</table>

* Colored golds of 18k and less should be water quenched from the annealing temperature to retain softness and ductility.  
** Ni-white golds should be air-cooled to minimize phase separation and color change.  
Source: Adapted from Grimwade 2009.

Table 1.8 Typical annealing temperatures for precious metals and their alloys.
played on the surface. After annealing, remove the flame or cover the metal in a fuel-only (yellow) flame to reduce oxidation in cases where oxidation is a problem. When the metal has lost its reddish glow, quench it in water (except for nickel white-gold alloys, which are air cooled). Immerse the annealed metal in a warm pickle solution to remove the surface oxides.

Slow cooling may result in effects similar to heat treating, in which the metal is partially hardened by holding it at a low temperature for an extended period. Many alloys can be intentionally “heat treated” or “age hardened,” with each alloy having its own time and temperature requirements.

ASSAYING

A number of methods for measuring, or assaying, the quality of precious metals have been used for centuries, particularly to determine the gold content of gold-bearing alloys. Fire assay, or cupellation, has been used for nearly 4500 years. It is an extremely accurate procedure in which scrapings of an alloy are subjected to a series of elaborate steps that include weighing, melting, rolling, dissolving in acid, and reweighing. The beginning and ending weights are compared to determine the fineness of the original sample. The touchstone or acid testing procedure has also been in use for centuries. This system is quick and simple but not as accurate as fire assaying. In this method, the alloy in question is rubbed on a smooth dark stone next to a similar rubbing from a standard alloy of known content. A set of test needles with tips ranging in purity is used as the standard. A stripe of acid is spread across both rubbings, and the results are compared. The rubbing with the higher gold content will be more resistant to the acid and leave a clearer, brighter stripe. Although this system is dependent on visual comparison, it is sufficiently accurate for use in a jewelry workshop. CAUTION: Acid is highly corrosive and harmful if brought into contact with skin or eyes.
Even though goldsmiths produce objects in precious materials, this book stresses the value of the process rather than the product. In other words, the real value is to be found not in the finished ring or chain but in the procedures by which it is created. Rings and chains may wear out with time, but mastery of the techniques that make beautiful objects is timeless.

Strive for perfection at every point. The first step in making a piece of jewelry is always the most important, that is, until the second step comes along. Just as the placement of the four corners of a building determines the course of the construction that follows, in making jewelry, layout is also a critical step. The finished product will never be more accurate than the first step.

Although the ultimate goal is to work both flawlessly and rapidly, the novice should concentrate exclusively on the former. Ordinarily, the first time a craftsman attempts a new project it can take as much as three times longer than the time required by an experienced craftsman. You cannot cut corners until you know where they all are. Speed comes with practice. As the project nears completion, look for areas that need a little more attention. There will always be some way to improve your work. Do not stop until you are convinced that you have done the best job possible, even if it takes longer than you expected. In the end, the results will be worth the effort.

**THREE STEPS FOR CORRECTING ERRORS AND IMPROVING YOUR WORK**

First, closely examine and analyze your work. Take measurements with calipers, dividers, spring gauges, machinists squares, and flat edges, to check angles, flatness, and dimensions and to make comparisons. It is often helpful to use a marker to write the measurements on the work itself. During this step, concentrate on studying the situation; do not even consider the remedy yet.

Next, try to figure out what is wrong and plan actions to correct or improve it. Consider filing, sanding, sawing, forging, or other techniques. Imagine the tools in your hands and their effects on the metal. Do not begin working until you have studied and planned, step by step, all facets of your action. Finally, when you have thought it out and you are absolutely sure what to do, take action and execute your plan.

**HANDWORK**

Frequently when novices are confronted with the prospect of making a simple yet tedious component for a piece of jewelry, such as a jump ring or a piece of tubing, they ask whether there isn’t an easier way, such as purchasing the element commercially. It is often easier to purchase commercial parts—in fact, it would be even easier to purchase the entire piece of jewelry! But remember that it is the mastery of technique that yields the greatest satisfaction. Aside from pride in craftsmanship, there are several practical reasons for developing the skill and knowledge to make every component of your work. First, the design may call for a finding in an uncommon size, color, karat, or shape that cannot be purchased. Even if the finding you require is available, deadlines often preclude waiting to receive it.

