GEM CUTTING

J. DANIEL WILLEMS

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By J. Daniel Willems

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To My Wife

MARIAN HUTCHINS WILLEMS

who these many years has been my

chum, companion,
comrade, friend

and

whose inspiration guided me into
this fascinating
hobby of

Gem Cutting

Foreword

During recent decades, the collecting of minerals and the subsequent fashioning and mounting of them as gems have become a fascinating hobby of thousands of nature lovers in the United States and Canada. These so-called *amateur lapidaries* are ever eager to obtain authoritative information concerning proven methods for the successful cutting and polishing of gem materials. Gem Cutting, by J. Daniel Willems, is such a text and is based upon the author's extensive experience.

As the fashioning of the various cabochon cuts is the easiest for a beginner to learn, the methods to be used are described first. These are then followed by instructions concerning the cutting of faceted stones. The successive steps in the various operations are explained in great detail and can be easily followed by those desiring to acquire expertness in the art of the lapidary. The list of don'ts at the end of many chapters as well as the bibliography covering three pages should prove to be very helpful.

The book is amply illustrated and well printed. Amateur and professional lapidaries alike will find Willems' Gem Cutting a very useful guide.

Edward H. Kraus

Ann Arbor
Michigan

Preface

Gem Cutting is written for the purpose of making available dependable information on the cutting and polishing of gem stones. It is intended to be clearly and easily understandable to all interested readers whether they have any technical knowledge about the subject of gems or not. There are a considerable number of professional gem cutters (as distinguished from diamond cutters) scattered through many of our larger cities but they have little practical contact with each other. They have developed skills and machines of their own, but no one has ever made an effort to collect this widely scattered knowledge into one available source.

In addition to these professionals, there are many more amateur cutters. They are spread over the entire country, working singly or in groups, in cabins, homes, schools, and clubs.

There are also many collectors of minerals and gem stones who are interested in how they are cut but have had little opportunity to find out.

Last, but far from least, the interested general public has long been entitled to a book that will give satisfying information on a subject that has for centuries been veiled in semi-mystery and secrecy, and yet has a most absorbing attraction to every person who loves the eternal beauty of the purest of luxuries — gems.

This book will find a place in the professional's shop as a manual, on the mineralogist's laboratory table as a guide, on the jeweler's bench for information to customers; on all library shelves, in school classrooms, as a beginner's instruction book, and near the big chair by the fireplace in the home.

The material as presented here has been largely drawn from the author's own experience as an amateur, or shall I say as a semiprofessional, gem cutter. To this has been added many a trick taught him by professionals as well as amateurs, and the technical knowledge gained from a limited number of books, pamphlets, and technical magazines available on the subject. A list of the literature contained in the author's library will be found in the back of the book.

This book is written in language as nearly nontechnical as a highly complicated craft will permit. All difficult terms are carefully explained and clarified, often with the addition of drawings. Text and illustrations are directed toward general principles, illumined by meticulous details and variations. The book is a carefully planned description in logical sequence of the steps by which a gem is produced.

The beginner who studies the instructive discussions here with diligence should be able to go a long way in learning about gems and how to cut them. It is entirely possible that he can teach himself even the most skillful procedures with only this book as a guide.

Gem Cutting will be supplemented by a 16-millimeter moving-picture film in color, and also by a set of 2 x 2-inch (35 mm.) slides in color, which will present the various phases treated in the book. It is contemplated that there will be several reels in the movie. Each reel will be complete in itself and will constitute a visual demonstration of a section of the art of collecting, studying, and cutting gems. The several reels will run in series, making a logical sequence of the entire process. This motion picture is being produced at this time by the author and his associate, and it is believed that it represents the first effort to make such a film available to the general public.

The author wishes gratefully to acknowledge the valued counsel and assistance of many individuals, all of whose help he appreciates. Among those who have contributed in

an outstanding way are Mr. William Barabas, who prepared the drawings with patience and skill; Mr. Arthur A. Kahn, who has brought to the author much knowledge not available outside the ranks of professional cutters; and Mr. S. N. Green, whose advice and encouragement have been exceedingly valuable.

All of the photographs, as well as the color plate, are the product and property of the author.

J. D.W.

Chicago, Illinois
February 4, 1948

PREFACE TO THE SECOND EDITION

The author and the publishers are greatly pleased with the reception which the first edition of this book has enjoyed. It is evident that the largest number of readers is among the amateur gem cutters, and that number is steadily increasing. In carrying on the original purposes of the book it seemed, therefore, unnecessary to make extensive changes. However, a number of clarifications in the text and drawings have been made, and for better instruction 50 new photographic illustrations have been added. In doing this the author has endeavored to select pictures that tell their own stories.

J. D. W.

Chicago
May 25, 1952

Contents

CHAPTER I

Introduction

We were walking on the beach. The tide was falling and high seas were running. There was no storm, no wind to speak of; only a gently drizzling rain, continuous and steady.

Long curling waves rushed in from the open ocean, moving forward with a fateful force that could be positively felt. After each wave was spent, there was a retreat of rushing water which exposed the sea gravel, freshly washed and glistening.

The beach was gravel, coarse and fine. The pebbles rolled under the turbulent water, then slowly came to rest as the waves retreated. We were walking near the water's edge scanning the pebbles, those little rounded stones pounded and ground into shape on the ocean floor, and now tossed up to rest upon the open beach.

It was my keen, nature-loving wife who saw a small pebble that looked definitely more attractive than the rest. She picked it up and handed it to me, as many a woman had done before. That was the beginning of a hobby that has grown with the years and now is represented by a collection of hundreds of beautiful gem stones, all collected in the rough and cut by myself. Love for the beautiful in nature had now discovered a never-ending source of supply as well as a stimulus.

That small pebble was taken to the government agent on this dreary Indian reservation for information. He pronounced it a "California moonstone." That, I learned later, was a misnomer; the correct and more truly poetic name is chalcedony.

The agent reached up to one of his shelves and took down several glass jars filled with agate and chalcedony pebbles, all gathered by the Indians on that beach. We bought a handful for a small sum — and were on our way to collecting.

Eight years later this collection of rough gem materials had grown to sizable proportions by accumulations from thirty-five states and several foreign countries. But thrift and discriminating selection in acquiring material was not enough. My knowledge had to be enriched by repeated visits to the gem rooms of various museums, and by reading books and magazines on the subject.

In time, it became evident that the next step was to learn how to cut the rough pebbles and chunks into precious and beautiful gems. The cutting and polishing of gem stones is one of the most skill-demanding of all the arts. To develop this skill to its highest perfection, the cutting of faceted gems, the cutter must begin with the simplest task and advance step by step to the more complicated.

The equipment required for cutting is simple and is almost exactly like that used a hundred years ago. The common gem stones are easily obtained and the cost is not excessive; therefore, given a small supply of innate ability to use the imagination and a little cleverness with the hands, it is safe to assume that the vast majority who will try to cut gem stones will succeed. As in all other arts and skills, so in this one some will succeed to a far greater degree than others.

The beginner should assail all available sources of information. This book, it is hoped, will be a great stimulus to do just that. He should visit the museums and study the exhibits; he should haunt libraries for all available books on the subject; he should subscribe to some of the semi-technical magazines for mineralogists, collectors, and gem cutters; he should request descriptive literature from manufacturers and dealers who advertise; and above all he should keep right on collecting worth-while gem materials against a day when he can begin cutting them into gems.

CHAPTER II

Gem Materials

GEMS are largely derived from minerals. A few come from organic substances. Gem stones occur abundantly in nature, and many can be produced artificially in the laboratory. Some can be imitated by glass and plastics. A few, notably the pearl, can be cultured or grown. Of the organic gems, some are of animal origin, others of plant origin — for example, coral and amber.

Varieties and Qualifications of Gem Minerals

Minerals, as they are found in nature, are of three general varieties: opaque, translucent, and transparent. The opaque gem materials are valued mainly for their color and hardness. The translucent stones add luster. The transparent gem stones are usually of greater value and have the additional property of transmitting light. By refraction, reflection, and dispersion of the light rays, brilliancy and diaphaneity are added to the other qualities.

All gem stones are endowed with enough hardness to make them durable and exceedingly resistant to wear. Thus beauty of color, rarity, durability, and splendor or radiance are the distinguishing qualities of gems.

The gem minerals with few exceptions occur in the form of crystals.

Occurrence of Gem Minerals

Many varieties of gem materials can be found in our mountain states, both east and west. The highway traveler will come upon numerous roadside stands offering rocks and minerals for sale. A small proportion of these are of gem quality. There are also several well-established, reliable dealers in rough gem materials where supplies of rough gem stones can be bought. The enterprising collector, however, can find plenty of sources of supply on our ocean beaches and gravel piles, in river gravels, on old mining dumps or in shafts, and in the desert. Maps and travel directions appear from time to time in the various journals devoted to mineralogy and gem collecting.

Organic Gem Materials

Organic materials which are useful as gems are far less abundant than the minerals. Of these, the pearl is in a class all by itself, being a gem which is "perfected by nature, and requires no art to enhance its beauty" (Kunz, *The Book of the Pearl*). It is also the only gem that is now being cultured or grown. There is no reason to believe, however, that certain others cannot be cultured.

The other organic gems which are well known are coral, amber, and jet. The pearl and coral are of animal nature; amber and jet belong to the plant kingdom.

Table I is a list of gem materials sufficient for most purposes. The interested beginner will soon make himself acquainted with their names and, likewise, with their more important characteristics so that he can recognize a piece of worth-while gem rough at once when he discovers it, or when it is offered to him for purchase.

Artificial Gem Materials

Artificial stones may be either *synthetic* or *imitation.* These two varieties should not be confused with each other.

SYNTHETIC GEMS. The synthetic variety is practically identical with the natural gem, as to its chemical composition and physical properties but is actually produced artificially by highly specialized processes. Formerly, synthetic corundum

TABLE I

Common Gem Stones

Precious Stones

- Beryl
  - Emerald
- Corundum
  - Ruby
  - Sapphire
- Diamond
- Pearl

Semiprecious Stones

- Amber
- Azurite
- Benitoite
- Beryl
  - Aquamarine
  - Golden Beryl
  - Goshenite
  - Morganite
- Bloodstone
- Carbuncle
- Chlorastrolite
- Chrysoberyl
  - Alexandrite
  - Cat's-Eye
- Chrysocolla
- Coral
- Feldspar
  - Amazonite
  - Labradorite
  - Moonstone
  - Peristerite
  - Sunstone
- Garnet
  - Almandite
  - Demantoid
  - Hessonite
  - Grossularite
  - Pyrope
- Jade
  - Jadeite
  - Nephrite
- Jet
- Lapis Lazuli
- Malachite
- Obsidian
- Opal
- Peridot
- Petrified Wood
- Quartz
  - Agate
  - Amethyst
  - Aventurine
  - Cairngorm
  - Carnelian
  - Chalcedony
  - Citrine
  - Jasper
  - Onyx
  - Plasma
  - Rock Crystal
  - Rose Quartz
  - Rutilated Quartz
  - Sardonyx
  - Smoky Quartz
  - Tiger's-Eye
- Rhodonite
- Spinel
- Spodumene
- Thomsonite
- Topaz
- Tourmaline
- Turquoise
- Variscite
- Zircon

and spinel were produced largely for use in watches and other fine precision instruments as jewel bearings. Now these materials are being used for gems. They are largely "rubies," "sapphires" in all colors, and "spinel"; but "emeralds," "aquamarines," "alexandrites," and a few others are to be expected. Perhaps new names will be found to attach to some of them. Whatever the names or colors, the composition, so far, is limited to corundum and spinel.

While the manufacture of synthetic gems might render a cheaper product available to the purchaser of limited means, this should not in the least detract from the value and desirability of the natural gem stones. For the informed lover of gems, the natural stones have the same attraction that first editions have for the book collector.

Imitation gems. Imitation stones in the past consisted of glass, colored more or less to the exact shade of the natural material. At the present time, plastic materials are being perfected for the cheaper jewelry trade. Neither of these materials will ever have the appeal to the lover of gems that the product of nature, the true gem, holds. Glass imitation stones are often referred to as "paste." It is not too difficult, even for the amateur, to detect the ordinary quality of glass imitations, because in most cases the facets are not flat surfaces but shallow saucers.

Artificially Altered Stones

Artificial alteration of natural gems should also be mentioned here. Certain materials, notably agate, can be dyed or stained by chemical means. In Idar-Oberstein, Germany, this has been developed to such a high degree that numerous slices cut from the same chunk can be stained in different ways to show a wide variety of colors in pleasing combinations.

In some gems, principally zircons and citrines, heat treating results in change of color, usually from an unattractive to a brighter one.

Exposing colored stones to X-rays has recently attracted some attention. The native color of the stone is often enhanced to a pleasing degree, but the color is likely to return to its original state in a short time, especially if the gem is exposed to strong sunlight, as in wearing a ring, which is not removed conveniently.

Costume Jewelry

Another method frequently used in clear, transparent stones to give them added glitter is not, strictly speaking, an alteration of the stone, but is so commonly practiced in manufacturing costume jewelry that it merits mention here. This method consists of covering the back of the stone with tinfoil. When the stone is clear, colorless quartz it is referred to as rhinestone. Occasionally foil of other colors is also used. Recently the term rhinestone has come to include glass imitations of the plain white, transparent variety.

The Naming of Gem Stones

The naming of gem stones has been indulged in by the best brains through the ages. Many of the names are words that would seem to have no specific meaning, are not descriptive of anything. Yet their sound has an immediate appeal that stimulates the imagination to pleasant activity. Among such names are opal, sapphire, topaz, zircon, and agate. Even their appearance in print is attractive and distinctive.

Scientists, however, prefer names which are descriptive of the mineral of the gem, such as fluorite and hematite; or of the locality of origin, such as labradorite and benitoite; or of the discoverer, such as kunzite and thomsonite. These names may well be more descriptive and scientifically acceptable than the romantic and imaginative kind; but gems appeal to romance and the artistic sense far more than any cold scientific classification. Surely, an opal under the name of amorphouscite would suffer unfair indignities and could be remembered only by cold-hearted scientists; and who would possibly care to remember, or spell correctly, the name kunzite if the gem bore a more interesting name, expressive of its delicate, rare loveliness?

CHAPTER III

The Art of Cutting and Polishing

Gem stones occur in nature in a rough and irregular state. Their surfaces are so dull as often to give the appearance of frosted glass. They may be chipped or broken, which is usually true of those removed from mines. Or they may be roughly smoothed, as in the case of pebbles on ocean beaches or of river gravels. As one investigates such stones, he finds that pebbles from ocean beaches are flattened ovoids, while river gravels tend to be more spherical or slightly angular. A small proportion of rough gem stones occur as more-or-less perfectly formed crystals.

All of these imperfections conceal the true beauty of the gem, which can be brought out only by proper cutting and polishing. The only exception to this is the pearl, which needs no polishing or other treatment.

The Lapidary

The cutter of gem stones other than diamonds is referred to professionally as a lapidary. Lapidarist and lapidist are other terms meaning nearly the same thing. A lapidary shop is a factory for cutting and polishing gem stones. When a stone is cut it is said to be lapidated. These words are derived from the Latin *lapis*, meaning stone.

Thus the terms gem cutter and lapidary are practically identical, yet neither applies to diamond cutters! A diamond cutter is just that and nothing else.

The Purpose of Cutting Gems

The purpose of cutting stones into gems is to give them smooth, highly polished, shining surfaces, free from flaws and imperfections (if that is possible), and also to shape them so that they are suitable for mounting in the precious metals as jewelry; and to show to best advantage their full color and surface luster (in the case of opaque and translucent gems), and in addition their brilliance and sparkle (in the case of transparent gems).

Styles of Cuts

There are two basic styles of cutting, the cabochon cut and the facet cut (which will be described in detail in a later chapter). These differ widely and are far apart in the skill that is required in the actual process of forming the gem. Each style has a number of variations.

The two styles can be mixed in the cutting of a stone so that either the upper or the lower part is in one style and the opposite part in the other style. Quite frequently a gem will be cut with facets on the bottom but with a cabochon top. Rarely, however, is the top cut with facets and the bottom left flat.

The Cabochon Cut

The word cabochon comes from the French *en cabochon*, meaning "like a bald head." The similarity of a bald, shining pate to the rounded top of a gem stone is quite apparent.

In cabochon cuts, the curving of the upper surface is commonly convex and varies from curves that are nearly flat to those which are very high. The widest portion of the gem is called the girdle; that portion above the girdle is the top; that portion below, if there is any, is the bottom or back. The back in the simple cabochon style is the flat undersurface. It should have a narrow, beveled edge at the girdle for the purpose of making it easier to pick up the stone from a flat table top, and also to allow for slight irregularities in the metal mounting around the soldered seam between the base

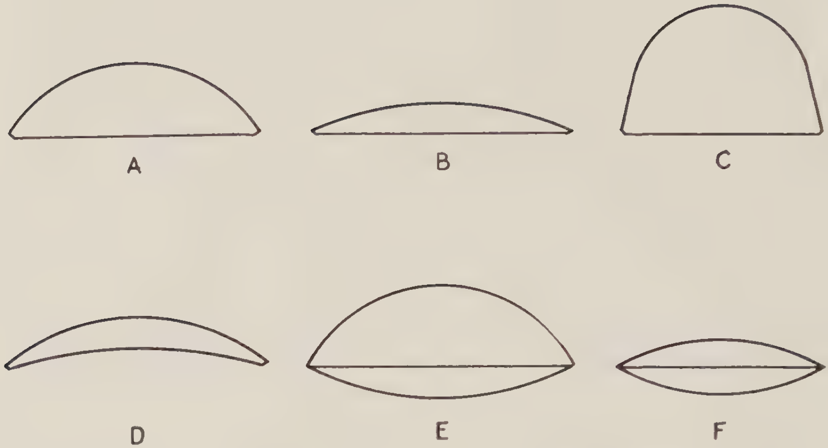


Figure 1. Styles of Cabochons, Side View. A, simple cabochon; B, low cabochon; C, high cabochon; D, hollow cabochon; E, double cabochon; F, lentil cabochon.

and the bezel of the jewelry piece into which the stone is being set (Figure 1).

Simple cabochon. The simple cabochon as seen from the side (Figure 1-A) has a flat back and a simple, curved top. In the same illustration, note also the bevel around the girdle. The stone may be round, when looked at from above, or it may be elliptical, or oval, or rectangular, or any other shape. The cutter can adopt any idea that comes to his mind. A heart shape is always popular. Hearts are advantageously cut, however, as lentils (Figure 1-F) so that both sides can be polished and either side can be worn outward on a chain. When there is a marked difference in the colors or the patterns of the two surfaces, such a heart can be harmoniously adapted to several different dresses.

Low cabochon. The low cabochon has a much flatter top than the simple cab (Figure 1-B). It is suited for softer stones, such as turquoise, where a high protruding top is apt to be chipped and worn dull in a comparatively short time.

High cabochon. The high cabochon (Figure 1-C) has an especially high top and is thus particularly suitable for hard stones. Translucent material such as chalcedony or rose quartz is well adapted to this style because it preserves the greatest depth of color and at the same time acquires a deep glow from within the stone in addition to a high surface polish.

Hollow cabochon. The hollow cabochon has a concave bottom or back (Figure 1-D). This style of cutting is used for transparent stones which are so dark in color that light is largely lost in passing through unless the gem is cut in this way. Carbuncles, or deeply colored garnets, are materially enhanced in their beauty when cut this way.

Double cabochon. The double cabochon (Figure 1-E) is a style where both top and bottom are convex; the curvature on the back is less than that on the top. It is useful where the stone is translucent, or where it has certain inclusions, as in a moss agate, which will add to its beauty if retained rather than cut away by flattening the bottom.

Double cabochons should always be polished on both sides.

Lentil cabochon. A lentil cabochon is one which has identical curves on top and back (Figure 1-F). Opals, when cut this way, often present two sides which may be equally beautiful and yet quite different. Such stones when set in a pendant can be worn with either side presenting, as the wearer's fancy dictates. Hearts as well as other pendants are favored by many cutters for this style of cutting.

Like double cabochons, lentils should always be polished on both sides.

Other styles will, of course, come to the cutter's mind, and he should let his fancy run freely. Among the styles that should be mentioned but need no further description are the table-top or flat-top cabochon and the step-top cabochon. In the former, the top and back are parallel. In the latter, the top has a number of flat faces similar to the faceted step cut. (This

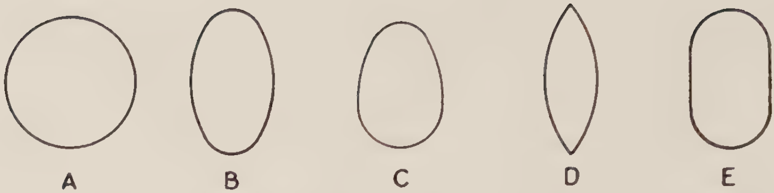


Figure 2. Cabochon Shapes. View from above showing curved outlines. A, round; B, elliptical; C, oval; D, lentil; E, mixed.

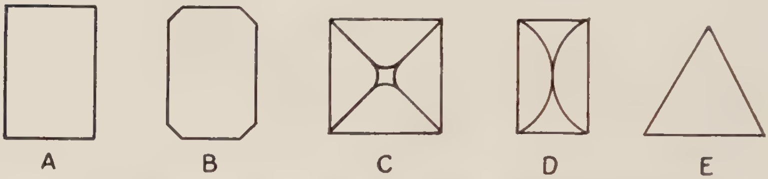


Figure 3. Cabochon Shapes. View from above showing straight outlines of sides and ends. A, rectangular; B, cut-corner; C, square; D, winged; E, triangular.

will be found discussed in detail in a later chapter). In general, it is not advisable to cut opaque stones with facets because facets lose their value when they cannot refract as well as reflect light rays from within the gem.

Cabochon shapes. So far, descriptions have dealt mainly with styles of cabochons as they appear when seen from the side. When viewed from above, an almost infinite variety of shapes will come to the lapidary's mind. Figure 2 shows a few of the common shapes, those whose girdles are curves. Figure 3 shows those where the girdles are straight lines.

It should be noted here that the terms "ellipse" and "oval" are often confused and erroneously used. An ellipse is a figure with regular curves at the sides and ends; an oval is egg shaped. The terms as used here correspond to these definitions.

Facet Cuts

These cuts will not be discussed here. This style requires advanced skill and a special set-up of lapidary equipment. The subject will be completely treated in a later chapter.

Standard Sizes of Cabochons

When cabochons are cut for use in jewelry, certain standard sizes are preferred by jewelry manufacturers. These sizes take into account the length and the width of the stone and are said to represent the artistic balance between the two dimensions. The commonly used gem stones in jewelry are either elliptical or rectangular. The different sizes are listed in Table II.

TABLE II

STANDARD SIZES OF CABOCHON GEMS FOR JEWELRY SETTINGS

Elliptical Stones		*Rectangular Stones*	
25 x 18 mm.	18 x 9 mm.	18 x 13 mm.	14 x 12 mm.
24 x 14 mm.	15 x 10 mm.	16 x 14 mm.	14 x 10 mm.
24 x 10 mm.	14 x 12 mm.	16 x 12 mm.	12 x 10 mm.
22 x 8 mm.	14 x 10 mm.	16 x 9 mm.	12 x 8 mm.
20 x 12 mm.	12 x 10 mm.	16 x 8 mm.	10 x 8 mm.
18 x 13 mm.	10 x 8 mm.	15 x 11 mm.	8 x 6.5 mm.

The cutting of cabochon gems consists of the following separate operations, which will be described in minute detail and in proper order in subsequent chapters: sawing the rough material into rough slabs or slices; rough grinding; dopping; finish grinding; sanding or smoothing; polishing; removing the gem from the dop and cleaning.

Any amateur with only the slightest mechanical ability and aptitude can easily and quickly learn to cut cabochon gems. This author cut his first gem, a beautiful moss agate, in one evening with only fifteen minutes of instruction. If he could do it, anyone can who has the necessary simple mechanical equipment and a bit of perseverance.

CHAPTER IV

The Technique of Sawing

Sawing is the first operation in the process of gem cutting. All pieces or chunks of gem material are sliced unless they are so small that sawing them in two would render them too small to make gems of them.

Forms of Rough Gem Material

The rough material is sawed into suitable sections before cutting or grinding. The only exceptions to this rule are the small crystals or pebbles. Materials obtained from the mine come in irregular blocks or chunks, large and small, and often much flawed by fracture and by cracks produced by hammer blows. Material picked up on the ocean beaches or river banks is in the form of boulders or pebbles which are more or less waterworn. Much of the best material is in the form of crystals. This latter is especially true of the transparent material suitable for facet cutting (Figure 4-A-B-C).

Irregular chunks usually have sharp corners or acute edges. Thus they can be easily and securely held in a wooden or metal clamp in the saw. Pebbles are rounded and are therefore quite difficult to hold firmly. Such pebbles may be flattened slightly by a bit of grinding on two opposing sides in parallel planes, after which they can be tightly clamped.