No matter how well trained and experienced a craftsperson is, there will always be new and unexpected challenges. Goldsmiths are often asked to make items of jewelry that are unlike anything they have encountered before. In cases like these, craftspeople must improvise and seek new solutions that may be a variation of techniques that they have used previously. Sometimes they even must create new techniques. In many ways, the test of a master is not what he or she already knows but what he or she can improvise based on similar experiences and the requirements of the project at hand. With the pressures of a commitment pushing from behind, necessity becomes the mother of invention. Sometimes this will result in failure, but more often it will result in success. In either case there is something valuable to be learned.

**USING THE METRIC SYSTEM**

The metric system originated in France around 1790. Although the United States was the first country to introduce metric currency—the dollar in 1789—it has been one of the slowest to adopt the metric system of measurement. Nonetheless, most countries in the world use only
the metric system of meters, liters, and grams. Calculations are far simpler in the decimal-based metric system in which 1 meter equals 100 centimeters which equals 1000 millimeters, rather than the English system in which 1 yard equals 3 feet and 1 foot equals 12 inches and then inches are divided into either fractions or thousandths. The basic metric unit used in jewelry is the millimeter, which is far smaller than the inch of the English system. For jewelry work, the metric system is superior to the English system because it is more precise and far easier to use.

**ACCURACY**

Goldsmithing demands attention to minute details. The very nature of fabricating small objects with hinges, clasps, settings, and so on requires that the components fit together well. The tolerance for jewelry handwork in this book is one-tenth of a millimeter, 0.1 mm, which is only about twice the diameter of the average human hair. That means that every piece of metal should be measured and corrected so that its dimensions are within 0.1 mm of the given specifications. Sometimes a greater error will be hardly noticeable, but in most cases, a variation of more than 0.1 mm will cause problems with fit or function. Accordingly, it is important to have accurate measuring tools at hand, several of which are described in Chapter 3. Although I have made every effort to give accurate specifications for the projects in this book, in reality some variation is understandable owing to the nature of handwork. Be sure to keep in mind, however, that the closer the components are to specification, the easier will be the job of fitting them together.

**MATERIALS**

It has been said that “nothing else feels like gold.” And although there is nothing quite like working in real karat golds, in fact most techniques can be applied to nonprecious metals. Nickel alloys, brass, and copper all saw, file, bend, solder, anneal, forge, form, and roll in nearly the same way as gold and silver. The benefits of learning with nonprecious materials outweigh the very small advantage of working in gold, silver, or platinum. As an analogy, the difference between driving a car at 40 or 60 requires no conscious adjustment; adapting what you do comes naturally once you know how to drive. Similarly, although the melting temperature of gold solder is higher than that of the silver solder you will use on brass or copper, the process of soldering is the same and adjustment to differences such as these will quickly become automatic.

An item made of precious metals is likely to be worn, given away, or sold, whereas an item created out of materials without intrinsic value will be saved for future reference. Imagine trying to replicate a project—or even worse, trying to make a variant of a project you made ten years earlier—without the benefit of holding the original in your hand. But if you have saved the original sample as a reference along with good notes, you can easily reproduce the process and replicate or alter the product to suit your current needs. A collection of nonprecious samples also serves as a three-dimensional portfolio, demonstrating the skill of the maker to potential employers and customers. Such a collection is small, portable, and durable, and it speaks for itself. While nonprecious samples have no intrinsic value, in actuality they are worth more than their weight in gold.
**FLAME TYPES**

Torches produce heat by sustaining combustion while feeding two different gases into the flame. In oxygen-fuel torches, both gases are supplied under regulated pressure: oxygen from a pressurized tank, combined with fuel from either a tank or city-gas supplied to the building. In air-fuel torches, fuel from a tank combines with air drawn either from the atmosphere, or supplied by a pressurized tank.

Three different types of flames are important to goldsmithing. A cool reducing flame has a pale blue flame with a yellowish tip, because there is more fuel than oxygen. A soft, bushy reducing flame is ideal for annealing and melting. Because of its size and composition, such a flame shields the surface from atmospheric gasses while absorbing oxygen that might otherwise combine with the metal.