Orientation of Rough Material for Sawing

The chunks, pebbles, or crystals are sawed into slabs of any desired thickness. For all-round cabochon work, slabs ⅛ to ¼ inch thick are suitable. If high cabochons are desired, the slices should be thicker. Opaque material can be

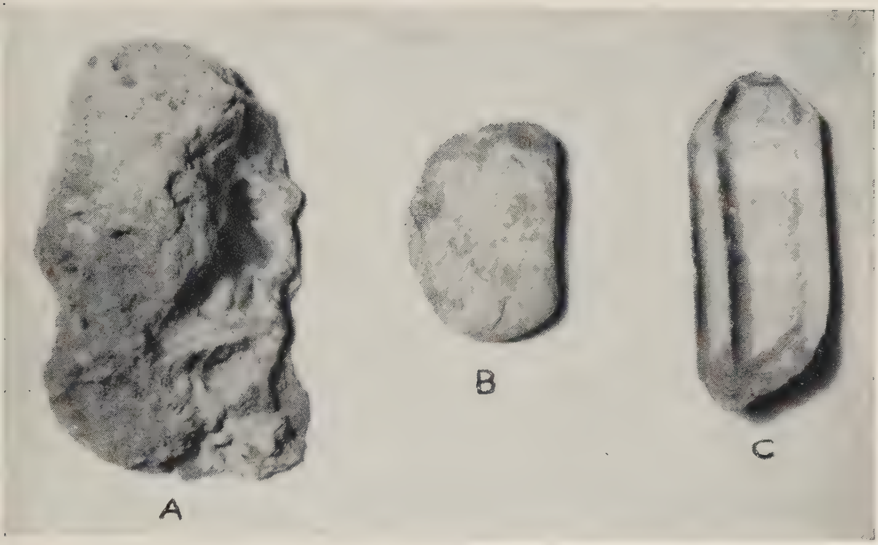


Figure 4. Forms of Rough Gem Material. A, irregular chunk or block; B, water-worn pebble; C, quartz crystal.

cut quite thin, which will cut out more slices per pound of rough and still show its color and pattern well. Translucent material needs more thickness. The thinner the slice the more color will be sacrificed.

For certain materials, such as labradorite or opal, where color play is especially valued, the slabs may be cut quite thin, provided the material is opaque. The amateur will quickly learn which thickness suits him best.

When sawing material which shows marked irridescence, opalescence, chatoyancy, or color-play in certain parts of the stone, careful study must be made to decide exactly which way the slices shall be cut. The high point of the top of the cabochon should be located at the same point where the greatest beauty of color-play is seen. The chunk of rough is held in the hand so that the light is above and in front of it. The stone is then turned in all possible directions to bring out all the angles at which the light shows the changes in the material. The plane of the saw cut, which later forms the back of the cabochon, is then located horizontally and the direction of slicing established. In this way, the beauty of the stone is brought out to its best advantage.

Among the materials so treated are opal, moonstone, sunstone, obsidian, amazonite, peristerite, labradorite, tiger's-eye and cat's-eye.

In sawing, one must also take due notice of pattern and color combinations in such stones as agate, jasper, thomsonite, and chlorastrolite in order to have the best parts of the stone on the top of the cabochon.

Rough stones should not be broken up with the hammer or crushed in a vise because numerous cracks are produced thereby, to say nothing about shattering, which often completely ruins a fine piece of rough.

Types of Saws

There are several types of saws in use in the modern lapidary shop: (1) the diamond saw, (2) the mud saw, (3) the band saw, (4) the wire saw, (5) the carborundum saw.

For the amateur just as much as for the professional, the diamond saw is preferable because of its efficiency and ease of operation, and that is the saw that will be described in greater detail here. The other types are not in general use in modern shops except for special jobs of sawing, such as on large book ends or museum specimens.

The Diamond Saw Blade

The diamond saw blade is a thin metal disc from 6 to 12 inches in diameter. For special purposes, such as sawing large chunks for book ends or fountain pen bases, it may even be 14 or 16 inches in diameter. In fact, blades up to 30 inches in diameter have been made. For general use in sawing slabs for gem stones, the 12-inch blade gives excellent service.

How to Make a Diamond Blade

Usually the blade is made of steel, but copper and bronze are also used. The blank disc can be made by a machinist, or it can be purchased at quite moderate cost from lapidary-supply firms.

The thickness of the metal disc varies as to the diameter. Saw blades of 10 and 12 inches are usually made of 22- and 20-gauge metal, respectively. Table III gives the gauges which are satisfactory for general all-round purposes and the diameters of the saws recommended.

TABLE III

UNITED STATES STANDARD GAUGES FOR SHEET METALS

Gauge Number	*Thickness in Inches*	*For Diameter of Disc*
16	0.0625	30 inches
17	0.0563	
18	0.0500	20 inches
19	0.0438	
20	0.0375	14 inches
21	0.0344	12 inches
22	0.0313	10 inches
23	0.0281	6 inches

The edge of the blank disc is notched to receive the diamond dust. For this purpose, it is placed between two boards which are long enough to stand on the floor, with the blade between the knees of the operator who sits comfortably in a chair. (The reader will notice in various chapters of this book that the author believes in comfort fully as much as in efficiency.) In this position, the notching is accomplished (Figure 5).

NOTCHING THE BLADE. The edge of the blank disc is notched by placing a sharp knife blade squarely across it and striking the knife with a hammer (Figure 5); or an old file sharpened to knife edge can be used. The notches should be equally spaced. There should be twenty-four to the inch

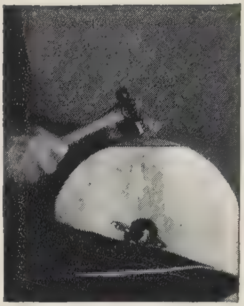


Fig. 5

Fig. 6

Fig. 7

Figure 5. Notching a Diamond-Saw Blade. The blank steel disc is notched with a knife and hammer. Figure 6. Charging a Diamond-Saw Blade. Diamond bort is distributed to the notched edge. Figure 7. Setting the Edge of a Diamond Saw. The bort is imbedded and the edge of the blade is flared or "set" by gentle hammering.

running all around the disc. They should be slightly slanted in a forward direction, not in the line of a wheel spoke. The slanting makes for better imbedding of the diamond dust, especially as the saw gets more and more use.

Charging the saw blade. After the saw blade has been notched all around the periphery, it is ready for charging with diamond dust. This dust can be obtained from various dealers who handle lapidary equipment or precision tools. Diamond dust is also known as bort. It comes in various grits indicated by numbers (Table IV).

TABLE IV

Diamond Powder Number and Grit Sizes

Diamond Powder	*Grit Equivalent*
No. 1	60 to 100
No. 2	220
No. 3	320
No. 4	400
No. 5	500
No. 6	600

For a 12-inch disc, ⅔ carat of No. 1 diamond powder (60 to 100 grit) is mixed with olive oil or castor oil to make a paste. This takes only a few drops. The paste is then carefully smeared upon the edge of the disc and evenly distributed all around, using one finger. With an orangewood stick such as is used for manicuring fingernails, the oil and bort mixture is worked into the notches (Figure 6). Then the minute dust particles are driven into the edge of the saw blade by gentle but steady blows with a small hammer (Figure 7). In this way the diamond dust will become imbedded in the metal all around the edge, especially in the notches. At the same time, the notches will be closed, gripping the diamond particles. A slight flaring of the edge, the "set," will also be produced by the hammering (Figure 8-A-B-C). The set is necessary to keep the saw from binding while sawing. After considerable service, the edge will become worn off, and then it

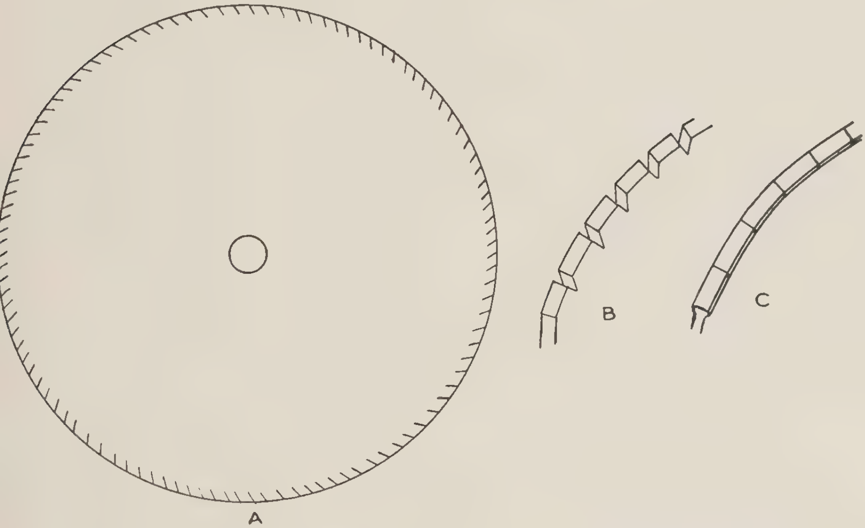


Figure 8. The Diamond-Saw Blade. A, 12-inch steel disc notched and charged with diamond dust; B, detail of notching at edge of disc (exaggerated); C, notches closed and holding the diamond dust; note the "set" (exaggerated).

needs to be gone over again with the hammer. This will bring more of the diamond dust into use and thus sharpen the saw. In going all around the periphery of the blade with the hammer, great care must be taken to deliver all the blows with equal force so that the edge will be smooth and even. A lopsided saw is not fully efficient.

Another popular method for charging a diamond saw blade is to spread the paste onto a small steel roller and then run the roller with heavy pressure back and forth over the edge of the disc, thereby driving the dust particles into the metal. Or the roller can be held against the blade while it is slowly running. These methods are, however, somewhat more wasteful of the diamond powder than the one previously discussed.

The cost of a diamond charge. The cost of the diamond dust is not excessive considering the amount of sawing a carefully charged blade will deliver and the time that is saved. At this writing, bort is offered at from $1.75 to $2.25 a carat, depending on the size of the grit.

Ready-made saw blades. The amateur beginner will have far less trouble, however, if he buys ready-made blades from dealers. They can be had with standard charge and with supercharge. The latter contain more diamond dust and work faster and longer.

These saw blades are now manufactured by mass-production methods and give excellent service. They can be run at higher speeds, which means more rapid cutting. They also seem to give longer service than hand-charged blades. At this writing, a standard 12-inch saw blade costs $10.50.

There are many cutters who would not have the ability to make satisfactory saw blades themselves, and some who would far rather spend the time sawing than making saws.

Mounting the saw blade. The charged disc must be mounted or set up for use. The simplest way to mount a blade is in an arbor of the same type that is used in the later process of grinding. For those who desire it, a specially adapted arbor for lapidary use can be had from supply firms. An ordinary arbor, however, is obtainable at any hardware store or mail-order house. Such an arbor with double spindle will be fully described in the next chapter, which deals with the equipment for grinding. The reader who is not fully aware what an arbor consists of should turn to those pages and study them before proceeding.

In mounting the 12-inch, diamond-charged blade on the spindle of an arbor, the flanges gripping the sides of the blade should be at least 2 inches in diameter, and the nut should be well tightened to prevent the slightest play, and also to prevent slipping of the blade on the spindle (Figure 9). The blade must be free from wobble and must be true-running. Mechanically made saw blades available from various dealers come up to these specifications.

The Splash Guard

After the saw blade is set up on the arbor, there is needed a splash guard with a well or trough for the blade to run in. An adequate guard must be built and placed over and around the blade to prevent as much as possible the splashing of the cutting fluid all over the shop. The splash guard may be made of plyboard. If desired, however, it can be made of galvanized iron. It should be at least 4 inches wide to allow space for cutting rough blocks of that size, since the stone must be moved forward between the sides of the guard (Figures 9 and 11). The greatest amount of space possible should be allowed on the right-hand side, from which the sawing proceeds to the left as slice after slice is sawed away.

The well is a narrow metal pan 2 inches deep, 2 inches wide, and 10 inches long, in the bottom of the splash pan. The splash pan is a rectangular box placed underneath the arbor. The splash pan with its well is thus placed so that the well is directly below the saw blade. The splash guard fits

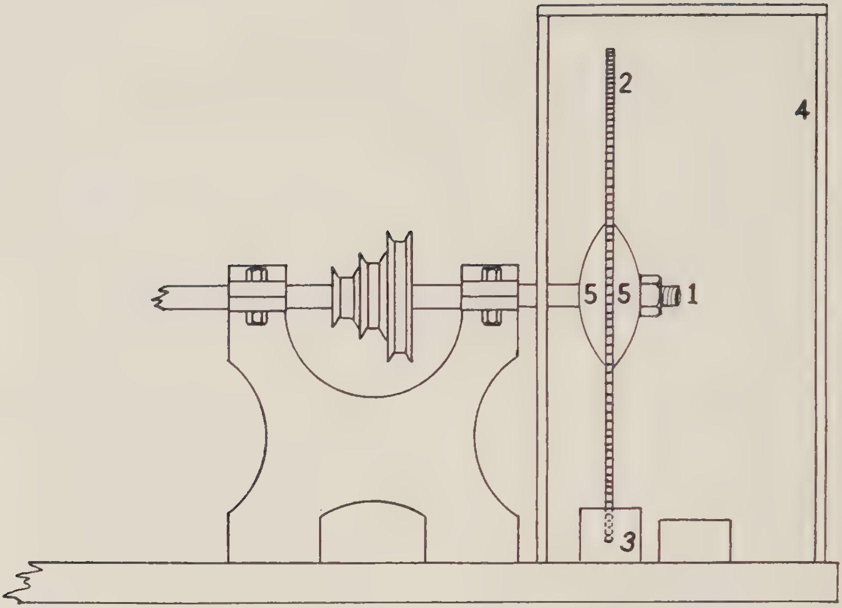


Figure 9. Front View of Diamond-Saw and Splash-Guard Assembly. 1, spindle of arbor; 2, 12-inch saw blade; 3, lubricating well; 4, splash guard; 5, 2-inch flanges. In this view the carriage is not shown.

over the top of the entire saw set-up but inside the rim of the splash pan. In this way, the cutting lubricant runs and drips into the pan and its well and is not thrown over the entire shop by the running blade. The splash pan and the well are made of tin or galvanized iron. The saw blade should run in about ½ inch of the lubricant at all times (Figures 9 and 10).

The Lubricant

The fluid for lubricating the saw blade is usually a half-and-half mixture of kerosene oil and a light, cheap automobile oil. However, the mixture has a strong and irritating odor and for that reason as well as others many cutters prefer the light oil without the kerosene.

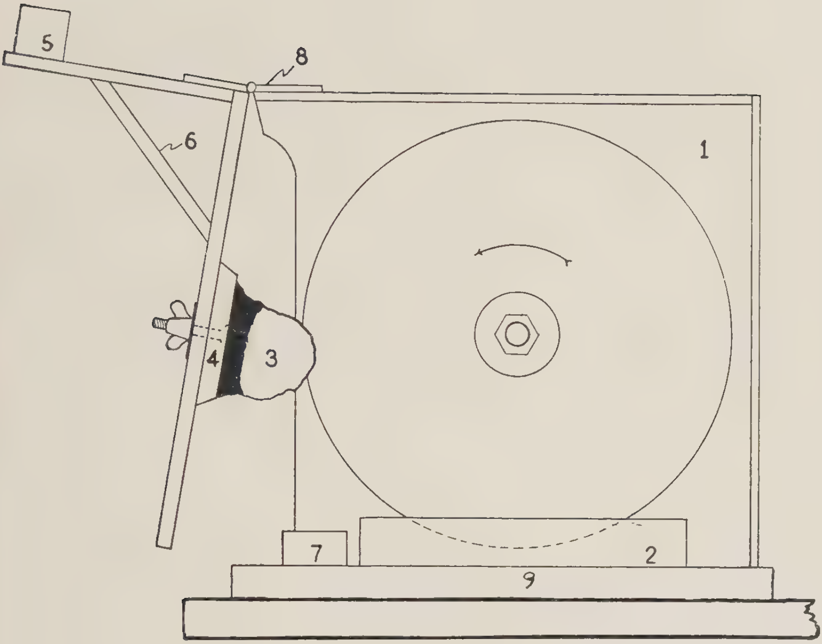


Figure 10. Side View of Diamond Saw, Splash Guard and Carriage Assembly. 1, splash guard; 2, lubricating well; 3, stone being sawed; 4, stone holder; 5, weight; 6, bracket; 7, carriage stop; 8, hinge; 9, splash pan. In this view the near side of the splash guard is not shown, so as to give a better view of the interior.

Soapy water has also been recommended, but this has the disadvantage that it will be absorbed by the wood in the splash guard and the carriage. These parts will then swell and warp and for that reason may become displaced from their true positions.

During the last war, Socony-Vacuum developed an oil especially adapted to quartz-crystal cutting for radio purposes. This oil has been found excellent as a lubricant for gem cutting with the diamond saw.

There are also advertised preparations of more-or-less secret compositions which are quite satisfactory as lubricants for diamond sawing.

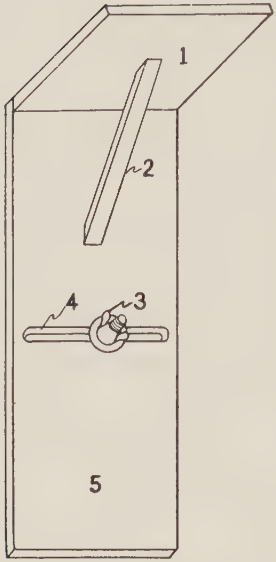


Figure 11. Front View of Diamond-Saw Carriage. 1, platform for weight; 2, bracket; 3, wing nut in carriage; 4, slot for cross-slide; 5, front of carriage.

The Carriage

There is next needed for the saw assembly a simple arrangement for holding the stone against the saw steadily and at constant pressure. This carriage for holding the rough stone is fastened to the top of the splash guard by a hinge (Figures 10 and 11). It serves the purpose of holding the stone rigidly and carrying it forward against the saw during operation. It is a board 1 inch thick, 4 inches wide, and 11 inches long. It has a horizontal slot running crosswise which serves as a slide for advancing the stone to the left from ⅛ to ¼ inch as slice after slice is cut away while sawing (Figure 11). The part that holds the stone is a block of wood 4 inches square and 1 inch thick. A bolt with its head sunk into the block runs through the slot in the carriage. A washer and wing nut fix the block in the correct positon for sawing (Figures 10 and 11). The stone is cemented to the 4 x 4-inch block with sealing wax or with one of the various lapidary cements.

The carriage has a platform extending horizontally forward for the purpose of carrying a weight to apply constant, even pressure of the stone against the saw. From 3 to 10 pounds may be applied, according to the hardness of the rough material and also depending upon the sharpness or dullness of the saw blade. To strengthen the platform, a simple bracket is placed fixing it firmly to the carriage (Figures 10 and 11). The entire carriage assembly can be turned up and rested on top of the splash guard, thereby exposing the saw and the work to full view for inspection and readjustment.

Near the bottom of the splash guard, there is an offset or stop. When during operation the carriage reaches a point where the offset stops it from further advance against the blade, the edge of the saw has reached the exact level where the stone has been completely cut through (Figure 10). The 4 x 4-inch block is thus left intact so that it can be used for an indefinite number of times for sawing.

Running Speed of the Saw

Exactly what is the best running speed of the diamond saw is a matter of individual experience. Some workers recommend a speed as low as 1500 surface feet per minute for 10- and 12-inch blades. Others use speeds which are much higher, even up to 6000 s.f.p.m.

The final solution of these variations probably lies in the quality of the diamond saw itself. A well-made blade, one that is smooth all around the edge, free from bumps and flats, has an even charge all around, has the proper set, and is absolutely true-running, can be used at the higher speeds at great efficiency. But the ordinary saw is best used at medium speeds or lower in order to be on the safe side. This author has found that speeds close to 500 revolutions per minute for a 12-inch blade give the best results.

Translating surface feet per minute into revolutions per minute can be easily accomplished by the following formula:

$$\text{Revolutions per minute} = \frac{\text{surface feet per minute}}{3.1416 \times \text{diameter (in inches)}} \times 12$$

For a 12-inch saw, the answer comes just under 500 revolutions per minute.

For smaller saw blades, the speed can be markedly increased. The periphery of the blade is much shorter, making the s.f.p.m. much less per revolution. Therefore the revolutions can be increased.

Power Required for Sawing

The diamond saw described above is powered adequately by a ¼-horsepower electric motor. A used motor from a washing machine or refrigerator will give satisfactory service.

The standard speed of a motor is 1725 revolutions per minute. It becomes necessary, therefore, to figure out the size of the motor pulley and also the size of the arbor pulley in order to obtain the correct speed of the saw. Pulleys for use in the saw as well as in the grinding, sanding and polishing arbors (to be described later) should consist of four-step pulleys for half-inch V belts. The sizes of the pulleys should be from 1 to 5 inches in diameter. By using the calculations in Table V, the correct size for the arbor pulley can be found for each of the motor pulleys listed in the first column.

TABLE V

Approximate Speeds Obtainable from Four-Step Pulley for Motor

Motor Pulley Size in Inches	*Arbor Pulley Size in Inches*								
	2	3	4	5	6	7	8	10	12
2	1725	1075	781	614	505	425	371	295	245
3	2550	1725	1252	980	807	685	596	458	392
4	3800	2360	1725	1345	1100	940	820	650	540
5	4875	3040	2205	1725	1425	1210	1050	835	695

It will be seen that for a 2-inch motor pulley, a 6-inch arbor pulley is required on the saw for a speed of 505 revolutions per minute.

Mounting the Saw Assembly and Motor

The saw is now assembled in its arbor, fitted with its splash pan and guard and carriage, connected with its motor by a half-inch V belt, and needs only to be mounted on a firm bench or table. Any sturdy bench 38 inches high is usable, but the author prefers a table because this makes it possible to sit down during the operations and be comfortable. This table will be fully described in a following chapter.

The motor is placed in the middle of the table upon a floating rail. By this arrangement, one motor can be used for two arbors, one at each end of the table. The floating rail is obtainable at hardware stores or at mail-order houses at a cost of about a dollar. The motor is simply lifted from the rail, turned around, and replaced on the second rail, from which it serves the arbor at the other end of the table.

The diamond saw which has just been described is simple and effective although quite amateurish. The main feature is its low cost, which makes it desirable for the beginner. It can be built by almost anyone, even those having little experience but some practical resourcefulness. It is slow but fairly efficient. It is rather messy and sloppy. Even the best guard will not keep a little of the oil and mud from getting thrown around. It is far inferior to a modern diamond saw such as can be purchased from lapidary-supply dealers.

Ready-made Diamond Sawing Outfit

The lapidary who can invest a little more money in his shop will usually not set up the simple type of saw but will purchase one of the several types of ready-made saws on the market. One of these has been used by the author for a number of years with satisfactory results. A description of the basic outlines and principles of this sawing outfit will be given in some detail in the following paragraphs. This saw can be recommended highly, and with proper care will last indefinitely.

The saw has a blade 12 inches in diameter. This blade is mounted on an arbor which is firmly fixed to the side of a

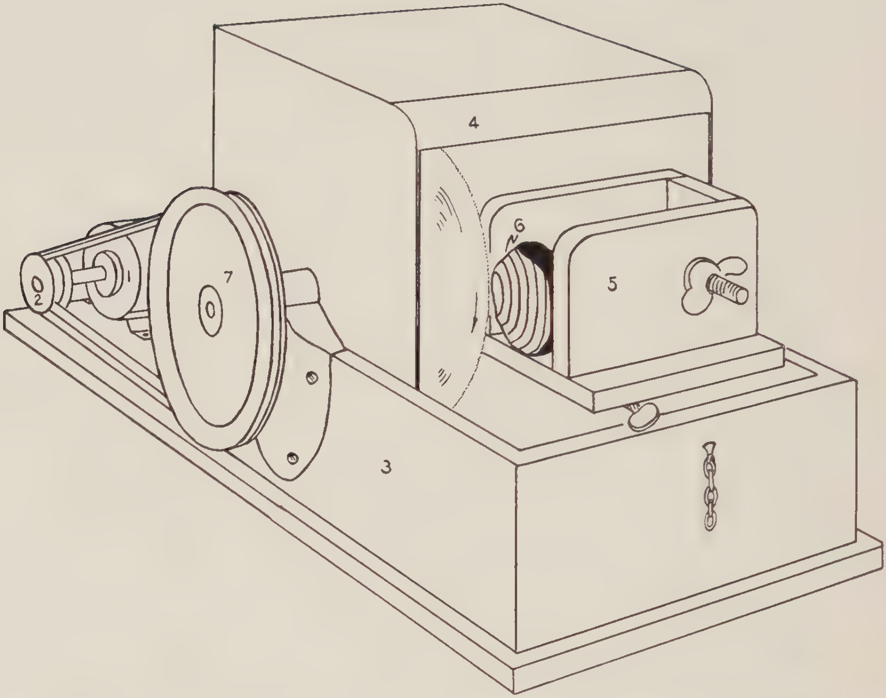


Figure 12. A Ready-made Diamond-Sawing Outfit. 1, motor; 2, pulley; 3, tin-lined box; 4, splash hood; 5, sliding clamp; 6, material in clamp; 7, arbor pulley.

strong box, 12½ x 19½ inches (Figure 12). This arbor has a spindle ⅝ inch in diameter, the inner end of which is cut down to ½ inch to fit the arbor hole of the saw blade. The outer end carries an 8-inch pulley for the accommodation of a half-inch V belt. The blade runs inside the box, which is lined with tin.

The lower edge of the blade runs within a well in the bottom of the box where the lubricating fluid should be kept at a constant level high enough to keep not less than ½ inch of the edge of the blade running through it (Figure 13-A).

The fluid used has already been described in preceding paragraphs.

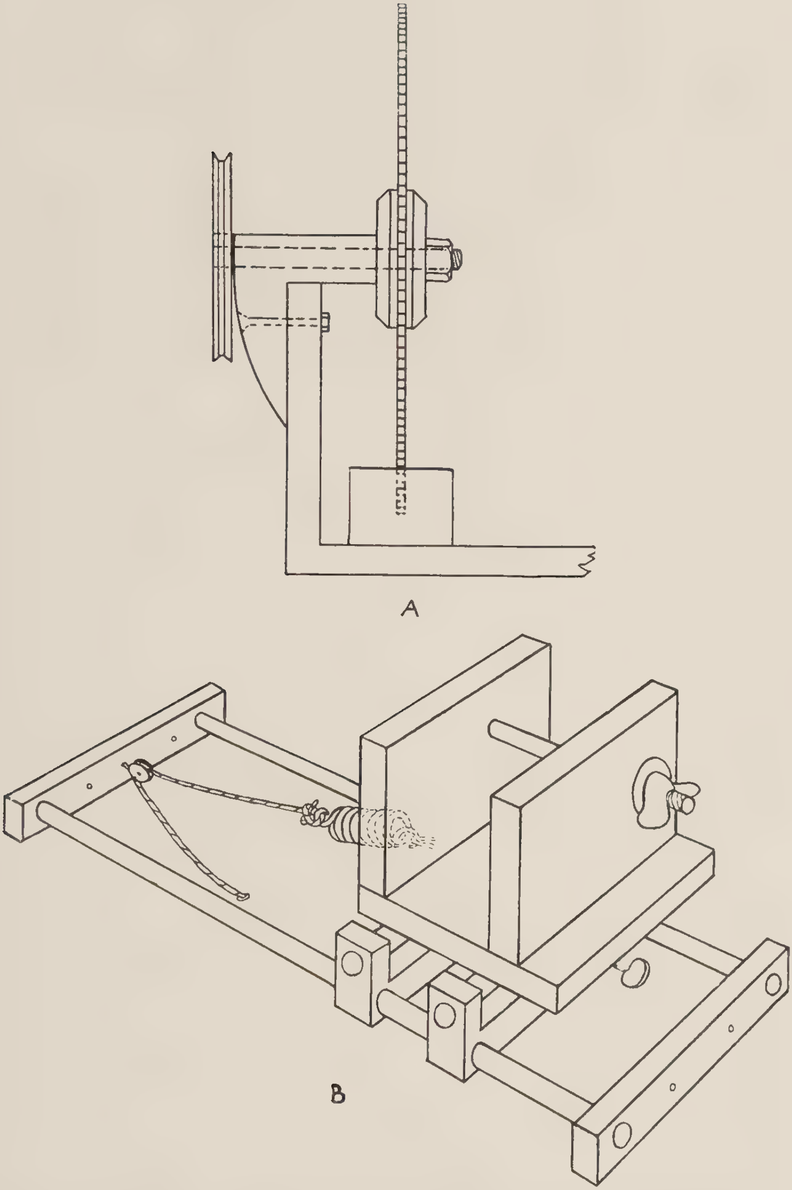


Figure 13. Details of Outfit Shown in Figure 12. A, detail of arbor and of lubricating well; B, detail of carriage and clamp. These two figures should be studied in connection with Figure 12.

The block of rough material to be sawed is held firmly in a clamp which moves on a carriage. This carriage has double action. It runs back and forth upon two $\frac{5}{8}$-inch rods which are mounted within the box parallel to the plane of the saw blade. It also slides crosswise upon two shorter rods. This carriage has attached to it a clamp of hardwood which holds the material to be sliced. The long carriage allows the material to advance against the saw as the cutting proceeds, while the cross carriage allows the clamp to be moved into position before the blade as each succeeding slice is sawed off (Figure 13-B).

Attached to the back of the carriage is a large spring. A cord runs from the spring over a pulley and then forward to the front of the box, where a chain is attached. This chain emerges through a key hole which engages the links. By this method constant tension is provided (Figures 12 and 13-B). This tension can be regulated by pulling more of the links of the chain through. A spring pressure of from 3 to 10 pounds is used for the actual operation.

Over all of this assembly, a metal guard is placed with the open side down and the front end open. The sides and the far end of this guard or box fit snugly into the tin-lined box. This keeps the lubricating fluid from splashing all over the place. The open front may be covered by a cloth; however, a better method is to obtain a discarded X-ray film 10 by 14 inches in size from some hospital or laboratory. One end of this film is placed under the upper edge of the splash hood; the other is placed inside the front edge of the box. The film curves in front of the blade and the carriage and forms a perfect protection. The fluid as it is thrown peripherally from the running saw is caught up by the film and returned to the inside of the box. At the same time, the film, being cleared of its emulsion, is transparent, allowing the progress of the sawing to be continuously observed.

A very efficient and more pretentious splash guard can be made by making a wooden frame from half-inch plyboard, fitting it over the front and the sides of the opening. This frame is then cut out to make a window in front and another on top. A clear X-ray film is then tacked over the openings in the inner side. This forms a watertight splash guard with two windows of clear film for constant observation of the cutting as it proceeds.

Electric motor for sawing power. For power, a ¼-horsepower electric motor is used. The entire saw assembly forms a unit which can be placed upon a table or a workbench where it can be firmly and temporarily held by clamps, or permanently attached by bolts.

Operating the Diamond Saw

We are now ready to operate the saw. First the lubricating fluid is poured into the well. Next the material is placed into the clamp, properly oriented, and the clamp firmly tightened. After tightening, the rough material is grasped with the hand and shaken to test it for firmness in the grip of the clamp. If the clamp holds it without any play or slipping, we proceed.

The material in the clamp is then gently brought against the edge of the blade without pressure or tension, the splash hood is adjusted, and the motor is started. The first biting of the saw into the stone must be done under guidance with exceedingly light pressure to avoid injuring the blade. As the cut begins to deepen in a few seconds, the tension can be increased gradually. The tension chain is then tightened to about 8 or 10 pounds pressure, and we're off.

While the saw is running, the operator may sit and watch it or he may turn his attention to some other task while the sawing proceeds more or less unobserved. When sawing specimens of more than 1-inch thickness, the tension will gradually play out and the chain will have to be tightened from time to time to maintain proper pressure of the work against the blade. Each time a slice is completed, the work is readjusted and the next slice is started.

It is not well to allow the saw to run through the cut completely so that the slice falls off. When the cutting edge is almost all the way through the rough work, the tension should be relaxed and then eventually taken off entirely just before the blade cuts completely through the work. By drawing the saw blade out of the groove, the sliced section can be detached completely with only slight pressure by snapping off the small remaining portion by which it is still held.

The cross carriage is then slid over, bringing the next slice to be cut into line, and we're off on the second slab.

Slices may be cut any desired thickness; ⅛ to ¼ inch is desirable. Thickness is influenced by the design or pattern brought out in the surfaces which are cut, as well as by other factors (Figure 14).

The speed of the saw should be calculated on the basis of surface feet per minute. This has been discussed in considerable detail earlier in this chapter.

Sawing outfits built along the general basic lines as described here are advertised by dealers in lapidary equipment at moderate prices.

The Cut-Off Saw

A smaller diamond saw in a different assembly is used for the sawing of small sections out of slabs and for finer crystals. Slabs which have been sawed by the larger saw may contain many cabochons. Such slices have to be sectioned or divided up into smaller parts. Sawing saves much material and avoids the method of breaking up the slabs by hammer blows. Slabs which contain markings or stripes or designs need to be carefully laid out to get the most out of the finished cabochons, and that is where the cut-off saw comes in.

This saw blade is 6 or 8 inches in diameter. It can be

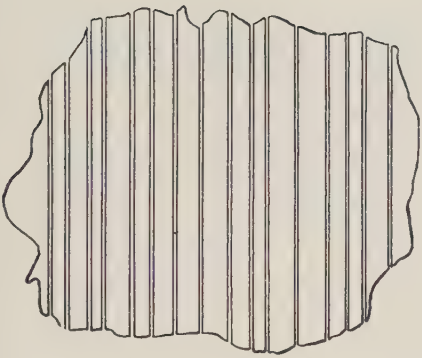


Fig. 14

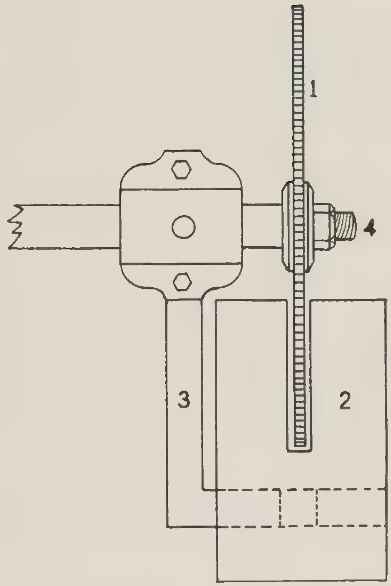


Fig. 15

Figure 14. A Chunk of Gem Material Sliced Into Slabs of Various Thicknesses. Figure 15. Small Cut-Off Saw as Seen From Above. 1, 8-inch saw blade; 2, work platform; 3, tool rest holding platform; 4, arbor spindle.

mounted in an arbor identical with the one used for grinding operations, which will be described under that heading in the next chapter.

There needs to be added to the arbor itself a flat work base on the tool rest of the arbor. This work base consists of a hardwood platform 3½ x 5 inches and 1 inch thick. A slot $\frac{1}{16}$ inch wide is cut lengthwise in this platform for a distance of 3 inches. The platform is mounted flat so that the saw blade will run within the slot. The slab to be cut into smaller cabochon blanks is laid upon the platform or work base and slid forward against the saw by hand (Figures 15 and 16).

Also needed is a splash guard consisting of a simple box 11 x 11 x 3 inches, with open front. It is made of half-inch plyboard, and is placed over the saw, protecting the back, sides, and top while the front remains open for access to the sawing edge.

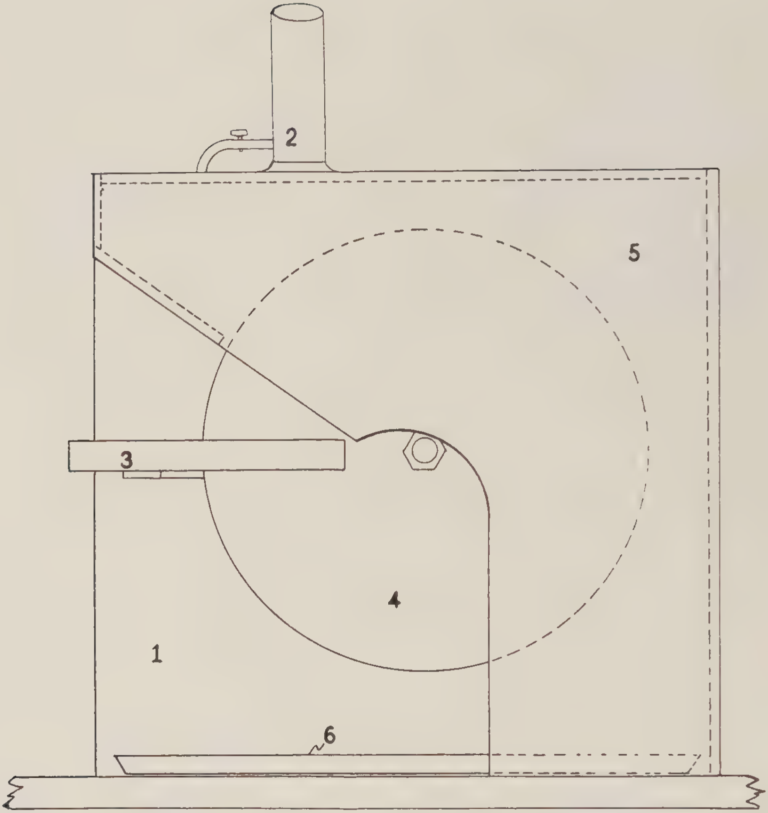


Figure 16. Side View of Cut-Off Saw. 1, left side of splash guard; 2, oil cup for lubricating fluid; 3, work platform; 4, 8-inch saw blade; 5, right side of splash guard; 6, drip pan.

The left side should completely cover the saw, but the right side is partly cut away to allow for room for the slab and the cutter's hands while working.

On top is placed a simple oil cup which when filled will drip lubricant through a small hole exactly onto the point of contact between the blade and the work (Figure 16).

Laying Out Cabochon Blanks on a Slab

The slab from which cabochon gems are to be cut is

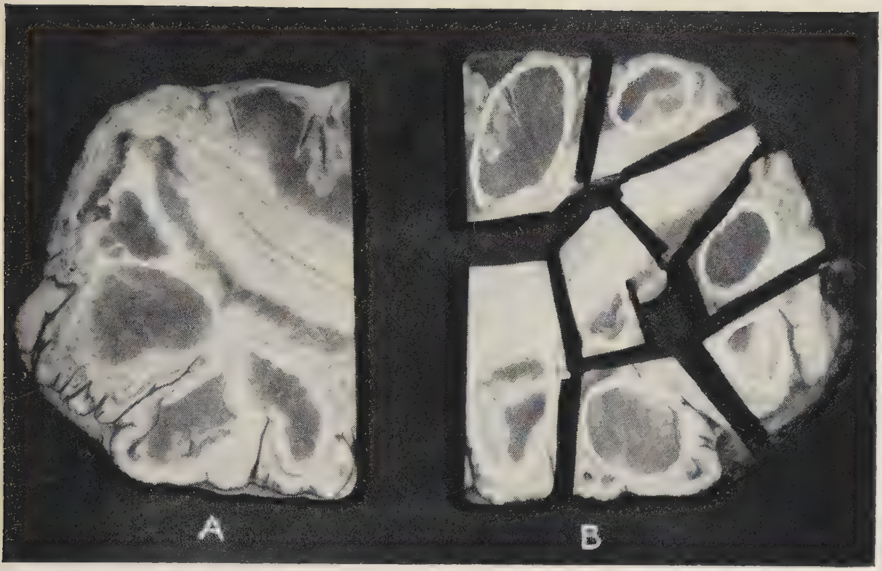


Figure 17. Lay-Out of Cabochons on a Slab. A, a slice of variscite showing markings and color patterns in matrix; B, cabochons laid out and slice sawed into blanks.

carefully studied and the cabs to be cut are laid out on its surface with a pencil. Instead of an ordinary pencil, which is not likely to make recognizable marks permanently, an aluminum pencil may be used. This is made simply by sharpening on the grinding wheel a rod of aluminum, such as is used for welding operations, much like a pencil is sharpened. Aluminum marks will withstand oil and water well.

The layout takes into consideration the markings on the slab so as to bring out to best advantage desirable and attractive designs or color combinations in the finished stone. Figure 17-A-B shows such a layout.

All sliced material is first studied and the blanks for cabochons are carefully laid out. No haphazard cutting should be indulged in — or the gem will be mediocre and haphazard, too, instead of fully developed in all its possibilities.

Operating the Cut-Off Saw

The slab is next laid flat on the work platform of the cut-off saw and cut into cabochon blanks from which the gems are to be ground out later. The slab is carefully pushed into the saw in a perfectly straight line, riding on the work platform. Cuts are made from the periphery inward, so that each time that two cuts meet a blank is cut away. It can be easily seen that breaking up the slab with a hammer would be most disastrous. A cut-off saw will pay for itself in a short time by saving material and by producing far more beautifully designed gems.

The speed at which the small cut-off saw should be run is calculated on the basis of surface feet per minute, as described earlier in this chapter. This means that the revolutions per minute will be much greater than for the larger saws.

Mud Sawing

Mud saws can be set up like diamond saws. The discs are usually 10 or 12 inches in diameter, but they are not notched, nor do they have a "set." Instead of imbedding diamond dust in the metal, the disc is simply run through a mixture of water and silicon-carbide grit with about 10 per cent addition of Norbide grit, plus a small quantity of clay flour to make the consistency of the mixture like that of cream. The usual size of grit used is 120. The mixture is placed in the well of the sawing outfit, and the blade picks up the abrasive while running through it and passes it over the stone.

Mud sawing is much slower and much messier than diamond sawing. The speed of the mud saw should be about one fourth that of the diamond saw. This type of saw is not recommended for fine lapidary work. It finds its use mainly for sawing large specimens.

Protection of the Hands

Sawing by any and all methods is apt to be quite messy.

Where oil is used extensively, the cutter may even get enough exposure to the irritant to develop a dermatitis. It is wise as well as much more pleasant to use large tweezers for picking up slabs of material from out of the well. Mail-order stores have gloves which have been dipped into what appears to be a mixture of asphalt and synthetic rubber. These gloves are completely impervious to water and oil.

Cleaning the Sawed Slabs and Cutter's Hands

Slabs which have been sawed are usually dripping with the lubricating fluid. This should be wiped away at once to prevent the saturation of the stone with it. For the first wipe, crumpled newspaper is quite satisfactory. This should be followed with cloth. Or a rinse of tribasic sodium phosphate solution seems to cleanse the slab quite thoroughly.

For cleaning the hands, the author can recommend most highly a preparation known as pH_6 skin cleanser, together with cornmeal scrubber. It is obtained from chemical-supply firms that furnish machine shops with oils, soaps, and other chemicals.

DON'TS FOR DIAMOND SAWING

(1) Don't run the saw dry. Keep plenty of lubricant in the well and change it frequently.

(2) Don't start the saw before the work has been placed in contact with the blade.

(3) Don't run a blade unless it is firm and tight in its arbor. Play in the flanges can ruin it.

(4) Don't put too much tension or pressure on the blade.

(5) Don't expect a saw to cut a surface that is slanting. Unless the stone is set squarely against the blade it will run off to the side following the slant and may be ruined.

(6) Don't attempt to cut with a blade that has lost its set. Give it a new set.

(7) Don't force a blade when it binds or sticks. Remove it and renew its set.

(8) Don't fail to clamp the work firmly so that no slipping can take place.

(9) Don't run a blade faster than recommended by its manufacturer. If in doubt, play safe; use a speed close to 500 r.p.m. for a 12-inch saw.

CHAPTER V

The Technique of Rough Grinding

GRINDING the rough gem material into the general shape of a cabochon is the second operation in gem cutting.

Any small piece of rough, such as a pebble, can be ground to shape without previously sawing it into slabs. But most material comes in chunks large enough so that it needs slicing. Quite often, even small pebbles can be sliced in two, thus making it possible to get two cabs out of one pebble. Every pebble and every slab should be fully evaluated as to the best possibilities for attractive gem stones.

Study and Lay-Out of Rough Material

Figure 17 shows a reproduction of a slab of Utah variscite. Note that it has beautiful markings and color variations. In a fine piece of material like this, nothing should be wasted that can possibly be made into a gem. Even its smallest parts are usually suitable for cabochons.

The entire piece should be studied and the markings so placed in the contemplated cabochons that the finished gems will have a pleasing and symmetrical appearance. The best patterns of color and design should be brought out in the most advantageous way. Stripes may be placed across the middle, or diagonally, or some other attractive direction — the point being that planning and study are necessary for best results.

On every sawed slab a number of cabochons are first marked out by means of a pencil. A plain black pencil will not leave permanent marks; any fluid will wash it off. For making markings on slabs of gem material that will withstand a lot of washing and rubbing and yet be recognizable, an aluminum pencil should be used.

The Use of Templets

Many persons will find it difficult to draw curves of the proper degrees to make circles or ellipses. Grinding stones into such shapes, may, therefore, be quite a problem to them. For them templets, guides, or models which indicate the shapes of the finished work will be of great help. Templets of metal or celluloid are to be had from firms dealing in surveying and drawing instruments. Circles, and ellipses of various degrees of curvature, as well as squares, triangles, and other shapes, are exceedingly useful, also, in cutting gems to exact size, especially where a certain size and shape is to be duplicated a number of times (Figure 18).

After marking, the slab is cut into small parts with the small cut-off saw as already described in a previous chapter (Figure 17-B). The small pieces, which are cabochon blanks, are now ready for grinding into rough cabochons. This is called roughing-out the stone.

Roughing-Out the Cabochon

For the start of this operation, the motor is turned on, the water is started dripping, the cutter puts on his apron, rolls up his sleeves, and the grinding begins.

What the cutter wears. The modern cutter wears an apron of blue denim or some other similar material. Aprons are available in mail-order stores at low cost. The apron used by printers is entirely satisfactory. In this way, the cutter protects himself from being splashed, but, what is far more important, minute grains of grit are caught and held which otherwise might reach or be transferred to the polishing wheel where they become easily imbedded. A felt or leather polishing wheel with even one grain of grit on it scratches and rescratches the gem, preventing proper polishing.

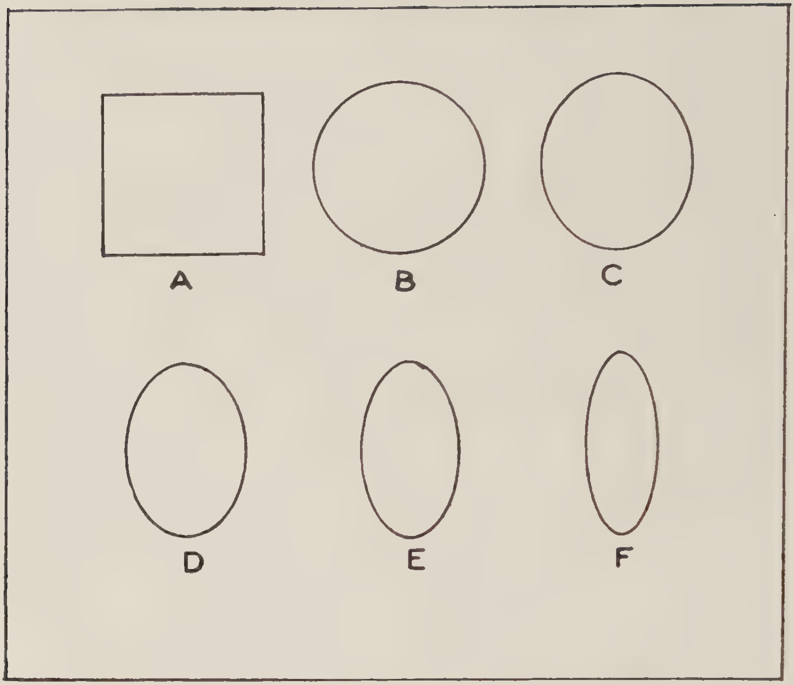


Figure 18. Templet. A, 1-inch square; B, 1-inch circle; C, 60-degree ellipse; D, 45-degree ellipse; E, 35-degree ellipse; F, 25-degree ellipse.

The apron used for grinding can also be used for sanding. But under no circumstances should the cutter take chances. He should have a special apron, to be used for the polishing operation only.

Some cutters can do better work wearing an eyeshade. Hand lenses or magnifying glasses are also of help where they are needed. However, they are more important when polishing, where it becomes necessary to detect even the minutest scratches. This can only be done by the aid of a good light and a good lens.

How to hold the stone. The stone is taken in both hands, bottom up, between the thumbs and forefingers, and held firmly against the periphery or edge of the running

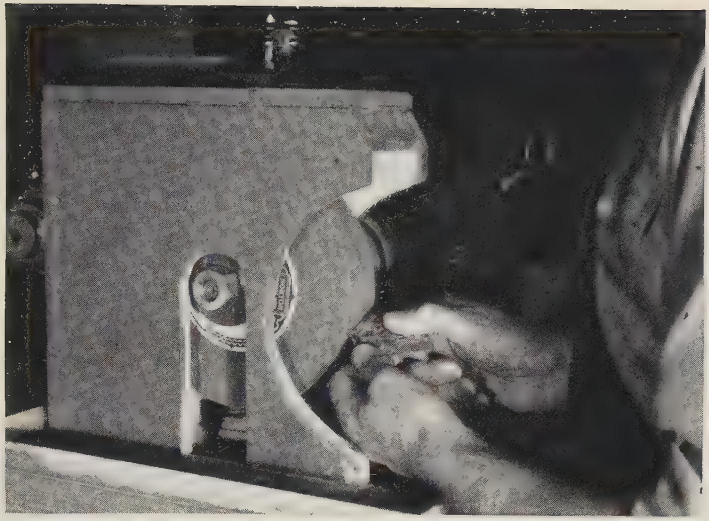


Figure 19. Grinding the Rough Stone. The direction of the grinding wheel is clockwise when viewed from the left side of the wheel. Note the manner of holding the stone to the wheel.

grinding wheel (Figure 19). The forearms, elbows, or wrists (at least one of them) should be securely rested upon a block or arm rest, or upon the splash pan or some other fairly solid fixture. This avoids slipping and bumping of the stone. It also keeps the arms from getting too tired; it helps to make the cutting even and smooth; and it keeps the grinding wheel from becoming uneven and bumpy.

As the grinding proceeds, the stone is turned so that the highest point, that point which needs the most grinding to get it into the desired shape, is always in contact with the wheel. Only moderate pressure is used against the grinding wheel. In fact, the softer and the more brittle stones are ground with exceedingly light pressure. The stone is kept constantly in motion from side to side of the periphery of the wheel.

Side grinding is suitable only for flattening the back or for smoothing the top when that is flat or very nearly so.

Pressure should not be great when grinding on the side because the wheel might become grooved, after which it is useless for flattening bases. Side grinding is done on the side of the grinding wheel by simply holding the flat part of the stone there. A certain amount of sliding, back-and-forth motion is necessary to keep the stone from wearing grooves into the side of the grinding wheel.

The cutter's mind should be made up before he begins to grind which side of the slab he wishes for the bottom and which for the top of the finished cabochon. It will be advantageous to do the grinding mostly away from the girdle and toward the top. This will keep the girdle fairly sharp and smooth. By grinding toward the girdle, chipping cannot be avoided, and, indeed, a stone may be completely ruined by the tearing away of a large chip out of a delicate, sharp girdle.

As the grinding gets underway, the rounded curves of the elliptical cabochon or the straight girdle lines of the rectangle will gradually take shape. Keep turning the stone, always presenting the highest point for grinding it down. The gem stone needs to take on only the approximate shape in this operation. The finer finish will come later. When the cab is roughed-out to the desired shape and roundness at the top, the rough grinding stops.

The Grinding Wheels

The grinding, also called cutting, is done on two different wheels (Figure 20-A-B). These are made of silicon carbide or boron carbide. Minute, sharply angular grains of these exceedingly hard substances are cemented together with a "bond." The grains are of varying sizes. There are, therefore, two factors to consider when selecting grinding wheels: (1) the grit, and (2) the bond.