With the addition of more oxygen, a neutral flame is achieved. Such a flame is all blue, without any yellow at the tip. This flame has a softly defined bright blue inner cone within a pale blue outer cone. This type of flame is ideal for most soldering jobs where a large area can safely be heated. The hottest point of the flame is the tip of the inner cone.

When even more oxygen is added to the flame, the inner blue cone becomes smaller, sharper, and brighter. An oxidizing flame such as this emits a hissing sound as excess oxygen is forced into the flame. Useful for delicate soldering jobs where the heat must be intense and localized, this type of flame floods the work with unconsumed oxygen which can result in oxidation (tarnish). If used when melting, this flame will damage the metal.

**FINISHING JEWELRY**

There is no need to buff and polish work that is executed as a learning exercise. In fact, in some countries, candidates taking the practical portion of the test for their goldsmiths and master goldsmiths credentials are not permitted to polish, electroplate, engrave, or set stones into their work. The reason is that polishing hides the craftsmanship by diminishing sharp corners and crisp surfaces. By leaving a finely sanded (satin) finish, therefore, the craftsmanship is revealed for examination.

This said, we should also note that the appeal of jewelry depends largely on its finish. Polishing is the most common finish for jewelry made of precious metals, because it exploits their unique reflectivity and lustre. Buffing and polishing are a specialty apart from goldsmithing. Although basic techniques do not require much experience, more sophisticated techniques do call for a vast range of expertise and equipment. Because the focus of this book is on goldsmithing, we shall only briefly touch on buffing and polishing.

**SANDING**

In general, jewelry made of precious metals should be sanded to a fine finish in preparation for polishing. A piece is usually sanded to remove filing marks, scratches, and imperfections after all other work such as soldering, hammering, and filing have been completed. Sometimes, however, a complex piece with several components is sanded and polished before it is assembled because afterward some of the components will be inaccessible for polishing. During or after a piece is completed, sanding progresses from coarse abrasive paper (220-grit) to finer grades (400-600-grit), changing direction with each step up in fineness. A general guideline is that large flat surfaces (which are difficult to polish) should be sanded to a higher prepolish finish with
fine (600-grit) paper. Sanding sticks and sanding drums are good for holding abrasive paper and cloth. Other commercial and custom-made wheels and jigs can be used for sanding. Before going on to buffing, check to make sure that all of the file marks and scratches have been removed.

**SETTING STONES**

The responsibility of the goldsmith ends when the construction and finishing of a piece of jewelry are complete. If an item has stones to be set, this usually will be done by a stone setter, an artisan with specialized training and skills. Although contemporary jewelers frequently set their own stones, stone setting is a field encompassing complex techniques, that are too numerous to be included in this book.

**GENERAL SUGGESTIONS**

The following are a few general suggestions regarding the projects in this book and goldsmithing as a whole:

- Keep your work clean as you proceed. Use an abrasive pad to remove grease and oxides and to impart a fine satin finish during fabrication. It is easier both to see and to work on clean components.

- With most projects it is best to work from the inside out. That is, always file, sand, and polish the inside of rings (and most other items) first.

- A basic rule in goldsmithing is to work up a shape evenly and uniformly. If several components or parts of components are to match, bring them all up to form at the same time. Rather than concentrating on one area until it is finished, work alternately on all areas, collectively bringing the entire piece to the same stage of completion.

- Carry each step to the limit of your ability. Take a short break and then return to the work, looking for ways to improve the results even further.

- As you read through this book, remember that there is usually more than one way to do most jobs. Knowing only one tool or technique for a particular job, will not be enough because the method that usually works may not solve a slightly different problem. Be open to suggestion. Never discard someone else’s method, but file it in the back of your mind for the time when your old way will not work.

**SAFETY**

Although the procedures in this book are performed safely by thousands of goldsmiths every day, newcomers and experienced jewelers alike need to observe some safety precautions. Above all, concentrate on what you are doing whenever you are working with hazardous materials or tools. Consider what could happen and prevent accidents. Accidents take only a second to occur, so do not allow yourself to be distracted—even for a second. Note particularly the following:

- Acids can be extremely dangerous, so do not let them touch your skin and do not inhale the fumes. Contact with eyes can be especially harmful; for this reason wear a full face shield when working with acids and chemicals. Some workers wear safety glasses whenever they are in the studio. Pickling solution is kept warm and so should be used with adequate ventilation. Keep an open box of baking soda near the pickle pot for the immediate neutralization of acid spills. Quench metal in water or air cool it before submerging it in hot pickling solution. Never throw metal into the pickle; instead, use copper tongs to slide it into the solution without splashing.