The grit refers to the size of the grains or particles in the wheel. The coarser the grit the more rapidly will the wheel grind away the gem stone. At the same time, this has

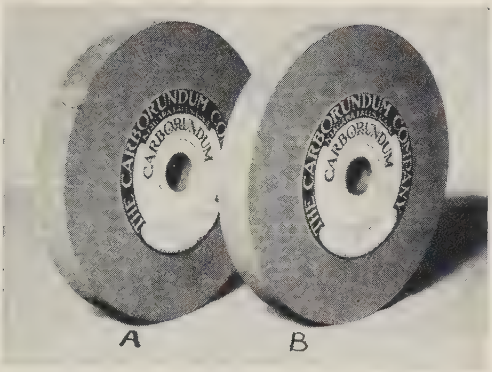


Figure 20. Grinding Wheels. A, 100-grit wheel; B, 220-grit wheel.

the disadvantage of ripping and tearing at the gem and often causing much injury to it. A grit of 100 is most suitable for the first or rough grind, while a grit of 220 is satisfactory for the finer finish grind.

The bond cements the carbide grains and holds them in place in the wheel. The harder the bond the longer and more tenaciously will the grit be held, and the longer will the wheel wear. And the other way around — the looser the bond the quicker the wheel will wear down.

In the hard bond, the carbide particles will lose their sharp edges and become dull and smooth and the grinding will be slow. Nevertheless, and often in spite of heavy pressure while grinding, the particles will be held by the bond. Accordingly, the wheel surface may become glazed and lose all its grinding grip.

A soft bond will grind away the material much faster, but will also tear down the wheel faster. Here the particles are more loosely held and therefore easily torn away from the bond.

It is necessary, therefore, to find a bond which the cutter will like best. Some will prefer the one, some the other. In the author's shop, a K bond for both the coarse and the fine wheel is used. This is considered a medium bond. As just said, the coarse wheel is a 100 grit; the fine wheel is 220. These wheels cut well and wear well but are not as speedy as a J bond and an 80 grit for the rough grinding wheel, and a 180 grit for the finish grinding wheel. Many cutters prefer to use L bonds, and some even use M bonds.

In general, gem stones of different hardness require different wheels of different hardness or bond. The harder stones take softer bonds and vice versa.

Running speed of the grinding wheels. The speed at which the wheels run is best calculated on the surface-feet-per-minute basis. This means that the linear periphery of the wheel is the standard. A wheel 8 inches in diameter has a peripheral length of about 25 inches. Each rotation of the wheel then runs 25 inches of cutting surface over the material.

For the best all-around grinding effect, the speed should be 3000 surface feet per minute — less, rather than more. This figures out at 1000 revolutions per minute for a 10-inch wheel. In the previous chapter, the reader will find a formula for determining the running speed in revolutions per minute where the surface feet per minute are known. He is also referred to Table V, where the speeds can be calculated on the basis of size of pulleys, when the motor speed is 1725 r.p.m. From this formula, the cutter can readily figure out and adjust the speed for any size of wheel.

Wheel sizes. The thickness of the wheel varies according to the whims of the cutter. The thicker the wheel the longer it will last. For a light wheel, a thickness of 1 inch and a diameter of 8 inches is a good size. For a heavier wheel, 1½ or 2 inches in thickness and 10 inches in diameter is satisfactory. Larger wheels than that need especially heavy support and a large arbor. They are not advisable for general all-around purposes.

Care must be taken when buying grinding wheels to state the diameter of the spindle so that the arbor hole in the wheel will fit correctly.

The author prefers wheels which are 1½ inches thick and 10 inches in diameter.

Watering the Grinding Wheel

The grinding must be done with the surface of the wheel wet at all times. This avoids overheating, which may cause cracking or fracturing of the rough material. It also washes away the mud and debris from the surface of the wheel which has been left there by the gem stone from which it has been ground away.

The water is best supplied to the wheel by the running-water method from a faucet. If running water is not available, a 1-gallon tin can with a small spigot may be rigged up above the wheel as shown in Figure 21-A. The water should drip at the rate of about 200 drops a minute, enough to keep the wheel thoroughly wet at all times.

Another method is to have a shallow pan beneath the wheel with enough water in it at all times to allow a small part of the lower edge of the wheel to be running through

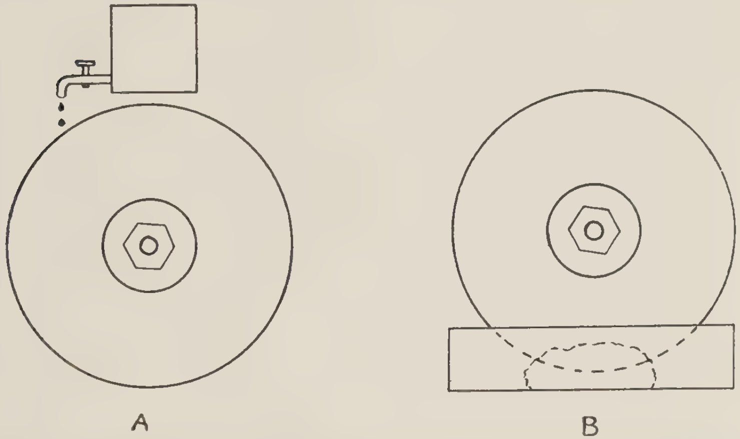


Figure 21. Methods of Watering the Grinding Wheels. A, side view of a wheel which receives continuous drip; B, side view of a wheel running in a shallow pan containing water and sponge.

the water constantly. In the pan may be fixed a sponge upon which the wheel surface rides. This keeps the splashing down to a minimum (Figure 21-B).

If the pan method is used, great care must be taken to remove all the water from the pan when stopping the wheel. A wheel which is allowed to stand with a portion of its periphery in the water while the rest is allowed to dry out will very often break when it is started up again. The increased weight of the wet portion can cause the lopsided centrifugal force to tear the wheel apart. A wheel must never be run unless it is all dry or all wet, and for grinding it must be wet.

Mounting the Grinding Wheels on the Arbor

The grinding wheels are mounted on an arbor. An arbor, or grinding head, is a metal frame holding a spindle. The middle of the spindle carries a grooved pulley for the belt from the motor. This pulley should be of the multiple step type, carrying three grooved wheels, the largest being 4 inches in diameter. At each end of the spindle a grinding wheel is mounted. Thus an arbor is run by a ¼ or a ⅓ horsepower motor and carries two grinding wheels, one at each end of the spindle (Figure 22).

The arbor must be sturdy. For wheels up to 10 and 12 inches in diameter the spindle should not be less than ⅞ inch in the middle, and ¾ inch in the ends. Wheels need ¾-inch arbor holes to fit such an arbor. This size of arbor is obtainable at most hardware stores or the usual mail-order stores.

Special Arbors

Arbors especially designed for the lapidary shop can be obtained from lapidary-supply firms. An arbor with babbitt bearings is quite satisfactory, but one with ball bearings will run smoother. In all cases, an effort at protecting the bearings

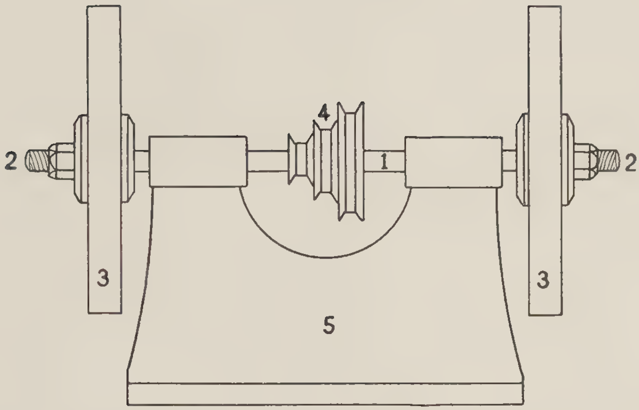


Figure 22. Grinding Arbor With Grinding Wheels Mounted. 1, shaft of spindle, ⅞ inch in diameter; 2, ends of spindle, ¾ inch in diameter; 3, grinding wheels, 1 inch thick, 8 inches in diameter; 4, step pulley; 5, heavy-duty base.

from grit is a wise precaution. Grit from the grinding wheels might otherwise enter and ruin the bearings.

The Motor for the Grinding Arbor

The motor can be a quarter horsepower but a third is more dependable. It should have a 2-inch driving pulley. This should accommodate a half-inch V belt about 32 or 40 inches long. The multiple pulley on the arbor should have four steps, and the largest should be at least 4 inches in diameter. This arrangement will allow sufficient leeway to produce variable speeds for the grinding wheels. As the wheels wear down and the diameter decreases, they should be speeded up. The proper speed and how it is calculated have already been discussed.

Dressing the Grinding Wheels

The periphery of a new wheel is regular. But quite shortly it will become uneven and bumpy from grinding. This is due largely to unsteady pressure of the stone against the wheel,

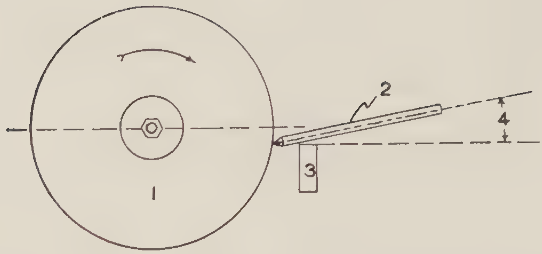


Figure 23. Wheel Dresser, Shown in Proper Position to Wheel. 1, wheel; 2, wheel dressing tool; 3, rest for tool; 4, angle at which the dresser should be held to the wheel.

but there are other causes, some of which seem to be unavoidable.

Wheels must be dressed or trued whenever they become bumpy. This can be done by means of a wheel dresser, commonly in use by machinists and grinders. The dresser is placed upon a block for a firm foundation, or it may be rested upon a tool rest if the arbor has such an attachment. The rest for the dresser must be firm. The dresser is first placed on the block or rest in front of the running wheel and is then slowly pushed against the wheel. The dresser must be held so tightly that no chattering or jumping occurs. Plenty of water must drip over the wheel. In this way, the wheel can again be made smooth and true. This is a job that must not be hurried. The correct pressure and grip are all-important.

From lapidary-supply houses, a silicon-carbide stick is also available which is advised for wheel dressing. Diamond wheel dressers can also be obtained.

The correct way in which the wheel dresser is held to the wheel for best results is shown in Figure 23. The point of contact of the dresser with the wheel is slightly below the midpoint of the spindle. The angle which the dresser makes with the wheel is about 80 degrees. Dressing of the wheel must be done with plenty of water dripping on the work at all times.

The Splash Guard

Since all the grinding is done wet, there is a great deal of splashing. Not only does the water get around everywhere, but also the mud, produced by the material ground away from the gem rough, gets into everything within its reach. And, worst of all, the grit lost from the grinding wheels is disastrous to bearings, as well as to the polishing wheels if it gets to them. A good splash-guard set-up is therefore a highly desirable article.

To protect the arbor bearings, closely woven cloth or oil cloth can be draped over them. This forms a fairly good barrier against the grit. But it is more satisfactory to have a complete splash guard for all-around protection.

Splash guards and pans can be made of plywood, of galvanized iron, or of a combination of the two. The author solved his problem that way, as follows:

A galvanized metal pan, 24 x 16 inches and ¾ inch deep is satisfactory. This is fixed to the top of the grinding table by four small screws. Four holes are drilled to allow bolts to pass through for fastening the arbor to the table. There are also two ⅝-inch holes with tapered spouts, 2½ inches long, for drainage. One such spout is directly beneath each grinding wheel. These spouts in the bottom of the pan go all the way through the table. Two lengths of rubber tubing are attached to drain away the excess water and much of the mud from the grinding into a bucket under the table (Figure 24).

The splash guards are made of half-inch plyboard, thoroughly impregnated with linseed oil, which makes them impervious to water so they will not swell and warp out of shape.

The sides of the guard are 11 x 11 inches; the top and back are 3 x 11. The front and bottom are open. The inner side has a U-shaped cut-out so that the guard can be slipped from above over the wheel and the spindle. There is also a

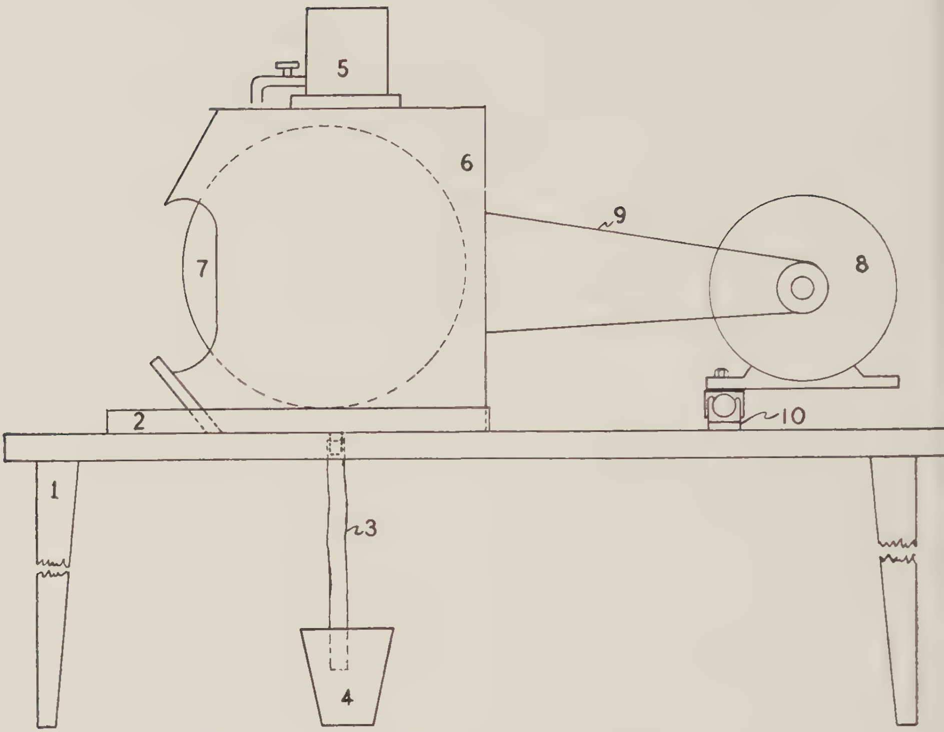


Figure 24. Side View of Complete Grinding Set-Up. 1, table; 2, splash pan; 3, drainage tube; 4, drainage bucket; 5, water reservoir; 6, plyboard splash guard; 7, grinding wheel; 8, motor; 9, drive belt; 10, floating-rail motor mount.

semicircular cut-out on the side near the front so that a part of the side of the grinding wheel is exposed for side grinding. The 1-gallon reservoir for water supply surmounts the splash guard (Figure 24). The guard is fastened by a screw or a bolt to a small projection on the arbor, thereby fixing it firmly to the entire grinding unit.

This guard has proved highly satisfactory because it allows adequate access to the wheel for grinding and at the same time guards the operation well. It is free from rattle and vibration and easily removable for cleaning.

It is to be mentioned that ready-made shields and guards are supplied by lapidary-equipment firms at moderate cost. They fit a large variety of arbors and wheels, but they usually lack drainage facilities.

The Work Table or Bench

The last thing to be described in this chapter is the table or workbench upon which the entire outfit is mounted. Any sturdy bench of adequate size will do. The author's own preference is not for a bench but for a table. It is low enough to allow the cutter to sit down. To have a bench means to stand up, and grinding is hard work when standing but much less wearisome when sitting. The comfort of sitting adds to the fun of working.

The table is sturdy (Figure 25). Yet it is not so large and heavy that it cannot be easily moved about the room together with all the mounted equipment. In the winter, it can be placed near the radiator, and for the summer it can be moved to the window. One table accommodates a grinding arbor with two wheels at one end, one motor in the center, and a second arbor at the other end for the cut-off saw and the sanding drum (Figure 27).

The two arbors are mounted at the ends of the table. The exact location of the arbor is such that the most forward point of the grinding wheel is 6 inches back from the front of the edge of the table. This allows the proper table space for resting the hands while cutting.

The motor is mounted upon a floating rail in the middle. It can be lifted from one running position to the other in a few seconds, and thereby one motor is made to serve two arbors.

The table top is 24 inches wide and 48 inches long and a full 2 inches thick. It rests upon four legs 3 x 3 inches and tapered slightly downward. The legs are 25½ inches long. There is a 2 x 4 frame all around the legs just under the top.

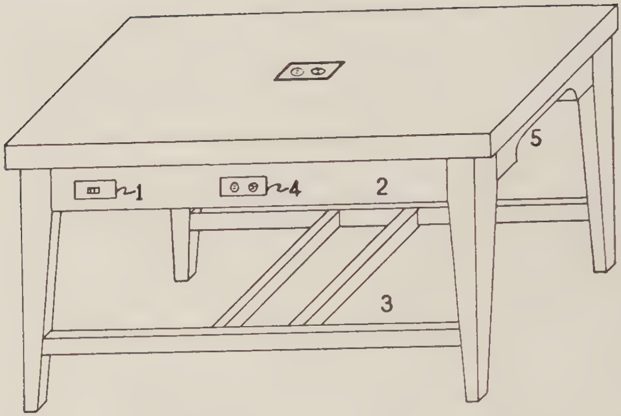


Figure 25. Work Table for Mounting a Double Spindle Arbor at Each End and a Motor in Between. 1, three-way electric switch; 2, 2 x 4 frame; 3, 2 x 4 bracing; 4, electric plug outlet (hot); 5, end cut-out to allow for cutter's knees when sitting down. Another electric plug, the inlet, is opposite 4. Also another three-way switch is located at the corner diagonally across from 1.

At the sides of this frame are the electric switches and plugs; at the ends there are cut-outs in the frame so that the cutter sitting at the end of the table has room to put the knees and feet comfortably under the table without interference (Figure 25). This is important as it makes for a great deal of comfort while sitting down to cut.

Eight inches above the bottom of the legs, a 2 x 4 brace runs along each side from leg to leg, forming a firm brace. These two braces in turn are braced crosswise by two 2 x 4's near the middle underneath the table (Figure 25).

This table just described is well made and sturdy. It will support the necessary machinery without the slightest vibration.

The wiring of the table is tricky but highly efficient. The source of the current is a sunken male plug, a so-called motor plug, on the side just underneath the edge of the table top. This plug can be connected by electric cord with any wall socket. On the opposite side of the table is a "hot" outlet

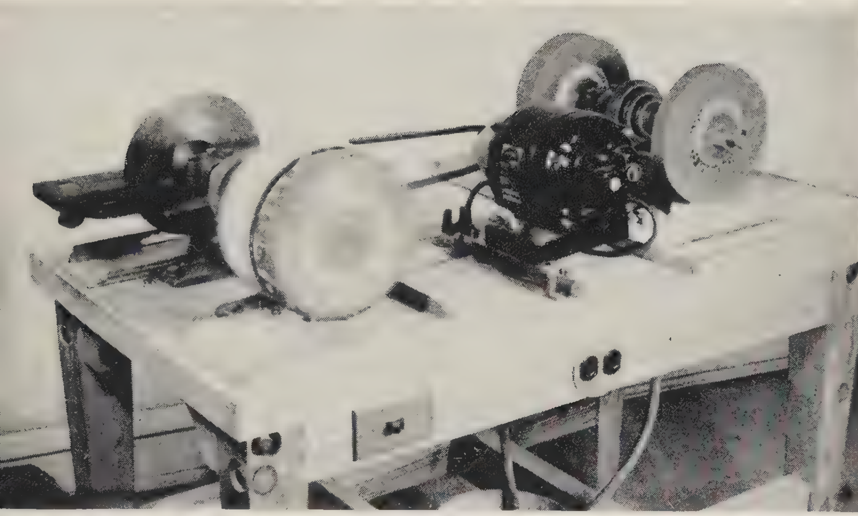


Plate I. Work table. The guards have been removed to show the motor mounted in the middle on a floating rail. The motor serves two arbors, one at each end. On the right are the grinding wheels, on the left the sanders and the cut-off saw.

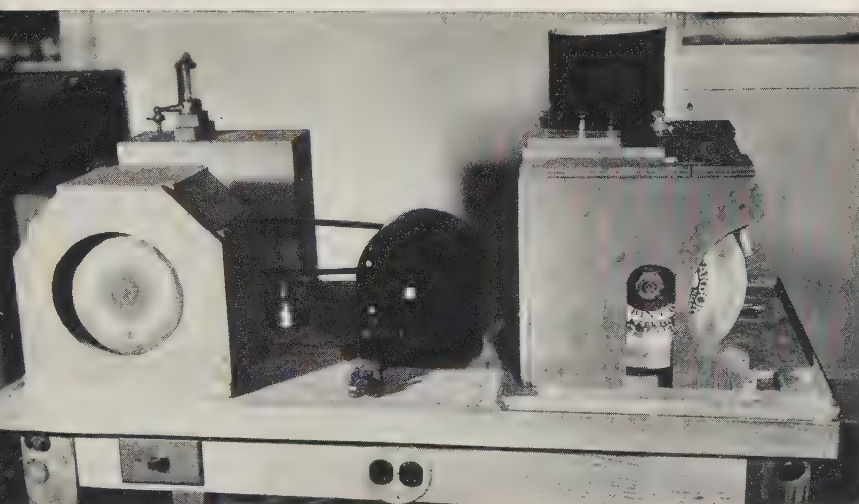


Plate II. Another view of work table with guards and watering receptacles in place.

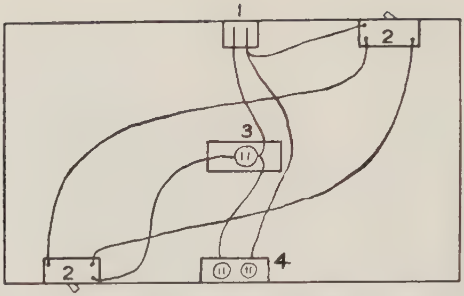


Figure 26. Electric Wiring of the Work Table. 1, source plug, for cord connecting with wall outlet; 2, three-way switches; 3, outlet for motor connection; 4, "hot" outlets for spotlights or floorlights. The outlet plug for the motor is on the top of the table; the switches and the other two plugs are on the sides of the table; all wiring is underneath the table. The switches are convenient to the right hand of the cutter when operating.

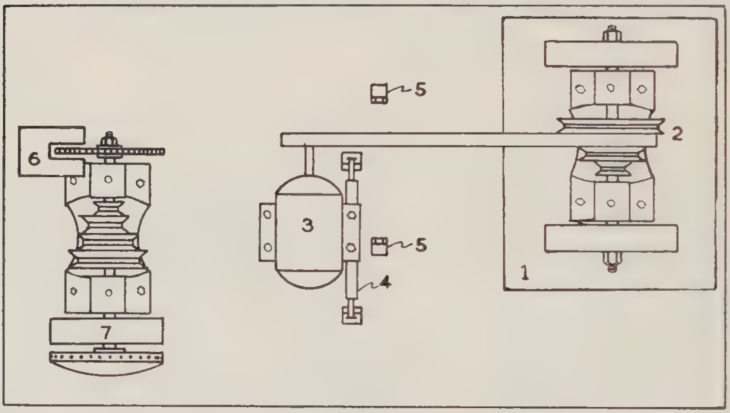


Figure 27. Top View of Work Table. 1, splash pan; 2, grinding arbor; 3, motor; 4, floating motor rail; 5, rests for second position of motor rail; 6, cut-off saw; 7, sanders. Splash guards are not shown in this drawing.

which takes the plugs of two spotlights or floor lamps. This socket is not dependent upon any switch. On the top of the table in its exact middle is the outlet for the motor. This is controlled by two three-way switches. These are so placed on the sides of the table near the ends, just underneath the edge of the table top, that the operator sitting in the work position at either end can reach the switch easily with the right hand to throw it out instantly. For further details, the reader should study Figure 26.

This arrangement of the two arbors and one motor, with independent wiring all in one unit, has proved exceedingly convenient. The unit is freely mobile, space is saved, and the noise of grinding is minimized (Figure 27).

The purpose of rough grinding is to get the material into the general shape of the cabochon. This is done on the coarser wheel. Then the gem is ready for the next operation. At this stage, the gem stone is often referred to as a preformed cabochon.

DON'TS FOR ROUGH GRINDING

(1) Don't use an arbor that is too light for the job.

(2) Don't use wheels which are too heavy for your arbor.

(3) Don't allow the wheel to stand with the lower edge in water. The wheel must be either all evenly wet or all evenly dry — never half and half.

(4) Don't run the wheel too fast; when in doubt, slow down.

(5) Don't grind in a single line; that produces a groove in the wheel.

(6) Don't try to grind specimens which are too large; the wheel will get bumpy.

(7) Don't try to get the stone into final, finished shape; that will be easier when the stone has been mounted.

(8) Don't allow the wheel to run bumpy; dress it early.

(9) Don't discard grinding wheels until they are worn to the diameter of the flanges; speed them up and they will continue to work.

(10) Don't fail to clean the entire grinding assembly now and then; it will give you better service.

(11) Don't forget to tighten the bearings from time to time; it will keep them running true.

(12) Don't start grinding a stone haphazardly without a definite plan; if a stone is worth cutting, it is worth cutting well.

(13) Don't be content with producing cabochons which are irregular or lopsided; get a few templets to guide you.

(14) Don't be alarmed about tuberculosis or silicosis; the former comes only from the acquired T.B. germs from some other person (not from grit or dust); the latter can be caused only by free silica (not by silicon carbide).

(15) Don't try to dress the grinding wheels dry; use sufficient water to keep the work soaked at all times.

CHAPTER VI

The Technique of Dopping

Dopping the roughed-out gem stone is the third operation the cutter will learn to perform. Dopping is also called setting-up. To dop a gem is to affix it to the business end of a dop stick, much like a rubber eraser is fixed to the end of a pencil.

Dop Sticks

Dop sticks are also called setting-up sticks or lap sticks. They consist of round hardwood sticks 3½ to 5 inches long. There should be three different thicknesses or diameters: ¼ inch, ⅜ inch, and ½ inch. It is well, also, to have a few that are ¾ inch in diameter, and a few that are very thin, like the old-style kitchen-match stick. Some cutters enjoy cutting tiny gems, often called "snake eyes," because of their small, beady brightness. And occasionally a pattern in a rough will demand that the cab be cut rather large. For such requirements, extra small and extra large dop sticks are needed.

There are several variations of shape and the cutter can have his choice. For cabochon cutting, the simple round stick is quite satisfactory. For the more complicated procedure of facet cutting, the dop stick requires a dull point which fits into the notch of the jamb peg. This will be described in a later chapter.

Some cutters prefer square or oval sticks, both of which are suitable, especially where large cabochons of corresponding shapes are to be cut. To mount a large square cabochon on a round stick leaves the corners more or less unsupported

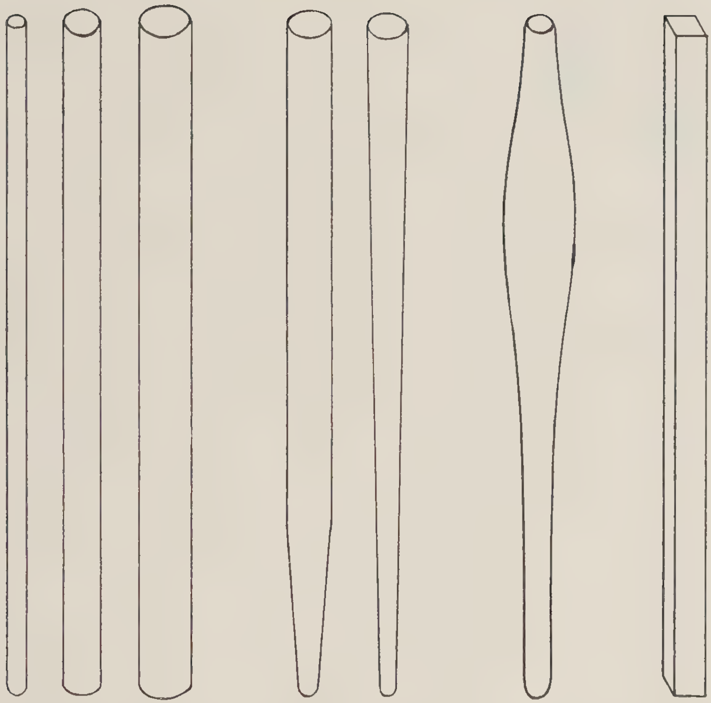


Figure 28. Types of Dop Sticks. A, plain, round, hardwood cabochon dops of various diameters; B, cabochon dops with shaped or pointed ends; C, dop stick for facet cutting; D, rectangular cabochon dop stick.

and in danger of cracking under the pressure of grinding.

Dop sticks should be of various diameters because they must accommodate various sizes of stones. A stick which is too thin will not handle a large gem, while a dop which is too thick cannot be used for a small gem. For the various types in use see Figure 28.

Dopping the Preformed Cabochon

To dop a roughed-out cabochon is to cement it onto the upper end of a dop stick of proper size. This is done by first softening a small quantity of dopping cement or sealing wax

Figure 29. Cabochon Dop Stick With a Mass of Cement on a Rolling Block, Being Rolled Into the Proper Cone for Receiving Roughed-Out Stone.

and then firmly fixing this mass onto the end of the dop. There is a little care and experience necessary to get a mass of dopping cement to adhere to a new dop stick. For this, a small flame from a gas jet or an alcohol lamp is needed for heating, and a small, smooth metal block 1 x 1½ x 2 inches for rolling the cement and rapidly cooling its surface. The cement should be in the form of small pieces like coffee grounds or rice. Heat the business end of the stick gently in the flame and then dip it into the cement. Some cement particles will adhere because of the heat on the stick. Then hold the stick over the flame again for a moment, softening the adhering cement. Dip this softened mass into the cement again, picking up more of it. In this way, a mass of any desired size can be made to adhere to the dop stick (Figure 29).

The soft warm mass will be shapeless and must be rolled on the metal block to give it the proper form for dopping the cabochon blank. The metal, being cool and also a good heat conductor, will prevent the cement from adhering to it. By rolling on the smooth block, the mass can be formed into a cone with its base flat and away from the middle of the stick, ready to receive the stone.

Where the cement is in the form of sticks, these can be broken up with a hammer to form granules or small pieces.

Next the stone is heated to a temperature of approximately 120 to 130 degrees F., which is about the temperature of the hottest water we can stand when washing our hands. This is done by picking up the stone with a pair of large-size tweezers in the left hand gripping the girdle (Figure 31). At the same time, the mass of cement on the dop stick is kept warm and soft by passing it occasionally through the flame, using the

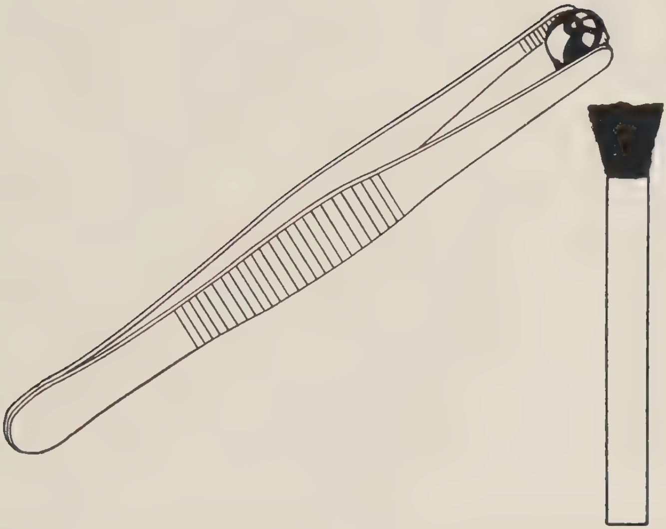


Figure 30. Tweezers Holding Stone to be Dopped. Note that tweezers should be of adequate size.

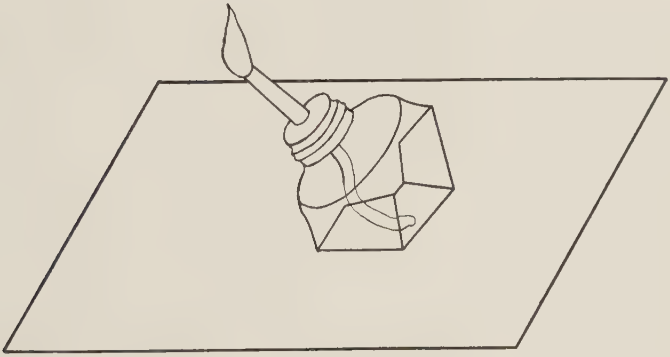


Figure 31. Alcohol Lamp Which Has Large Facets at an Angle So That It Stands at a Tilt.

right hand. It should not be so soft that it drips or runs but soft enough to work with the fingers and to roll it into a shape which will accommodate the gem. An alcohol lamp which has large, angular, flattened sides so that it can be set tilted on a table is ideal for this purpose because it allows the flame to be placed away from the center (Figure 30). Should the cement drip accidentally, it will not cover the lamp.

The soft, shapeless mass on the end of the dop can be rolled into a round or oval cone, or it can be squared, and a flat surface can thus be prepared upon which the warm gem stone can be placed with the tweezers. With a little pressure and a little working around the edges below the girdle of the stone, a smooth job of dopping can be done.

Proper dopping means that the stone is placed squarely, not lopsidedly, on the end of the stick; the end of the stick is in the center of the back of the stone, not off to one side; and the entire back is covered by adequate cement supporting the edge all around the girdle. Proper dopping aids greatly in perfecting the jobs of finish grinding, sanding, and final polishing. A good job of dopping is necessary to assure a symmetrical shape of the finished gem.

While working the cement or wax with the fingers, burns can be avoided by wetting the fingers either with water or saliva before touching the hot mass. This wetting will also keep the cement from adhering to the fingers when working it around the dop and stone. The metal rolling block, being cold, will not adhere to the cement.

Dopping Cement

Plain sealing wax may be used for dopping. It is more satisfactory to use one of the professionally prepared cements, however, because it is more dependable. Wax may let go of the stone in a crucial moment when grinding and the stone may be injured.

Commercial dopping cement is prepared by secret formula and may contain, in addition to sealing wax, other substances such as shoemaker's wax, clay flour, and shellac in varying proportions. The cost of the cement when obtained from supply houses is quite modest. Fifty cents buys enough for any ordinary one-man lapidary shop.

When the roughed-out cabochon has been dopped, it cannot be laid down on the table. The cement being still warm and soft will not hold the stone in position. It would shortly appear quite lopsided on the stick. Therefore some means must be devised for standing the stick on end with the dopped gem on top, or upward. A rectangular piece of wood about 4 x 6 inches and 1 inch thick is prepared by drilling holes into it 1 inch apart and ¾ inch deep. The holes should be of the same diameters as the dop sticks used. Into these holes, the sticks can be placed and allowed to remain upright for a half hour for the cement to harden. The dopped cabochon is then ready for the next operation.

The amateur will need a little practice in acquiring the proper technique of dopping, but it will be well worth the effort because a gem which is squarely placed, properly centered, and well supported is much more likely to turn out a perfectly shaped product (Figure 32).

Dopping is considered the easiest of all the techniques in gem cutting. The apprentice in a commercial shop is almost invariably started on his career by learning and mastering the technique of dopping.

Equipment Needed for Dopping

The articles needed for dopping are: (1) dop sticks of various sizes (Figure 28); (2) an alcohol lamp (Figure 31); (3) dopping cement; (4) a pair of tweezers (Figure 30); and (5) a small steel plate or rolling block (Figure 29).

DON'TS FOR DOPPING

(1) Don't overheat the stone when dopping. It will not adhere properly but will keep sliding over to the side of the stick.

(2) Don't burn your fingers by dropping hot molten cement on them.

(3) Don't touch the hot cement with the fingers unless they are wet.

(4) Don't be satisfied with a sloppy job of dopping. Do it right.

(5) Don't start working with the dopped gem until the cement has had ample time to harden.

(6) Don't fail to keep on hand three or more sizes of dop sticks, and use the proper size for each cabochon.

CHAPTER VII

The Technique of Finish Grinding

GRINDING the roughed-out, dopped cabochon to a perfect symmetrical shape and perfect curvatures all around the girdle and all over the top is the fourth process in the art of gem cutting.

The gem has already been roughed-out, which means that it has been ground roughly to the shape and size desired. The base has been made absolutely flat, or, in the case of a double cabochon, it has been given its curving surface. But there are many small grooves, flats, ridges, and deep scratches all over the stone's surfaces.

In that condition, the cab has been dopped. Dopping as shown in the previous chapter makes finish grinding easier because the stone can be handled more gently and accurately, and all the while there is a much clearer view of the actual process of the grinding, where the gem and wheel come in contact.

Grit Size of the Wheel

For this process of finish grinding, a grinding wheel of 220 grit is used. Turn to Figure 20 where this wheel has already been described. The double arbor previously discussed carries both wheels, the rough-grinding wheel and the finish-grinding wheel.

Some cutters prefer 180 grit for fine grinding. The grinding will proceed slightly faster, but the surfaces of the stone will be left slightly rougher. This author uses 220 grit for most materials, and even a wheel of 400 grit for delicate and fragile materials like opal and turquoise.

Running Speed of the Wheel

The speed of the wheel is the same as that of the rough-grinding wheel. The size of the finish-grinding wheel may also be the same, or it can be smaller. In general, the cutter will use up about two coarse wheels for one fine-grinding wheel.

Grinding the Finish on the Stone

Finish grinding is done much the same way as rough grinding, but with much less pressure of the stone against the wheel. Only the lightest pressure is used. Just a touch or a stroke may be all that is needed in many spots. The rough spots are smoothed; the high points evened down; the girdle is made perfectly symmetrical; deep scratches are smoothed away. All the grinding must be done wet, as described in a previous chapter.

Cutters usually grind evenly back and forth across the face of the wheel. This keeps the grinding surface of the wheel flat. This is to be preferred as the usual practice. However, some cutters prefer to grind a groove into the grinding face of the fine grinding wheel. This groove they keep curved or hollowed out so that it can be used for finish-grinding the cabochon curves by merely twisting or rotating the dopped gem in the groove.

DON'TS FOR FINISH GRINDING

(1) Don't rough-grind a stone on the finish wheel. Only the final touching up should be done here.

(2) Don't grind with a bumpy wheel. Instead of smoothing away the rough parts on the stone, new scratches and flats will appear. Dress the wheel so it runs true.

(3) Don't grind with the wheel dry.

(4) Don't grind towards the girdle, always away from it.

(5) Don't forget that the side of the wheel may be even more efficient for smoothing and rounding the girdle than the periphery.

(6) Don't forget to use a good hand lens to inspect the work frequently. You can do a much better job that way.

CHAPTER VIII

The Technique of Sanding

Sanding the dopped gem is the fifth process in cutting a cabochon. Sanding is a confusing name that has stuck from the early times when sandpaper was used in the operation. Modern cutters do not use sandpaper. Silicon carbide cloth is far more effective.

Sanding means to smooth down the tiny ridges all over the surface of the cabochon left by the finish-grinding wheel, and to remove all scratches, thereby preparing the surface for the last finishing step — the polishing. Sanding is one of the most important of all the operations because a good polishing job cannot be done without first having done a proper sanding job. All the scratches must be removed or else the polishing will affect only the highest portions, the ridges, leaving the valleys unpolished. Be these ever so minute, the effect of inadequate sanding will be to leave the surface of the gem dull. And a dull surface on an otherwise beautiful gem is like a house without a coat of paint. The gem will retain a "frosted" appearance; will lack luster and depth. A really smooth surface and a really high polish are the crowning glory of the stone. Do not fail to grasp the full meaning of this. Do not stop short of giving the stone the highest possible shiny finish that it will take.

Sanding the Dopped Cabochon

The gem, still on the dop, is held against the sander much the same way it was handled in the process of finish grinding. The stick with the gem on it is held in the hand much in the same way that a small paintbrush is held. The stone is then stroked against the sanding cloth. Rotary motions are also used, especially when sanding near the girdle. Only short strokes or passes are made against the sander, however, to avoid overheating. The stone must be in contact with the cloth only a moment, after which it is turned and another part of the stone is presented.

Sanding is always done dry. Because of this, the stone will heat very quickly, and if allowed to overheat or to heat up too rapidly, it may break or develop cracks or flaws from too rapid expansion. Many a fine gem has been ruined in this way. Therefore make a few passes or turns of the dopped gem against the sander and then touch it to the palm of the hand or somewhere on the forearm to test it for heating. Touching may also be done with a moist finger or with the tip of the tongue.

If the entire stone feels hot, lay it aside for a few minutes to cool. Pick up another one to work on for a few minutes. By keeping five or six dopped gems going at the same time, no time will be lost and no gem will be injured by overheating.

Another result of overheating is the softening of the dopping cement so that the gem will slide off the dop. The dopping will then have to be done again.

The sanding is accomplished by holding the cabochon gem rather lightly against the sanding disc or drum (Figure 33). When it is rotated or stroked back and forth, the pressure is never heavy, and it is never continuous on any one point. All parts of the curved surface of the top of the gem are given intimate contact with the sanding cloth.

Frequent inspection of the work will reveal very quickly what progress is being made. For final inspection, a magnifying lens is invaluable. The cutter will be agreeably surprised the first time he sands a stone. There will come a change over the surface after a few passes that will reveal the first signs of the true character and beauty of the gem.

Fig. 32

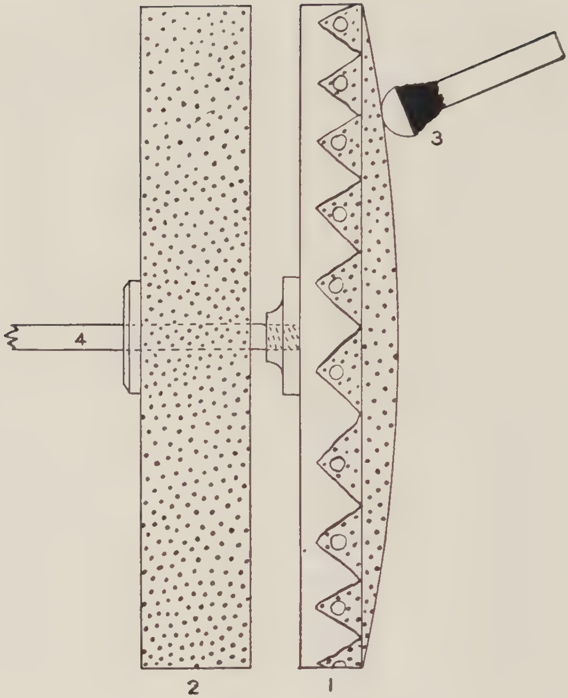


Fig. 33

Figure 32. A Properly Dopped Cabochon. Figure 33. Sanding the Cabochon. 1, sanding disc; 2, sanding drum; 3, dopped cabochon; 4, spindle. (No guards are shown.)

Sanding must be continued until all scratches and high spots are gone. There may also appear some low spots which may require a lot of careful sanding to make them smooth. Special attention must be given to the area adjacent to the girdle, where the careless cutter may leave imperfect areas which will be a disturbing eyesore to the admirer. A perfectly sanded girdle, when followed by a perfect polish, is the mark of a careful cabochon cutter.

The Drum Sander

The sanding may be done with a sanding drum (Figure

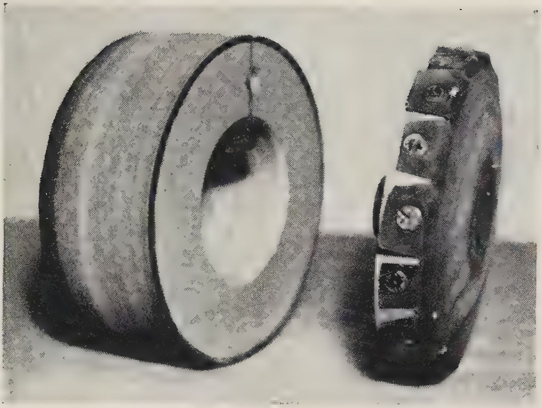


Figure 34. Sanding Drum (Left) and Sanding Disc (Right), Demounted to Show Details.

34). The drum consists of a wooden wheel having an edge 2 or 3 inches wide and 8 inches in diameter. It is made by gluing together half-inch plyboard layers until the desired width is obtained. The first one or two layers of the wood are simple discs, but the remaining are cut out to form rings or washers, so that a wheel of 2-inch face but with a hollowed inside, or a well, is produced. The rim has a slit cut into the face and in the middle of this slit is a round, tapered hole with a conical peg to match. The face is covered with a strip of felt ¼ or ⅜ inch thick, stretched tight and cemented smoothly to the wooden wheel.

Over the felt is stretched the abrasive cloth. The ends of the cloth are threaded into the slit and stretched tight by pulling on them in the well of the drum. The tapered peg is then inserted to hold the cloth firmly and smoothly in place (Figure 34).

The drum sander has an even level surface from side to side across the face; in the opposite direction, it is obviously curved. This flatness of the face makes the drum sander a satisfactory type to use for sanding flat surfaces, such as the backs of cabochons or the flat tops of square gems. It is also well adapted to sanding the larger flat surfaces of mineral specimens.

The Sanding Cloth

The abrasive cloth is silicon-carbide cloth. The grit should not be coarser than 180. For finer work or for the more delicate stones, 220 grit is better. However, when two sanders, a drum sander as well as a disc sander, are available (as shown in Figure 33), then the drum can be of the coarser grit, and the disc should be 320 grit for fine finishing work.

Instead of felt for a resilient base under the cloth, a strip of sponge rubber is used by some cutters who prefer the softer material.

A fresh sanding cloth will have a sharp, fast-cutting surface. This is desirable for hard stones but may be much too abrasive for the softer ones. It is, therefore, well to have two drums, one mounted on each end of the arbor. On one end, a fresh cloth is used which will work rapidly, while on the other end a worn cloth is used for smoother work. With each sanding cloth, there comes a time during its period of use when it is exactly perfect. But in the beginning, it is apt to be too rough, even the 220 grit, and after it passes the perfect stage it becomes too smooth. By having two drums the perfect sanding job is much more easily attained and retained. The cloth on the drums described and illustrated can be changed in a few minutes. The cloth is not changed until it is so smooth that it has no grip on the stone. It will have a smoothed, almost glazed appearance before it gets completely worn out. An old, smooth sanding cloth can sometimes prepare the gem for the polishing wheel so that it needs little extra work to finish it.

The Disc Sander

The sanding may also be done with a sanding disc (Fig-

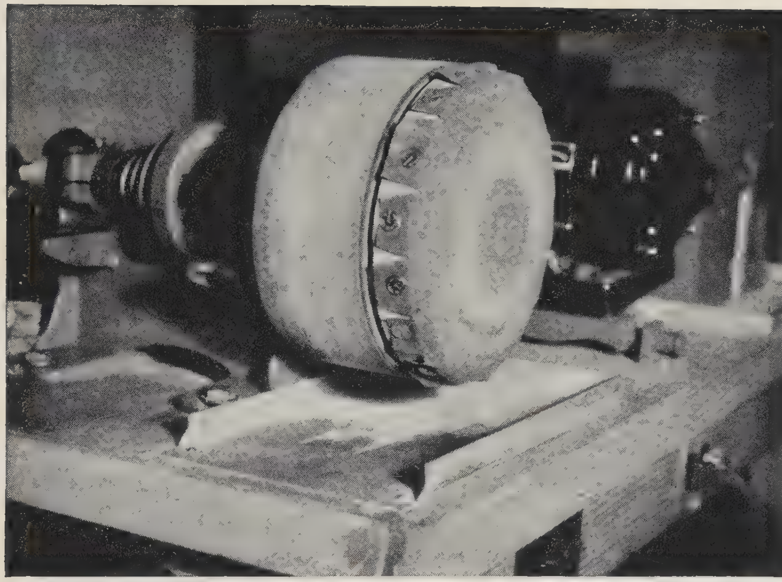


Figure 35. Sanding Drum and Sanding Disc Mounted on the Same Spindle. (Guards have been removed.)

ure 34). The disc runs vertically on the same arbor used for the drum. The type of disc to be described can, indeed, be mounted with the drum on the right-hand spindle as shown in Figure 35.

The disc sander is made of hardwood 1¼ or 1½ inches thick and 8 inches in diameter. The surface used for sanding is smoothly convex, the center of the disc being ¼ inch thicker than the periphery. To avoid having a hole in the center of the disc, a short metal faceplate is mounted on the flat side. This faceplate has an internal thread so that it will engage the end of the arbor spindle. The arbor to be used should be the same as described in the chapter on rough grinding. It is well to use, as much as possible, the same arbors throughout, so that all the arbor holes in saws, grinding wheels, sanders, and polishing wheels are the same size and the arbors interchangeable.

Covering the working surface of the sanding disc should be a disc of felt ¼ inch thick and cut to fit the sanding disc. Over this is stretched the abrasive cloth. The cloth may be held by a snugly fitting, welded metal hoop. The cloth should be of 220 grit when the cutter has only one sanding wheel available. In the event he has two, then the drum sander should have the 220-grit cloth, while the disc carries a 320-grit cloth.

Abrasive cloth for drums is obtained in rolls of the proper width. The rolls come in lengths of 15 feet and of 150 feet. For the disc sander, ready-cut cloth discs are available; however, the cutter can obtain squares of abrasive cloth and cut his own discs.

Instead of an iron hoop to hold the sanding cloth on the disc sander, two other methods can be used with complete satisfaction. The wooden wheel may shrink during days of great dryness, and it may swell during humid weather. A metal hoop does not follow these changes. A different method becomes necessary.

Around the edge of this wooden disc, a groove can be cut. The sanding cloth is folded over the edge and a heavy rubber band, cut from a discarded inner tube, is snapped on. This will hold the cloth in place quite well.

A method used by the author is to cut V-shaped tabs all around the edge of the sanding cloth. These tabs are then folded onto the edge of the disc and each tab is fastened down with a thumbtack (Figure 34).

Guarding the Sanders

Both sanders, the drum as well as the disc, need guards. If both are mounted on the same end of one arbor (as in Figure 35), a single guard can serve the purpose (Figure 36). This guard is made of half-inch plyboard, 11 x 11 inches. It is 5 inches wide and covers a 3-inch drum sander and a disc sander. On the front, there is an opening 5 by 6 inches to

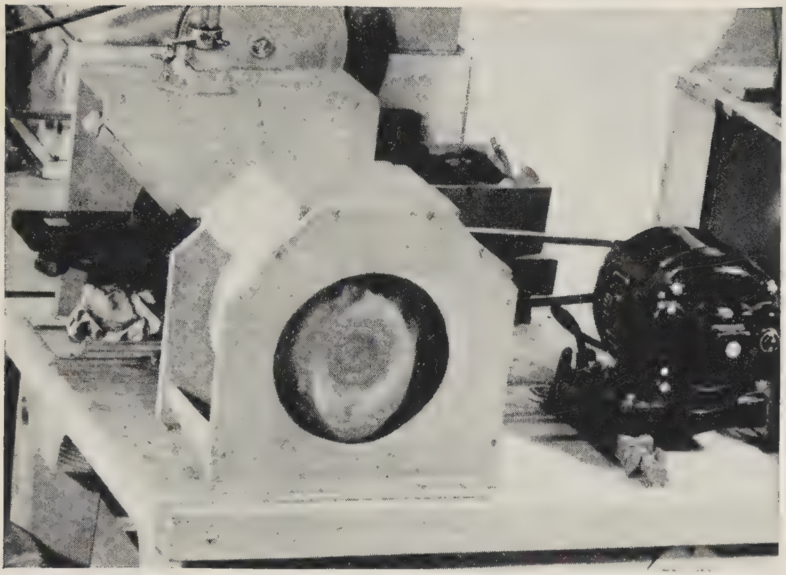


Figure 36. Sanding Drum and Sanding Disc Mounted and Guarded.

allow access to the drum (Figure 36). On the right side, a circular cut-out, 7½ inches in diameter, allows access from the right side to the disc. This guard catches practically all the grit and dust flying from the wheels and the work, and it keeps the bench clean.