- Torches and melting equipment are inherently hazardous, so never use them recklessly or even casually.

- Spinning tools such as a flex shaft, polishing lathe, and bench grinder can eject small particles at high velocities. Always wear goggles, tie back long hair and sleeves, and keep your fingers clear of the spinning tool. In addition, when polishing, do not entrap your fingers in work that could be grabbed by such rotating tools.

- Sharp tools such as files, drills, and gravers can cause injury and should be handled with care. Consider the effects of slipping with a sharp tool, and position your fingers accordingly.

- Fumes can be hazardous if inhaled. They are emitted by the pickle bath, solvents, glues, solders, and by drying correction fluid (used as an antiflux). Work in well-ventilated areas and avoid inhaling fumes.
We should explain here our protocol for the usage of safety alerts throughout the book.

**ACIDS**

Acid can be extremely dangerous. Avoid direct contact with the skin. Do not inhale the fumes. Contact with the eyes can be very harmful and for this reason a full face shield is advised when working with acids.

**Pickle:** Pickling solution is kept warm and should be used with adequate overhead ventilation. Keep an open box of baking soda near the pickle pot for immediate neutralization of acid spills. Metal is quenched in water or air cooled prior to submersion in hot pickling solution. Never throw metal into the pickle. Instead, use copper tongs to slide it into the solution without splashing. Think carefully before putting hot metal into hot pickle, because this is hazardous and forces the pickle into areas where it will be difficult to remove later. Do it only with extra face and hand protection and great caution. The submersion of hot metal into hot pickle increases the effects of pickling, resulting in acid leeching (depletion plating).

**HEATING**

Follow proper fire safety procedures, observe all gas handling rules, and use proper ventilation. Keep all flammable items away from the soldering area. Wear fire-resistant clothing and shoes. Tie back long hair and sleeves. Refer to the pickling safety procedures for cleaning metal after torchwork.

**Dopping Wax, Shellac, and Jett Sett:** Dopping wax and shellac, used to hold metal pieces when working, are melted with a cool, yellow (fuel-only) flame. Do not drip hot wax onto your skin. Do not overheat the wax. If it smokes, it is too hot. Avoid inhaling fumes from melting or smoking wax. Dopping wax dissolves in acetone, which is toxic. Shellac is a safer alternative because it dissolves in alcohol. Avoid breathing solvent fumes. Jett Sett is one brand of a plastic that becomes malleable in hot water and is used as an alternative to dopping wax and shellac in many applications. No solvents are required.

**Soldering:** Avoid solders containing cadmium or antimony. Avoid fluxes containing fluoride. Avoid skin contact with boric acid and do not ingest.

**Soldering Hollow Forms:** Drill a small vent hole before soldering a hollow form to allow expanding gasses to escape safely. The hole allows gas to move in and out during heating and prevents explosion.

Soldering a volumetric form closed is difficult and even hazardous. The problem is that air gets trapped and then expands tremendously when heated, especially if it contains any moisture. The expansion of the internal gas makes it difficult to solder a form completely closed. The force of the expanding gas may even blow a hole in the piece with the force of a firecracker, sending hot metal flying across the room.

**Soldering Platinum:** Because of the high melting temperature of platinum and platinum solders, use at least #5 filtered soldering/welding goggles when welding and soldering platinum. Annealing, soldering or welding platinum without filtered eye protection could lead to serious eye damage. Do not remove your glasses until the glow dissipates from the piece. Because of the high heat involved in annealing and soldering platinum, be sure the piece is completely quenched or air cooled before handling it. A plastic or glass quench bowl is not recommended.

**Antiflux:** Antiflux is a fluid that can be painted on seams before soldering to prevent solder from flowing again. If using typewriter correction fluid as an antiflux, paint it on seams and let it dry. Do not inhale the fumes and use proper ventilation during application and soldering.

**INVESTMENT**

Investment contains silica and is dangerous if inhaled. Use with proper ventilation and wear a dust mask. Avoid skin and eye contact. Investment removal should be performed under a fume hood or with appropriate protection.