Some cutters claim that sanding wheels need not have guards. This may be true in shops where the different operations are separated by large spaces. But certainly in a crowded shop every possible effort is needed to keep the grit from the grinding and sanding wheels from contaminating the polishing wheels.

Running Speed of the Sanders

The speed of the sanders should be approximately 20 per cent less than that of grinding wheels of the same size. For sanders 8 inches in diameter, a speed of 1000 revolutions per minute is fast enough. If in doubt, run them slower. How to obtain this speed from a known set of pulleys has been discussed in the chapters on sawing and on grinding.

Mounting the Sanders

By going back to Figure 27, it will be seen that on one suitable table a double grinding arbor is mounted at one end, and another double arbor for the cut-off saw and for the drum and disc sanders is mounted at the other end, with a single ¼ horsepower motor in the center. This motor can be lifted and turned around in a few moments, thus serving all of the machinery on the table.

The disc sanders should be mounted on the right-hand side of the arbor for a right-handed cutter.

DON'TS FOR SANDING

(1) Don't use water; all sanding is done dry.

(2) Don't overheat the gem.

(3) Don't oversand a spot on the stone; keep moving and turning it constantly.

(4) Don't use too much pressure.

(5) Don't overlook the advantage of having two sanders: one with a fresh sharp-cutting cloth, the other with a well-worn cloth.

(6) Don't forget the periphery at the girdle. This is often neglected and means sloppy workmanship.

(7) Don't run the sander at excessive speeds. You ruin more stones by overheating.

(8) Don't work one cabochon at a time. Five or six can be alternated while working so that the idle ones are always cooling off.

CHAPTER IX

The Technique of Polishing

POLISHING the cabochon, which by now is shaped and smoothed, is the sixth operation upon the gem. It is the final and in some ways the most important of all the stages of processing to which the gem must be subjected. Beauty of color, of design, of pattern, and of shape are all lost if the stone is dull and lifeless. It must be given a high, mirrorlike gloss all over. This will add that brilliance and luster necessary to lift it out of the class of pebbles and to put it into the class of gems. The final polish does to the precious stone what attractive painting and interior decorating do to a dwelling.

Up to this point, the cutter has worked with the gem stone on gritty wheels. The sawing operation had to do with diamond dust. The grinding and the sanding operations made use of silicon-carbide or boron-carbide grit. And then there was the mud which was ground away from the stone itself. Now all these substances must be eliminated. The presence of one single grain of grit on the gem when it is put to the polishing buff will cause havoc not only to the gem being worked but to succeeding ones as well. The grit becomes imbedded in the polishing wheel and from then on scratches every gem that it comes in contact with at every turn of the wheel. Therefore a thorough washing of the gem stone is necessary before it is taken to the polishing wheel.

Scrubbing the Stone to Eliminate Grit

Washing is done preferably in lukewarm running water. Where running water is not available, two buckets of water at room temperature will do very well. One of these is for scrubbing, the other for rinsing. Adequate quantities of water and a toothbrush for the slight depressions in the cement around the girdle of the stone are all that are needed. A typewriter cleaning brush is ideal because it has bristles of the right length and stiffness. But the washing must be thorough. Water which is too cold will contract the stone more quickly than the dopping cement and the gem may drop off. The scrubbing must include the dop stick and the cutter's hands.

When the polishing wheels and powders are not in use, they should be kept carefully covered or otherwise protected from the grit dust that may find its way there from the grinding and sanding wheels. The smallest amount of grit when it becomes imbedded in the polishing wheel will render the wheel useless.

Scrubbing the Hands

The dopped stone is now ready for polishing. But the cutter is not. He must scrub his hands as carefully as he scrubbed the gem. Then he changes his apron to one which he uses for polishing operations only. In this way, he will avoid bringing grit to the polishing machinery.

The gem is still on its original dop. It is handled, while polishing, along the same lines as discussed in the chapter on sanding.

Polishing the Cabochon

Before the polishing begins, the wheel must be thoroughly moistened. This takes several minutes during which the water must be applied by a small paintbrush, repeatedly and abundantly. A dry polishing wheel will heat the stone even more rapidly than the sanding wheel. After several minutes of wetting the wheel by dipping the brush in the water and stroking it on the wheel, it will gradually absorb the moisture, after which the polishing agent can be applied and the stone taken to the wheel.

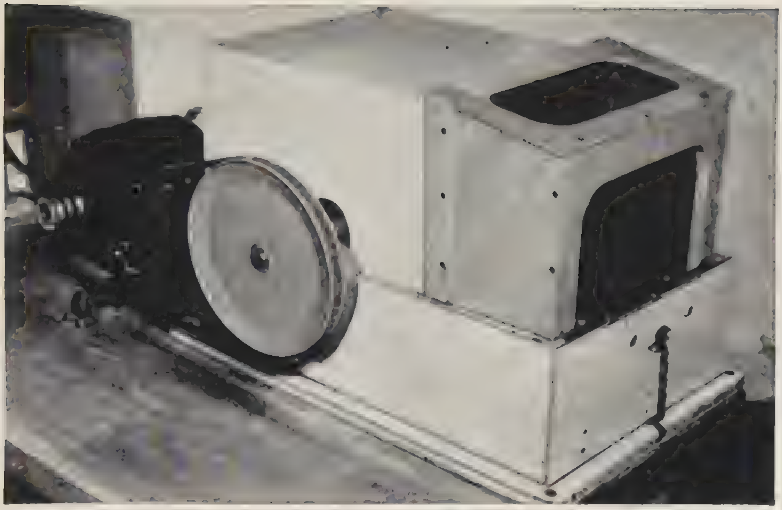


PLATE III. Diamond saw with motor and guards. Notice the windows in the front guard made from discarded X-ray films.

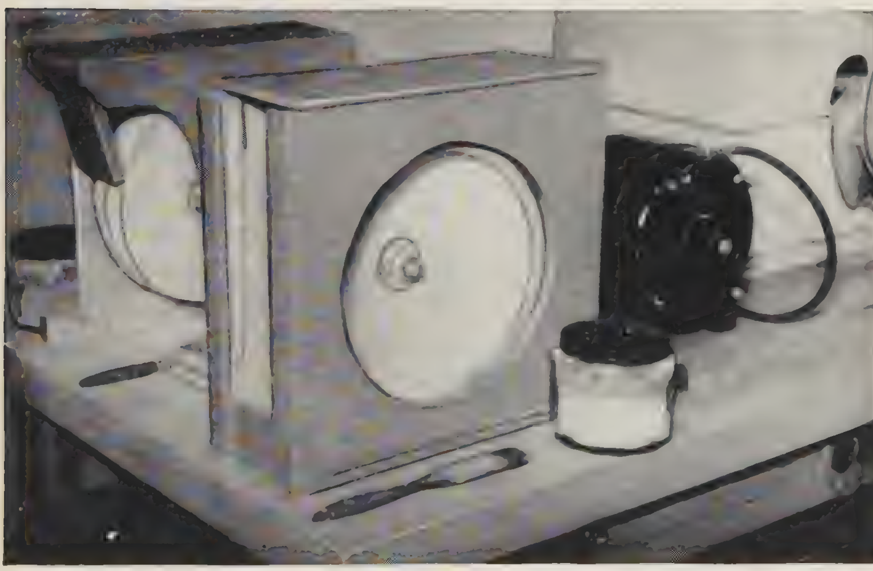


PLATE IV. Polishing bench, showing motor serving a double arbor with internal wooden polishing wheel and hard felt wheel.

The dopped gem stone is polished either by holding it against the periphery of the polishing wheel, against its side, or against the internal curve in the case of a hollow wooden wheel. The stone is constantly kept in motion, back and forth, being turned quite rapidly so that no one part of the gem gets heated more than any other part. Testing the gem on the hand as discussed in the chapter on sanding will easily tell the cutter when the stone is getting too warm.

It is well to have a clean cloth ready and handy to the left hand or in an apron pocket, with which the surface of the gem is wiped clean every now and then so that the progress of the work can be frequently inspected. A good magnifying lens is indispensable for inspection.

Types of Polishing Wheels

There are two principal types of polishing wheels: (1) the wooden wheel, and (2) the hard felt wheel. There are other types for special jobs, but for general purposes these two will suffice.

Wooden polishing wheels. The wooden polishing wheels are of two varieties. The first is a simple disc of hardwood, usually maple, 8 or 10 inches in diameter and 1½ inches thick. The sides as well as the periphery of this wheel are used.

The second variety is a hollowed-out wooden wheel for internal polishing. The wheel is made of a disc of hardwood 10 inches in diameter and 2 inches thick. The right side of the wheel is hollowed out as shown in Figure 37. Not only the periphery but also the entire hollowed-out surface is used for polishing.

The curve of the internal periphery is carefully cut out to make it suitable for the curved tops of cabochons, while the internal side of the wheel is used for the flatter surfaces. Another way to make an internal curve with varying degrees of curvature is to make it egg-shaped; that is to say, when

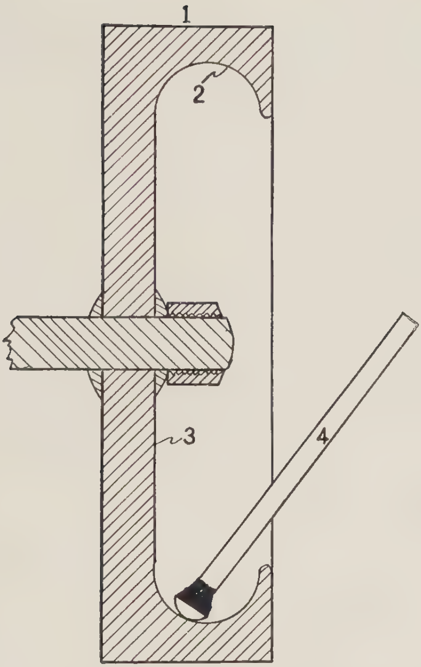


Figure 37. Wooden Internal Polishing Wheel. 1, periphery of wheel; 2, internal surface of wheel; 3, inner surface of wheel for flat, side polishing; 4, dopped gem stone.

an egg is placed into the curve of the hollowed-out periphery with the point of the egg inward the wheel curvature will follow the egg. Such a wheel has curvatures to suit all possible shapes of stones.

The internal polishing wheel has the advantage that it will retain the polishing agent, which on other wheels is thrown off from the periphery almost as rapidly as it is applied. Furthermore, the centrifugal force of the running wheel will tend to distribute the polishing powder equally all around the wheel and will keep it there. A small quantity of the agent, therefore, will last a long time.

The internal polishing wheel has the disadvantage that the internal polishing surface tends to become bumpy and must be trued from time to time. When repeated truing has reached its limit, the wheel must be discarded.

THE FELT POLISHING WHEEL. The wooden wheels are usually best for the first going over of the gem, but the final high luster is usually better applied by a hard felt buffing wheel. A felt wheel 1 inch thick and 6 inches in diameter is satisfactory. Felt wheels come in two grades — hard and soft. The soft felt is used only for the softest gems. A hard felt will do quite well for soft stones if used with light pressure and gentle stroking, so that it is not necessary to have two wheels unless there are a great many soft stones to be polished. The point is that it will require a little more careful working to avoid overheating when soft stones are polished on a hard felt wheel.

The harder the gem material, the brighter the final polish will be, and the longer it will endure. An agate, well polished, will retain its mirrorlike shine for many years. Soft stones like turquoise and variscite are apt to become somewhat duller with wear and may need repolishing from time to time.

It is of greatest importance to use only one polishing agent on a felt wheel. If more than one agent is used there should be a separate wheel for each powder.

Polishing Agents

The polishing is done with the aid of a polishing agent. There are a large number in use, but the two outstanding materials are powdered tripoli and tin oxide. Some cutters are quite fond of levigated alumina. Some of the less frequently used powders are Alundum flour, rottenstone, pumice, extremely find sand, jeweler's rouge, and Damascus ruby powder. Chrome oxide is said to be especially adapted to polishing jade. But for all general purposes, the two powders named first will be completely satisfactory.

Some lapidary-supply firms sell polishing agents under trade names. These are usually made up according to some secret formula, and they give good results, having been tested by experts who found them to their liking.

Tripoli when used on a wooden wheel will give a rapid, glossy polish, especially on the harder gems. The tin oxide is then used to finish off on a felt buff which adds the final mirror-bright luster.

The polishing agent is prepared in a small dish or jar by mixing it into a thin paste or cream with plain water. This is applied to the wheel with a small paintbrush. The brush is dipped into the paste, picking up a small amount. It is then stroked onto the wheel and the gem is immediately brought to the wheel before the paste can be thrown off or before it can become dry. All polishing wheels must be kept well moistened with the polishing cream at all times while actively polishing. The paste is kept in a small covered jar or similar receptacle to avoid contamination with grit.

Mounting the Polishing Wheel

The polishing wheels are mounted on an arbor like that described in the chapter on rough grinding. Or they may be mounted on a smaller arbor, because they are considerably lighter in weight and are subjected to much less pressure when in operation.

Whenever possible, the polishing wheels should be mounted on a work table or bench by themselves to avoid the possibility of grit contamination from the grinding and sanding wheels. Diamond saws are far less hazardous in this respect and when well guarded can well be mounted with the polishing wheels.

Guards for Polishing Wheels

Splash guards, while not as necessary as for grinding wheels, are nevertheless desirable for all but the internal polishing wheels. A suitable and quite satisfactory splash guard

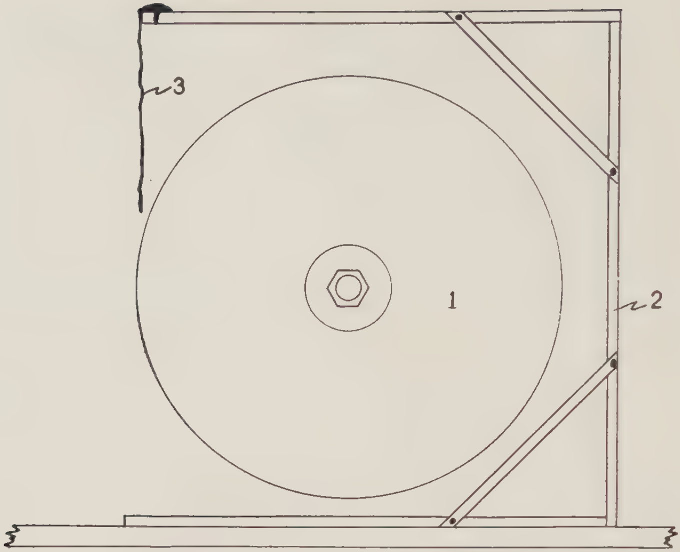


Figure 38. A Simple Splash Guard for Polishing Wheel. 1, felt wheel; 2, back part of guard; 3, cloth apron fixed to guard with thumbtack.

for the felt wheel consists very simply of three 3-inch boards, 11 inches long and arranged as shown in Figure 38. The corners should be braced, and at the front a short piece of canvas or toweling is attached with thumbtacks. This cloth hangs down like a curtain to where it almost touches the wheel. The sides of the guard are open for side polishing. More elaborate guards may be built when desirable.

Grooving the Felt Wheel

The front of the felt wheel can be worn into grooves which accommodate the curved tops of the cabochons, while the sides should be kept even for polishing flat surfaces. In wheels which are 1 inch wide, two grooves of different widths can be made. They will aid considerably in speeding up the job of polishing. Grooves are produced by holding the stone against the wheel in one position. Once a groove is started, it is easily deepened to the desired size.

A Separate Wheel Needed for Each Polishing Agent

If more than one polishing agent is used, there should be a separate wheel for each agent. Tin oxide should never be applied to a wheel which has had any other powder applied to it. And the same holds for all other agents. A wheel impregnated with one agent will not do satisfactory work with any other.

Running Speed of the Polishing Wheel

The speed of the polishing wheels is best reduced to approximately one half that of the grinding wheels, or even less. For the felt wheel, not more than 950 surface feet per minute are advisable. For the wooden wheels, the same speed can be used, although a little faster is not dangerous. For an 8-inch wheel, this will figure out 450 revolutions per minute.

How to calculate the correct speeds when the diameter of the wheel is known is discussed in detail in the chapter on sawing.

Polishing Wheels for Special Purposes

Leather polishing wheels. Polishing wheels using leather are excellent for certain work, chiefly for polishing opal, turquoise, variscite, azurite, and malachite. Such a wheel consists of a wooden disc 10 inches in diameter and 2 inches thick. On each side of this wheel, a circular groove is hollowed out, making the sides of the wheel a concavity all around (Figure 39-A). The leather is to be stretched over the sides of the wheel tightly, offering a springy but smooth and even polishing surface. The leather disc must be cut 12 inches in diameter and the edge cut into points (Figure 39-B). These points are folded over the wheel, and thumbtacks are inserted to hold them down (Figure 39-A-B).

In making such a leather wheel, cowhide with the smoother side out for polishing is satisfactory. The disc is cut, the edge serrated, and then the leather is soaked in water until quite soft. It is then stretched over the wheel and tacked down

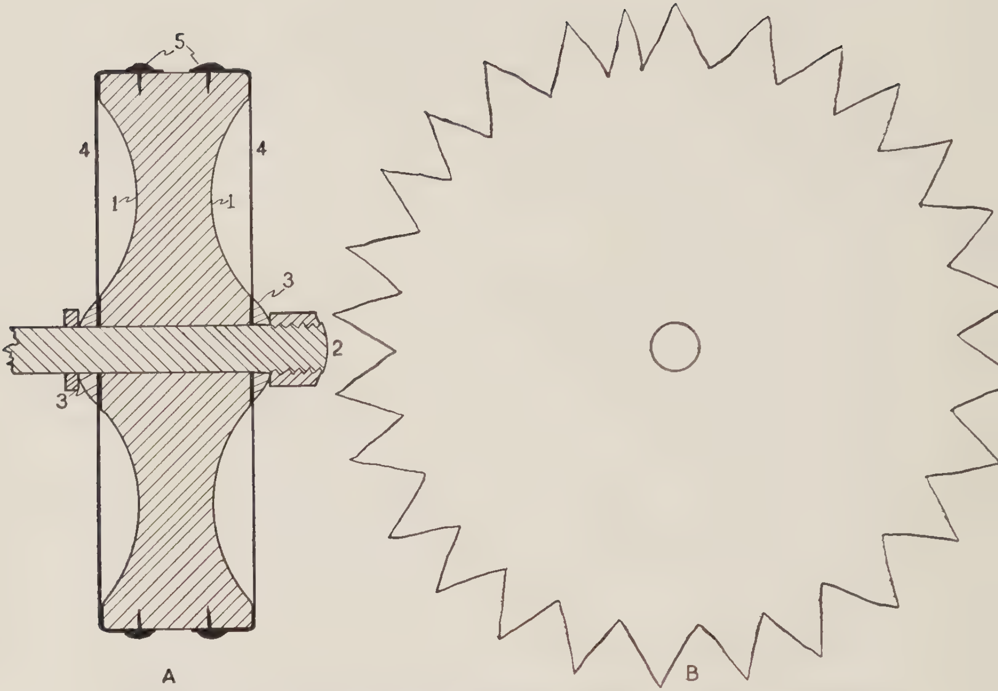


Figure 39. Double-faced Leather Polishing Wheel. A, front cross-section of wheel with leather polishing surfaces on each side; 1, concave sides of wheel; 2, spindle of arbor; 3, flanges; 4, leather surfaces; 5, thumbtacks. B, leather disc cut to size, with tabs around the periphery for tacking it to the edge of the wheel. The tabs need not be equal in size.

while still wet. In this way it will become drum smooth when it dries. A highly satisfactory polishing wheel for special jobs is thus available.

After a time, the smooth leather might become glazed and refuse to polish properly. With a knife blade, the leather can be scraped and the wheel will become efficient again.

The leather wheel is run at a speed approximately twice that of the felt wheel. In polishing, only slight pressure is used against the wheel. The same polishing agents can be used as those for the felt wheel.

Cloth polishing wheels. Wheels or buffs made by sewing together a number of layers of soft muslin or cotton cloth are also a valuable asset to the polishing department. These wheels need not be more than 3 or 4 inches in diameter but should have enough layers of cloth to make a thickness of at least a half inch.

Cloth buffs are run at high speeds, as high as, or even higher than, those for the leather wheel. The faster the wheel runs the harder will be the periphery by reason of the centrifugal force developed. A tapered buffing spindle attached directly to the motor will develop adequate speed.

Cloth buffs are especially adapted to such polishing agents as rouge and levigated alumina. Small amounts of the agent are used, and the wheel should be almost dry. A fine polish can be obtained by this method on the softer materials, particularly malachite, variscite, and turquoise.

Where Cabochons Should be Polished

All cabochons must be polished all over the top. But some materials are markedly enhanced in their beauty if the back is likewise given a polish. In general, that applies to all transluscent cabochons, especially to the harder ones.

Likewise hearts, pendants, and watch charms are well adapted to polishing both sides.

DON'TS FOR POLISHING

(1) Don't polish any stone which has not been made perfectly smooth on the sander.

(2) Don't fail to keep the felt polishing wheel thoroughly wet.

(3) Don't overlook the requirements of the different polishing wheels as regards their running speeds.

(4) Don't overpolish soft gems. They may undercut in certain parts.

(5) Don't give up if a polish does not result in a short time. You might have better luck if you try some other polishing agent.

(6) Don't expect one agent to work on all gems. Adapt the agent to the gem.

(7) Don't try to work too fast. Avoid overheating.

(8) Don't be satisfied with anything but a mirror-bright gloss.

CHAPTER X

The Technique of Undopping and Cleaning

THE SEVENTH and final operation in the production of a cabochon gem is its removal from the dop stick and its cleaning.

The cutter now has a completed gem stone on his dop stick and needs only to free it from everything else to see the product of his exacting efforts. The gem can be easily broken or the girdle can be chipped by the wrong method of removing it — which would be a tragedy indeed.

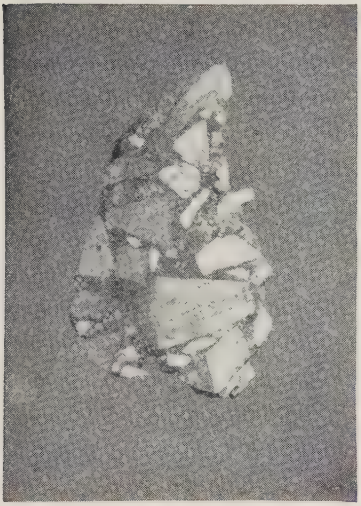
Undopping the Finished Gem

Many stones will drop away from the cement when dipped into chilling cold water for a few minutes. Or the stone together with the cement on the dop can be gently warmed over the flame of an alcohol lamp to about 100 or 110 degrees F. By slipping the thin edge of a knife blade around the girdle and pressing the softened cement away from the back of the gem a separation can be easily accomplished. Under no circumstances should the gem be pried; it will break if it is a brittle mineral, or if it has any cracks or fractures. Often the girdle will chip or crack or flake. Many a beautiful specimen has been ruined in that way, after all the cutter's work and diligent care.

Cleaning the Finished Gem

After removing the gem stone from the dop, it will be apparent that some small masses of cement are adhering to its surface, and that the entire surface here and there appears

A SERIES of 38 instructive photographic reproductions depicting cabochon gem materials and the operations by which they are transformed into attractive gems.

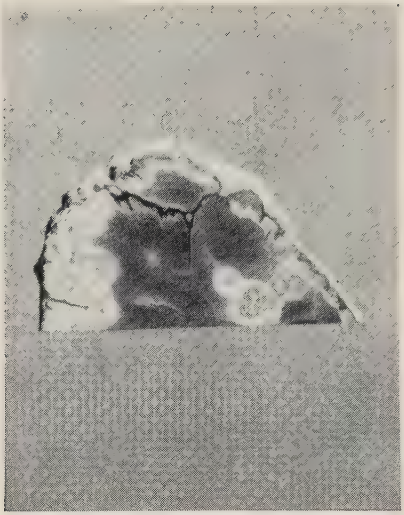


Cut 1. Brecciated Jasper from Rocky Mountain National Park, Colorado. This slab is characterized by a patchwork of striking pattern. Large and small sections of various colors are fitted into a "modernistic" design. The colors are red, orange, red-brown, pink, gray, and white.

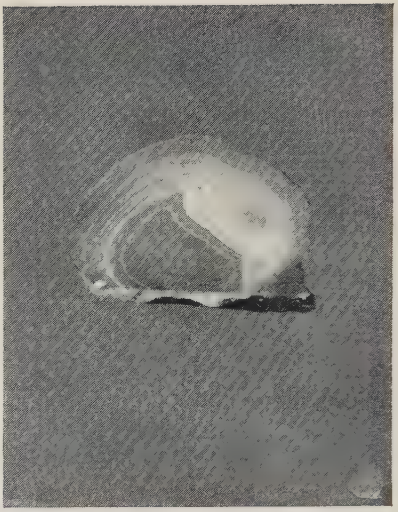
Cut 2. Petrified Wood from Kansas. Brilliant reds alternate with orange, yellow, pink, and gray-white. Small areas of white extend into a region of black. (Slab by courtesy of Dennis L. Smith.)

On this page and the following 15 pages there is presented a carefully selected group of common, easily available cabochon roughs for study by the amateur cutter. The beginner especially should find here the opportunity to familiarize himself with the appearance, the markings, designs, and characteristics of the natural minerals, as they appear when sawed into slabs preparatory to cutting. Observe the lines, arcs, contours, and figures which make up the patterns. The cutter who gives thoughtful study to these qualities and selects the most attractive designs will be well rewarded with more beautiful gems when his product is finished.

Following the six pages depicting gem materials, there is a series illustrating the operations in the process of transforming them into gems. The hands are given prominence in these views, showing their positions and manner of grasping or holding during the various actions of sawing, grinding, smoothing, and polishing.



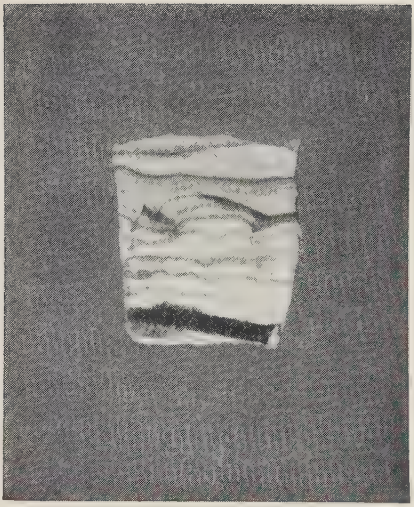
Cut 3. Variscite from Utah. This slab shows a brilliantly green field with lighter greens shading into blue-green, and more or less surrounded by crusts of bright yellow. Whorls and nodules with irregular black veining set the pattern.



Cut 4. Agate from the Lake Superior Region. A slab of deep red-brown color with parallel wavy bands of white arranged in a pleasing design. This is one of the most satisfactory materials to practice on. It is close-grained and compact, and it takes a mirror-bright polish with comparatively little effort.

Materials like those shown above vary greatly in hardness. The variscite has a hardness of five (on the scale of Mohs); the agate, seven. Not only that, but there is some variation in variscite from the green to the yellow. The cutter, to attain best results, needs always to remember that the softer materials require more careful handling against the rough grinding wheel, and in some cases a different polishing agent or a different running speed of the polishing wheel.

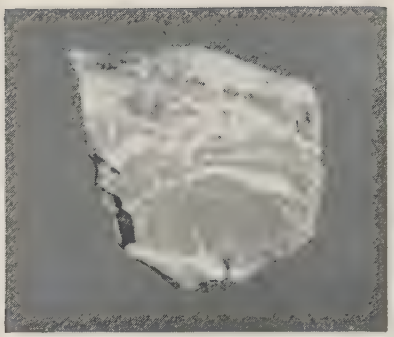
Cut 5. Tiger's-Eye from Africa. This material shows vaguely defined bands of black, brown, yellow-brown to bright yellow. Holding it properly to the light and moving it from side to side produces a strong chatoyancy, i.e., a changeable silky sheen. It is important to place the top of the curve of the cabochon so that the gem is bisected by the chatoyant band.



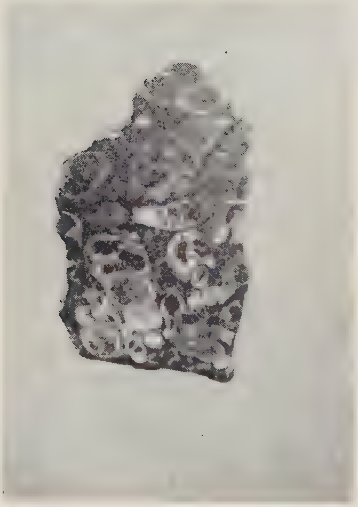
Cut 6. Landscape Agate from New Mexico. A variety of banded agate with irregularly parallel lines to give the illusion of a landscape. A highly attractive cabochon can be cut from such a slab by orienting the lines horizontally. The colors are tan, brown, gray, and black.

These two materials depend upon different properties for their beauty. The agate is opaque and has sharply cut outlines in its pattern. It requires only a high polish. The tiger's-eye is one of the so-called phenomenon gems, and must be cut in a certain way, then presented to the light properly, and then moved about to produce the phenomenon of chatoyancy. Other phenomenon stones are star sapphire and ruby, cat's-eye chrysoberyl, opal, alexandrite, and labradorite.

Cut 7. Scenic Agate from New Mexico. In red, yellow, white, and browns.

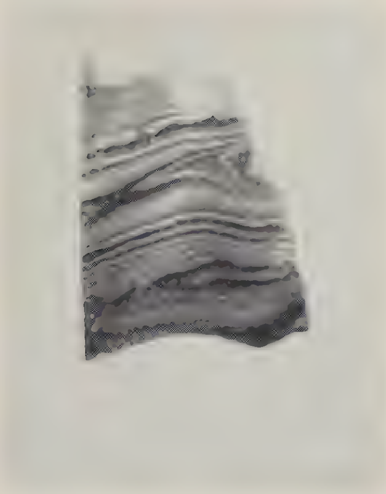


Cut 8. Jasper from California. Colors are deep red, orange, and white.



Cut 9. Turritella from Wyoming. White snails in a bed of black mud. Agatized.

Cut 10. Agate from the Lake Superior region. Rich red-brown with wave-like bands.



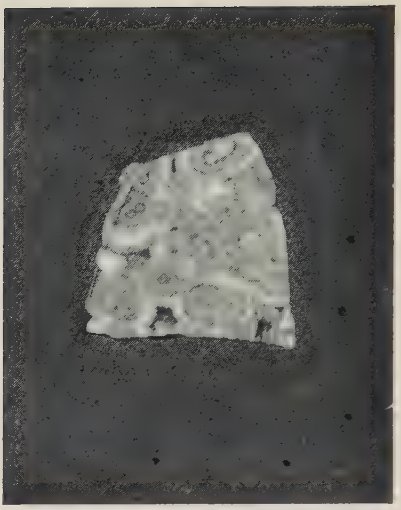
Cut 11. Doubleflow Obsidian from Oregon. Glassy, semitransparent stripes in blue-gray and black.

Cut 12. Thomsonite from Minnesota. Delicately pink suns bursting forth on a white background.

Cut 13. Jasper from California. Bright orange with rich red patches crossed by thin black lines.

Cut 14. Agatized Palm Root from California. Bluish whorls on a background of gray, flecked with white, orange, and tan.

Cut 15. Shattuckite from Arizona. Deep blue with brilliant brown mottling.



Cut 16. Orbicular Jasper from California. Brick-red spheres with gray centers, all on an orange field.

Cut 17. Nephrite Jade from Wyoming. A fine slab of rich apple green peppered with lighter green.

Cut 18. Jasper from California. Bright orange-red with irregular black veining.

Cut 19. Weighing a Gem Stone. Faceted gems are usually recorded by weight in carats.

Cut 20. Measuring a Gem Stone. Cabochons are usually recorded by dimensions in millimeters.

Cut 21. A Chunk of Morrisonite of Best Quality. This particular variety of jasper is found only in one area in Idaho. It is hard, smooth, and takes a fine polish. The colors are a riot of spectra, with the softer pastel tans, reds, greens, and browns prevailing. There is no other gem material just like it. (Material by courtesy of Dudley Stewart.)

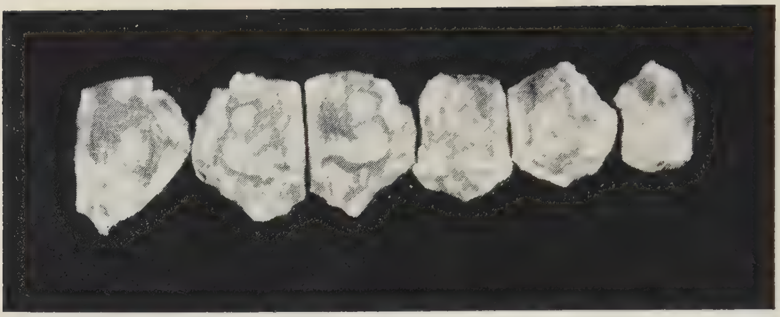
THE PROGRESS of a Gem Stone from the Rough Chunk to the Finished Cabochon.

Cut 22. Clamping the Rough Chunk of Morrisonite into the Diamond Saw. Note plastic gloves, which are highly useful for oily, messy work.

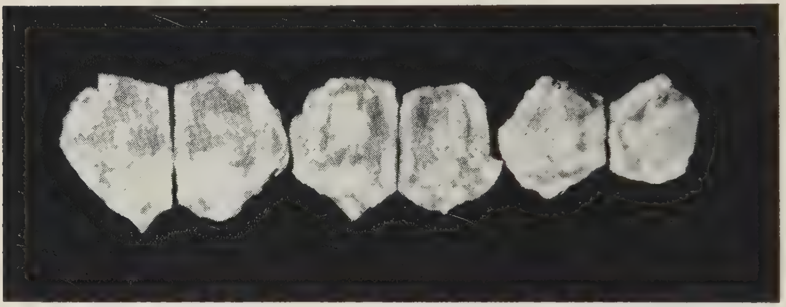
On the opposite page (Cut 21) is seen a fine chunk of jasper with its gorgeous array of colors showing. After deciding upon which is the best direction for dividing the rock into slabs, it is clamped into the jaws of the carriage of the diamond saw (Cut 22) and sawed into six slabs, each ¼ inch thick (Cut 23).

These slabs are now ready for thoughtful examination. The best possible patterns, color masses, combinations, and designs are ferreted out and then marked by means of templets with elliptical or other shapes to bring out the best there is in them.

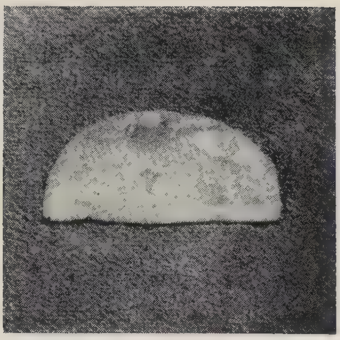
In order to make the purpose clear, three areas are to be picked out on the slabs which can be readily identified. These areas present each a somewhat fanciful picture. They are used only because they aid in giving a mildly dramatic angle to the point to be driven home. They do not in the slightest degree make better nor more beautiful gem stones. The possibilities in these slabs are limitless. Cuts 24, 25, and 26 illustrate the point.



Cut 23. Six Slabs Cut from Chunk of Morrisonite Shown in Cut 21. The top row is laid out to show adjacent (symmetrically opposite) sides.

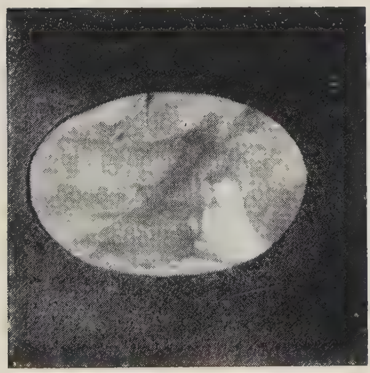


Cut 24. The bottom row shows the other sides, also symmetrical but different. The slabs are merely turned over. Both sides are carefully gone over and the best areas selected for cutting.

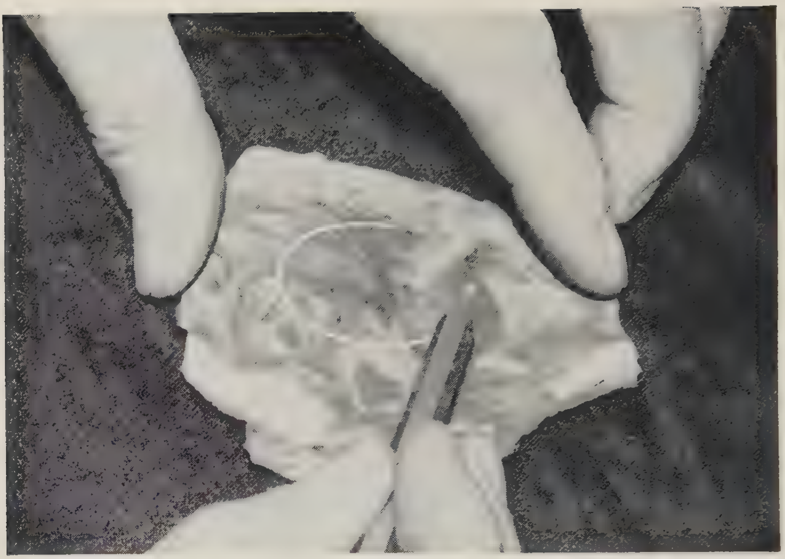


Cut 25. "Atomic Bomb in Frenchman's Flat." This view is greatly enlarged from the original, which is a small area in the fourth slab from the left, bottom row, Cut 24. It is difficult to find due largely to the fact that in Cut 24 the color values are all practically the same in the overall picture. The background is a mask cut from paper to block out confusing details all around.

Cut 26. "Sinister Oriental." This view is drastically reduced from the original. It can be easily located in the second slab from the left, bottom row, Cut 24.



Cut 27. "A Black Ghost Flits out of the Picture." This view is slightly reduced from the original. It can be identified by turning the page left ¼ turn, in the third slab from the left, top row, Cut 23. Compare the three slabs and note especially the areas covered by the "pictures." Compare also Cuts 25, 26, 27 with Cuts 36, 37, and 38.

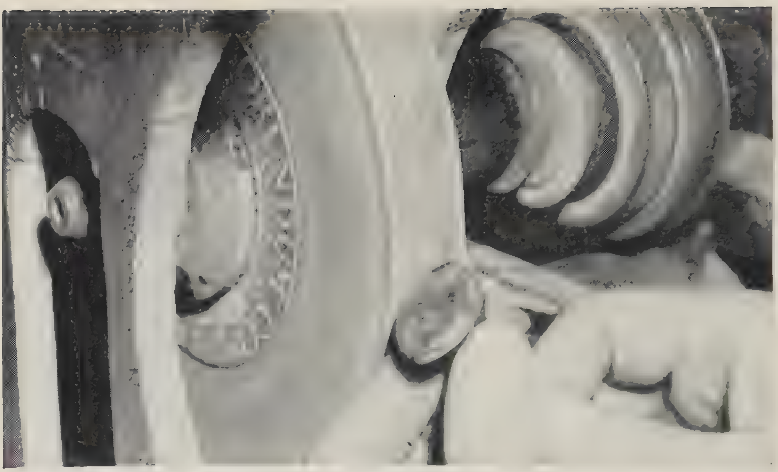


Cut 28. Marking Out the Area Selected for the cabochon shown in Cuts 27 and 38.

Cut 29. Sawing Away the Excess Material. The piece is fed into the saw by sliding it into the blade on a platform by hand. Note the plastic gloves protecting the hands.

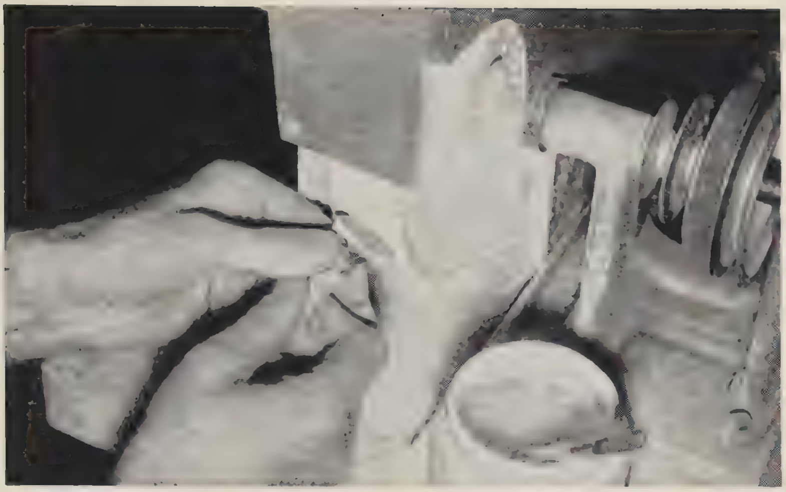
Cut 30. Rough Grinding the Cabochon. The purpose is to give the gem stone the general shape, size, and contour desired. Note the manner of holding the stone against the wheel.

Cut 31. Dopping the Roughed-Out Stone. The fingers work up the dopping cement to form a supporting shelf for the overhang of the stone.



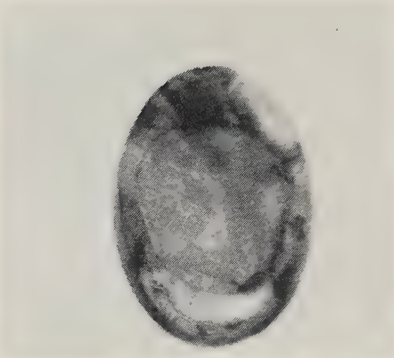
Cut 32. Finishing Off the Grinding. This gives the stone its true curves and smoothes down the high spots. This operation is particular and the stone is much more gently and delicately handled than in Cut 30, which is made possible by having it on the dop stick.

Cut 33. Smoothing the Gem Stone. A padded disc is covered with carborundum cloth of 220 grit, and the stone is gently stroked against it while the disc runs at moderate speed. The gem is kept constantly in motion by twisting as well as stroking to avoid overheating.

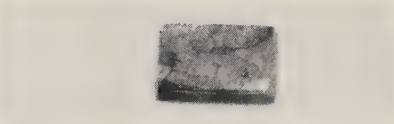


Cut 34. Polishing the Cabochon. The felt wheel rubs the polishing agent over the surface of the gem and gives it the final mirror-bright finish.

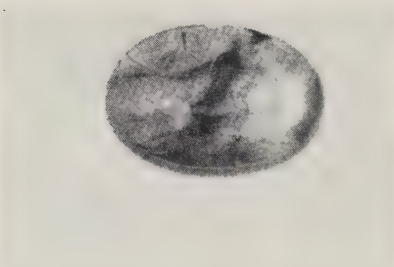
Cut 35. Undopping the Cabochon. Removing the gem from the dop stick is simple enough, but many stones are cracked or broken because the cutter pried the stone from the cement. The way to do it is to pry the cement away from the stone.



Cut 36. The "Sinister Oriental" after Polishing. (See Cut 26).



Cut 37. The "Atomic Bomb" after Polishing. (See Cut 25).



Cut 38. The "Black Ghost" after Polishing. (See Cut 27).

HERE THE THREE FINISHED GEM STONES are photographed to show their sizes on the same scale. The object of portraying these operations in some detail is to show how diligence and meticulous inspection of all surfaces of a slab can produce a better gem with better color balance and composition, giving it very often that final touch which lifts it above the ordinary.

a little smeary. The gem should be placed in alcohol for ten or twenty minutes and then dried with a clean cloth. Ordinary grain alcohol is excellent, but methyl alcohol will do quite as well and is much cheaper. All the cement or wax particles on the gem will dissolve, leaving a clean, shining surface all over the stone.

Beveling the Girdle

There is one last operation on the gem which many cutters perform but others omit. When the stone is to be used for jewelry, it is almost a requirement. This operation is the putting of a tiny bevel all around the girdle. A cabochon with a flat back and no bevel is difficult to pick up from a table. It is also difficult to get it to settle into a bezel when mounting it into a jewelry piece. A beveled girdle does away with these difficulties.

A bevel is ground onto the stone simply by holding it to the fine grinding wheel and turning it at an even stroke all around on the side of the wheel. Once around will do except with hard stones, which may have to be turned twice around.

The stone is now finished; it has been carried through all the various stages necessary to make of it a gem.

DON'TS FOR REMOVING AND CLEANING

(1) Don't pry, twist, or force the gem off the dop. Rather, work the cement away from it until it separates easily.

(2) Don't use a wiping or drying cloth which has grit in it. The gem will be easily scratched.

(3) Don't be chagrined if on removal you find cracks or flaws which you did not see before. They were there but not apparent.

(4) Don't expect every stone to come out a 100 per cent perfect gem. The deeper regions of the gem material cannot always be judged by the surface.

(5) Don't give up if the first one is disappointing. Only practice makes perfect.

CHAPTER XI

Facet-Cut Gems

Gems cut facet style are the aristocrats of the gem stones. They wear their brightest fronts, appear always at their best in proper surroundings. Diamonds are always cut that way. All gem stones cut from transparent crystals are profitably cut with facets.

Diamonds vs. "Colored" Stones

From the commercial point of view, the facet-cut gems are divided into two classes: (1) the diamonds, and (2) the "colored" gem stones. The diamond is considered in a class all by itself because of its distinctive properties, principally its hardness and brilliance. The "colored" stones are not limited strictly to colors; even the white or uncolored stones, like precious topaz and white sapphire, are given this classification. It includes all the faceted gems other than diamonds.

Arrangement of Facets

Facets are not cut on a gem stone in a haphazard way. The facets are small flat planes which are placed upon the surfaces of the stone in a definitely predetermined manner. Due attention is paid to the various sizes of the facets, their relation to each other, their angles in relation to the girdle of the gem, and the geometrical arrangement of the group of facets as a whole.

The Purpose of Cutting Facets

The purpose of facet cutting is to bring out the greatest possible brilliance in a stone by arranging the facets at such angles that the light which falls upon the gem will be properly refracted as well as reflected. In certain gems, dispersion of light rays also plays an important part. To be successful in producing this type of gem, the cutter must have at least a minimum working knowledge of the manner in which light rays behave when they enter a gem stone.

Terms Used in Facet Cutting

Before discussion of the optics involved in facet cutting is entered into it is necessary to learn the terms used by gem cutters, and the meaning of each. The following terms are in common use and are further clarified in Figure 40:

GIRDLE: The widest portion of the gem.

CROWN: The portion above the girdle (also called the top).

PAVILION: The portion below the girdle (also called the back).

TABLE: The large flat surface upon the top of the gem; the largest facet.

FACET: Any one of the many small flat surfaces, or faces, placed upon the gem by cutting.

CULET: The small facet sometimes placed at the tip of the pavilion; it is parallel to the table.

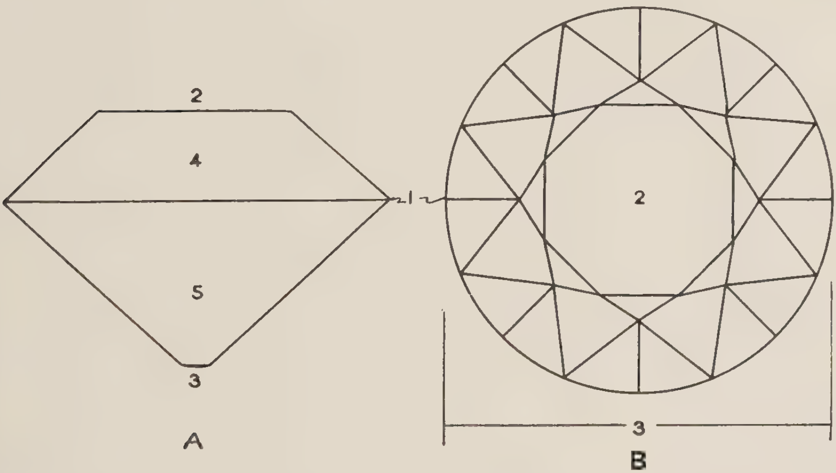


Figure 40. The Parts of a Facet-cut Gem. A, side view of a brilliant; 1, girdle; 2, table; 3, culet; 4, crown; 5, pavilion. B, top view of a brilliant; 1, girdle; 2, table; 3, spread.

SPREAD: The greatest breadth or expanse of the gem when viewed from above.

THICKNESS: The greatest depth of the stone; the distance between the table and the culet.

MAKE: The geometric form or shape of the cut stone; the arrangement of its various parts; the proportion and symmetry of its parts.

BRILLIANT: A style of cut which is used for most diamonds. It is round, has thirty-two facets on the crown in addition to the table, and twenty-four on the pavilion in addition to the culet. It is so designed that a diamond cut brilliant style will produce the maximum life and sparkle.

Cutting Facets According to Optics

The optical properties of gem materials involve the physics of light. This is not easy to explain, yet a basic knowledge of the way in which light rays behave when they enter and leave a gem stone is necessary in order to understand how to get the full beauty of brilliance out of a gem.

Many cutters, professional as well as amateur, cut their facets by simple mental calculation or even purely by guess. They have learned from experience just about what the slope of the main facets on a brilliant should be and they strive for that. Success, however, is not always assured in that way. Experience is, of course, highly valuable, but knowledge of the scientific laws which govern the optics of gems is essential for maximum results (Figure 41-A).

"Live" Stones, "Sleepy" Stones, and "Dead" Stones

A good stone which is accurately faceted according to the laws of refraction and reflection will sparkle with life and brilliance. One which is cut without regard to these laws is likely to be sleepy with a dull and indifferent glow rather than a sparkle. Or it may even be dead, which means, in the language of the gem cutter, without any light being reflected whatever.

Perfect and Faulty Makes

A gem that is sleepy or dead is said to be of a faulty or wrong make. The make may be wrong in various ways. The

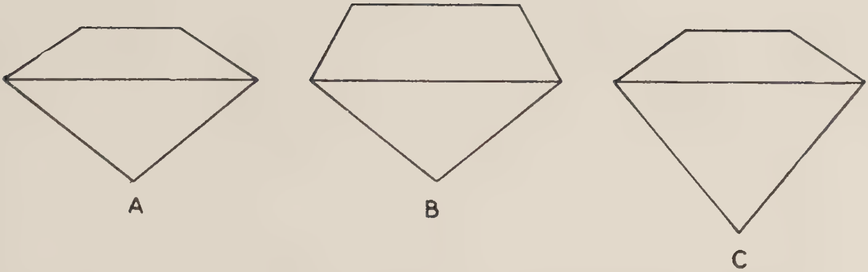


Figure 41. Proper and Faulty Makes of Diamond Brilliants. A, a satisfactory make; B, a faulty make, table too wide and too thick; C, a faulty make, pavilion too deep.

crown may be too thick in proportion to the pavilion, or it may be too steep, giving the stone not only a top-heavy appearance but also absorbing light instead of reflecting it. Such a stone is said to be lumpy. On the other hand, the crown may be too shallow. The pavilion likewise may be either too flat or too deep. (Figure 41-B-C).

Whether it is the crown or the pavilion or both that are cut wrong, the gem will lose brilliance. Since the scientific laws of light cannot be disregarded, it is necessary to understand them. Otherwise, the cutter will have failures now and then, even though he has considerable past experience without full knowledge of optics.

Proper Proportions of a Diamond Brilliant

A stone of the proper make has definite proportions. However, these proportions differ slightly according to the particular gem material which is under consideration. Using the diamond for purposes of discussion here, the following measurements are considered ideal: (1) The spread of the diamond should be to the thickness as five is to three (for other gems, the ratio changes in the direction of five to four, or even five to five); (2) the thickness of the diamond should be divided between the crown and the pavilion as one is to two — or, in other words, the crown is half the thickness of

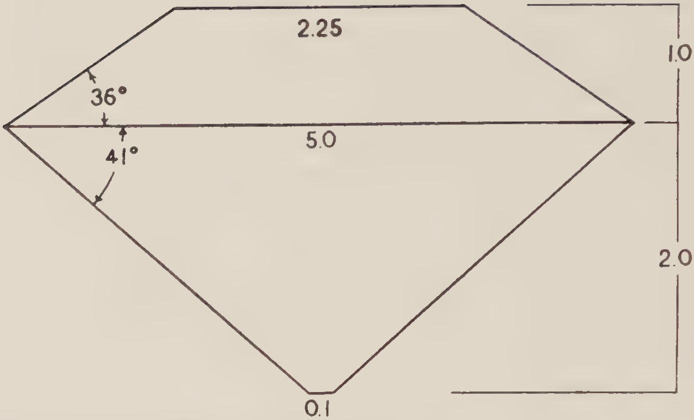


Figure 42. The Proper Proportions of a Diamond Brilliant. Diameter of the girdle, 5 parts; diameter of the table, 2.25 parts; diameter of culet, 0.1 parts; height of the crown, 1 part (or very slightly less); depth of pavilion, 2 parts (or very slightly more); angle of the crown, 36 degrees; angle of the pavilion, 41 degrees.

the pavilion; (3) the width of the table should be 4.5 tenths that of the spread (Figure 42).

In order to understand this better, let us assume that you are going to cut a diamond brilliant 5 millimeters in diameter at the girdle. Then the thickness should be 3 millimeters; the crown 1, and the pavilion 2 millimeters. The table would then be 2¼ millimeters. If then you measure the angle of the main facets with the plane of the girdle, it will be 36 degrees on the crown (authorities differ somewhat as to this — they give from 34 to 37 as correct). Likewise the angle of the main pavilion facets with the plane of the girdle will be pretty close to 41 degrees (the authorities here are remarkably close in agreement). The reader at this point should study carefully Figure 42.

Proportions and Angles of Colored Gems

In the colored gems, especially the darker ones, the table is often much less than that of the diamond, and the thickness of the crown may be to the pavilion as one is to three.

Each mineral has its own make for maximum beauty and the cutter will soon become aware of the fact that even the finest material may be utterly disappointing when improperly cut.

The angles at which the main facets are cut depend entirely upon the optical properties of the material being cut. The most important of these are refraction and reflection. They will be fully discussed later.

The cutter should pay the closest attention to the angles which the main facets make with the girdle. If he adheres to the known standards, he will not go very far wrong. Taking again the diamond as an example, the angle of inclination of the crown main facets from the plane of the girdle is 36 degrees; that of the pavilion main facets is 41 degrees. For other stones, these angles may vary as much as 9 degrees, but they are seldom less, usually more, than those of the diamond (Table VI).

TABLE VI

Angles for Ideal Facet Cuts for Standard Brilliants

	Main Crown Facets	*Main Pavilion Facets*
Beryl	45 degrees	42 degrees
Chrysoberyl	37 degrees	42 degrees
Corundum	37 degrees	42 degrees
Diamond	36 degrees	41 degrees
Garnet	37 degrees	42 degrees
Quartz	45 degrees	42 degrees
Spinel	37 degrees	42 degrees
Spodumene	43 degrees	39 degrees
Topaz	43 degrees	39 degrees
Tourmaline	43 degrees	39 degrees
Zircon	43 degrees	40 degrees

Authorities are far from completely in agreement on this subject. The angles given in this table are those which are accepted by the majority of cutters.

The cutter does not have to adhere to the proper angles as closely when cutting stones of a marked degree color as he does when cutting gems which are white or colorless. The latter depend entirely upon sparkle and brilliance for their beauty, while gems of deep color have both brilliance and color to show. Often color makes up for what the gem lacks in brilliance.

Angles of a Step-cut Gem

In the brilliant cut, the angles of importance are those of the crown main facets and the pavilion main facets. But in a step-cut gem which is cut for sparkle and brilliance, the important angle on the crown concerns the widest facet next to the girdle; on the pavilion, the culet facet—the one farthest away from the girdle. This is desirable for white, or nearly colorless, step-cut stones. For the deeper colors, the cutter may find it desirable to reduce these angles to gain the best color at the expense of brilliance.

A "Well" or "Hole in the Middle" of the Gem

If a stone is cut with a bad make in which the angles of the main facets on the pavilion are less than 40 degrees, it is entirely likely that it will have a well or a hole in the middle. There will be little or no reflection from those facets upward through the table, and the gem will have the appearance of being transparent or open in the areas of those facets whose angles are too small. An otherwise good stone may thus lose much of its beauty because the lower facets do not reflect the light upward and out through the crown but allow it to pass on through and out of the pavilion, where it becomes lost. Thus it has the appearance of having a hole in the middle. How this can be avoided will be fully discussed in a later chapter.

CHAPTER XII

The Optical Properties of Gem Materials

When a ray of light falls upon the surface of a gem, one of three things happens: (1) It is reflected from that surface; (2) it passes from the air into the gem; or (3) it is more or less completely absorbed by the gem.

Reflection of Light

In the first case, where the ray of light is reflected the gem has either a bright, mirrorlike polish and is opaque and does not allow the light to enter, or it is transparent and would allow the light to enter if it had fallen upon the surface at the proper angle, but only then. In speaking of transparent gem stones, therefore, light is reflected from the surface, any surface, of a gem when it strikes that surface at certain angles, but it is passed on into the gem when it strikes at certain other angles.

The ray of light which falls upon the surface of the gem is called the incident ray, and the angle at which the incident ray strikes the surface is called the angle of incidence. This angle is measured not between the incident ray and the reflecting surface but between the incident ray and the perpendicular, called the normal.

When the incident ray strikes the gem, it is reflected like a rubber ball bounces off a wall. This ray is called the reflected ray. The ray of reflection has the same angle as the ray of incidence.

This behavior of light when it is reflected is the reason why knowledge of the optics of gems is of prime importance

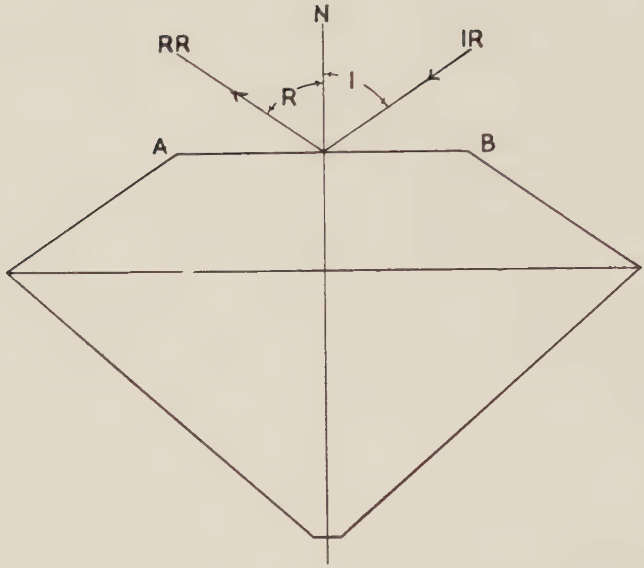


Figure 43. Light Reflection in a Gem. AB, reflecting surface; N, normal; IR, incident ray; RR, reflected ray; I, angle of incidence; R, angle of reflection.

in figuring out the true angles for facet cuts (Figure 43).

Refraction of Light

Now let us take the second case in which the incident ray of light is not reflected but passes from the air into the transparent gem.

As the ray strikes the surface and then enters the gem, it is bent, or refracted, and it then travels into the interior of the gem in a different direction but in the same plane. The bending, or refraction, of the ray is always toward the normal (perpendicular) when light passes from a rarer medium — the air — into a denser medium — the gem stone (Figure 44).

The angle which the light ray forms with the normal within the gem is called the angle of refraction. This angle is not the same as the angle of incidence. It is always smaller, with one exception, and that is when both angles are zero.

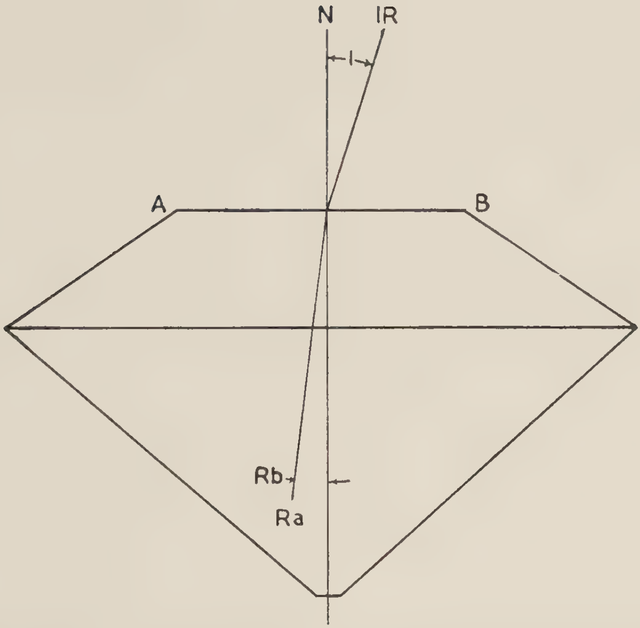


Figure 44. Light Refraction in a Gem. AB, refracting surface; N, normal; IR, incident ray; Ra, refracted ray; I, angle of incidence; Rb, angle of refraction.

With each change in the angle of incidence, there is also a change in the angle of refraction, according to a constant. This constant is named the refractive index (RI). For each of the many different gem materials, there is a definite RI (Table VII).

TABLE VII

Index of Refraction

Almandite (Garnet)	1.80	Obsidian	1.55
Apatite	1.64	Opal	1.45
Axinite	1.68	Phenacite	1.66
Benitoite	1.78	Pyrope (Garnet)	1.73
Beryl	1.58	Quartz	1.55
Chrysoberyl	1.75	Spinel	1.72
Corundum	1.76	Spodumene	1.67
Diamond	2.42	Topaz	1.62
Epidote	1.75	Tourmaline	1.63
Grossularite (Garnet)	1.75	Zircon	1.95

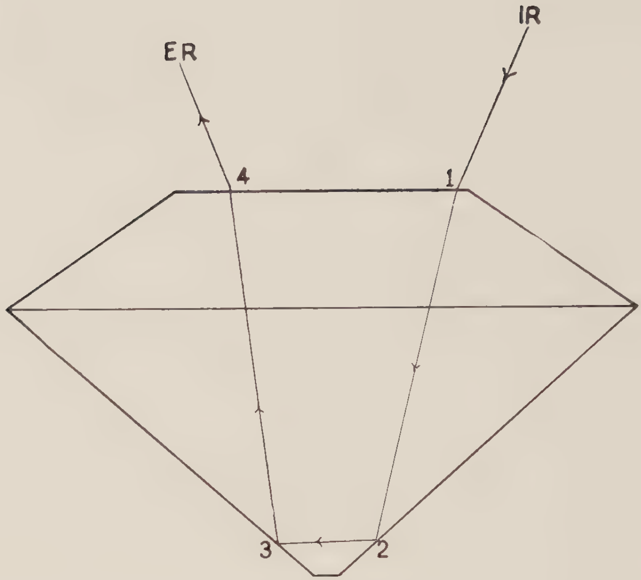


Figure 45. Light Passing Through a Diamond Which Is Correctly Cut Brilliant Style. IR, incident ray; ER, emergent ray; 1, incident angle, approximately 22 degrees, refracting; 2, incident angle, approximately 52 degrees, reflecting; 3, incident angle, approximately 46 degrees, reflecting; 4, incident angle, approximately 7 degrees, refracting.

The refractive index of any gem is easily determined by the use of an instrument called the refractometer, which measures the bending of the rays and shows the result directly on a scale.

Absorption of Light

In the third case, light rays falling upon the surface of an opaque gem stone enter the gem and are absorbed. If the material is black, all the light is absorbed. However, if it is blue, then all the rays except the blue are absorbed, and the blue alone is reflected. Similarly with all the other colors.

The Critical Angle

We have now traced a ray of light as it approaches the table of a gem and then enters and is refracted toward the normal. This ray will penetrate until it reaches the inner surface of the pavilion of the stone (Figure 45). There the light ray will behave exactly in the same way it did at the table on the crown, but in the reversed procedure. If it strikes the pavilion surface at the same angle that it enters the table, then it will pass through from the pavilion into the air below the gem. There it will be lost. If, however, the surface of the pavilion facet is so inclined that the light will strike it at an angle that will reflect it back into the interior instead of passing it on out, then the light ray will cross the pavilion to the opposite side (Figure 45). There the problem is repeated, and the gem stone which is correctly cut will have the proper inclinations to all its pavilion facets so that they reflect the ray once more. This time the light will return upward and reach the table, passing out of the top. This is the brilliance and sparkle that the observer sees in a lively stone when he examines it with the table up, the way it is set in jewelry.

When all the facets of the crown of a gem are cut at the proper angles each facet, including the table, will direct the entering light rays toward the pavilion. And when all the pavilion facets are also correctly cut, then all the light entering will be completely reflected and returned upward. This is called "total internal reflection."

If, however, the light traveling into the interior of the gem from the table to the pavilion will strike the inner surface at an angle that will pass it through as a refracted ray, rather than reflecting it, then the critical angle has been passed.

The critical angle thus is the angle, or tolerance, between the angle of reflection and the angle of refraction. To quote an authoritative though perhaps rather formidable definition, here is what the Century Dictionary says: "*Critical angle:* in optics, the limiting angle of incidence which separates the totally reflected rays from those which escape into the air."

And Webster defines it as: "The least angle of incidence at which total reflection takes place."

By the following formula, the value of the critical angle may be calculated:

$$\sin x = \frac{1}{RI}$$

where the critical angle is represented by x and the index of refraction by RI.

In cutting gem stones, the critical angle must be duly taken into consideration when determining the angle of inclination of the facets on the pavilion.

Other Optical Properties of Gems

There are several other optical properties in regard to gem stones which are exceedingly interesting to the scientifically inclined person but have little or no direct bearing on the methods of cutting. Among them are such phenomena as dispersion, pleochroism, and polarization. These properties are of greatest value in that phase of gemology that deals with identification of gem materials, but add nothing important to the art of cutting.

CHAPTER XIII

Forms and Types of Facet Cuts

THERE ARE two basic forms used for cutting faceted gems, (1) round, (2) square. These two forms may be varied greatly, so that from these basic forms many others are evolved. Some of these are mixtures or combinations of the two basic forms. Commercially, only a few forms and sizes are generally adhered to. This is for the purpose of standardizing the forms as well as the sizes so that jewelry manufacturers can engage in mass production of the gold and silver settings without special regard to the gem stones. Into the settings made this way, the standardized stones will fit more or less automatically.

Special forms of gem stones as well as odd sizes call for special settings which are often individually designed and then made by hand at great cost. While it is highly desirable to be the possessor of individualized jewelry, it is also quite expensive.

Round Gem Stones and Their Modifications

Round stones are always popular and acceptable. But fashion sometimes dictates that other forms shall be preferred.

The round form may be modified to an ellipse or an oval. The ellipse in turn may be modified to a double bow, called a marquise. The oval may be modified to become a pear shape, a drop shape, or a heart. Other modifications will suggest themselves to the cutter as he gains experience (Figure 46).

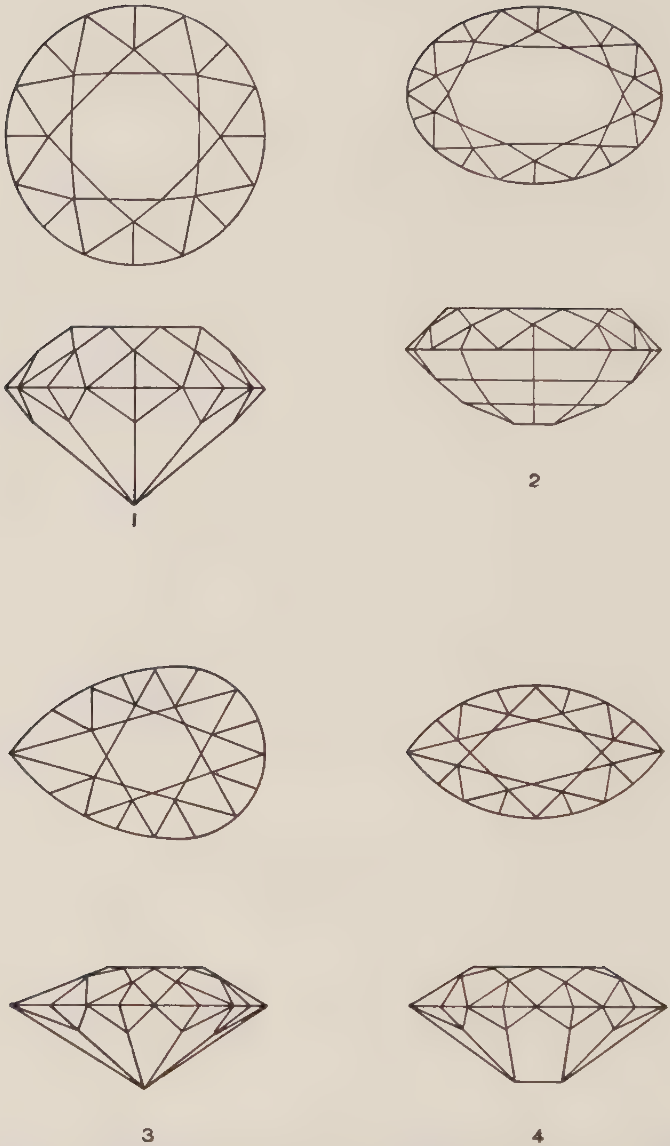
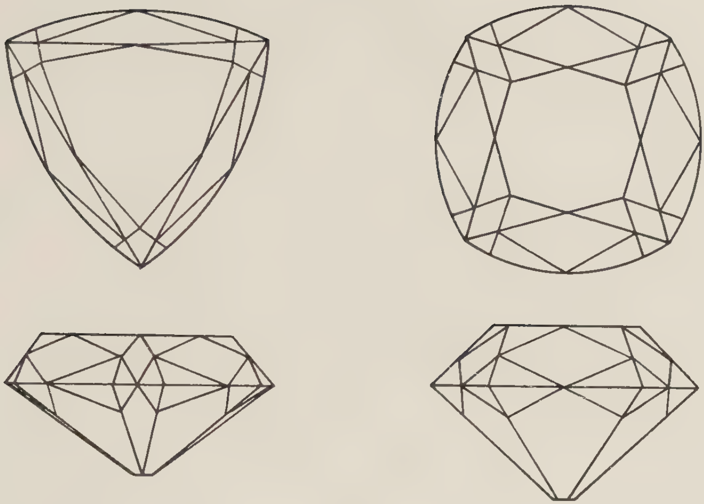


Figure 46. The Round Facet Cut and Its Modifications. 1, round brilliant; 2, ellipse; 3, pendaloque or pear shape; 4, marquise; 5, "heart"; 6, regent.



5 6

Figure 46 (*Continued*)

Square Gem Stones and Their Modifications

The square is likewise popular to some extent, principally for small stones, but it never has enjoyed the acceptance that the so-called emerald cut has always had.

The square form has an almost inexhaustible variety of modifications. The commoner ones are rectangles and cut-corner rectangles (the emerald cut). For commercial purposes, rectangles of specific proportions and with the corners cut to allow for the metal prongs of mountings are the most popular. The reader is referred to Figure 47 for a few of the simpler forms. For sizes and proportions of gem stones for commercial use he should turn back for further study of Table II in Chapter III. He will there find the sizes which are preferred by jewelry stone setters who keep in stock blank mountings ready to receive cut stones of standard sizes.

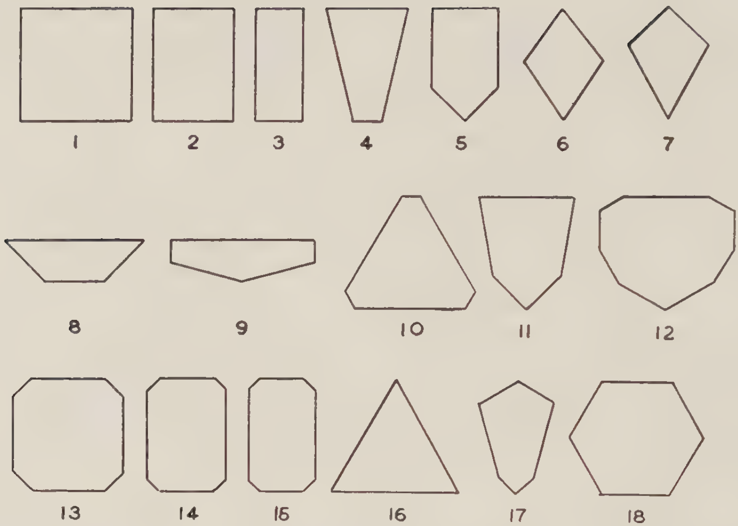


Figure 47. The Square Facet Cut and Its Modifications. 1, square; 2, rectangle; 3, baguette; 4, wedge; 5, bullet or pentagon; 6, diamond; 7, kite; 8, trapeze; 9, epaulet; 10, cut-corner triangle; 11, shield; 12, florentine; 13, cut-corner square; 14, cut-corner rectangle; 15, emerald; 16, triangle; 17, coffin; 18, hexagon.

It may seem somewhat of a mystery to the inquiring cutter why such an extensive variety of forms, especially odd forms, is desirable. Artists know that any new form, provided it has symmetry and balance, is attractive because it is lifted out of the ordinary by virtue of its originality. To illustrate the point, the reader should at once evolve an attractive original bracelet design around two trapezes (Figure 47-8) placed back to back. What a kick he will get out of it!

Combination Forms

The two forms described above are sometimes mixed in a single stone, such as a half moon, where one side is a part of a square while the other is half a circle. Other mixed forms are shown in Figure 48.

All combination forms are special forms and therefore

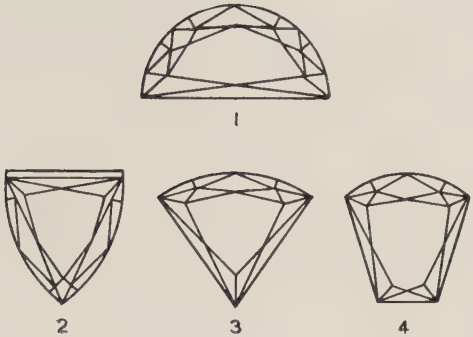


Figure 48. Facet Cuts Combining Round and Square Forms. 1, half moon; 2, half marquise; 3, fan; 4, keystone.

require special mountings, which jewelry manufacturers cannot mass-produce and keep in stock.

Styles of Facet Cuts

There are two basic types or styles of facet cuts used by modern cutters, (1) the brilliant cut, (2) the step cut (also called the trap cut). In addition there is a modified brilliant cut known as the scissors cut, and there are several cuts which are mixtures of the two principal types.

A style known as the "old rose cut" was formerly popular, but it is practically never found at the present time. It has no advantage over the other two cuts and, in fact, has been completely abandoned by commercial lapidaries.

The Brilliant Cut

The brilliant cut (Figure 49) consists of 57 facets. Of these, 33 are carried on the crown and 24 on the pavilion. The beginner should study the facets at this point so thoroughly that he will know them as he does the multiplication table.

The largest and most prominent facet is the table. It forms a perfect octagon when viewed from above. A large proportion of the light which enters a gem stone comes from above and enters by way of the table, and then it emerges by way of the table again. This is the reason why the correct angles of the pavilion facets must be adhered to, so that the maximum amount of light will enter and emerge through the largest facet, the table.

Next to the table is a row, all around, of star facets. These are small triangles with their bases upward, forming the sides of the table and giving it a symmetrical outline.

In the second row of facets are eight kite-shaped facets, their upper points touching the table, the lower resting on the girdle. These are the crown main facets and it is their angles that must be correctly placed when cutting — as the author has carefully discussed in a previous chapter.

The third and last row of facets on the crown consists of sixteen break facets which occur in pairs lying back to back, their bases on the girdle, their apices touching a point which is common to the corresponding star facet and the two adjacent main facets. This will become much clearer to the student if he studies Figure 49, p. 118, thoroughly at this time.

The pavilion carries 16 pavilion break facets which correspond to the crown break facets above the girdle. Their positions should be exactly lined up with each other above and below the girdle. If this is not done, light entering the stone will be more or less lost by leakage through the pavilion and the gem will suffer.

As on the crown, there are eight main facets on the pavilion; they should, however, not be kite shaped but somewhat more diamond shaped. These main facets should have one point on the girdle above and the other at the point of the pavilion (or the culet, if there is one) below, while the widest part of the facet is very nearly halfway between the two. This makes the facet almost diamond shaped.

The reader who is particularly observant will perhaps be a little confused at this point. Figure 49, he will have noticed, actually does show that the pavilion main facets are kite shaped, not diamond shaped. The explanation is that there is ample latitude in the facet shapes. In the case of a diamond, they should be diamond shaped because this stone is cut primarily for brilliance; in colored stones, the facets can be allowed to go over to the kite shapes in order to emphasize color a little more at the sacrifice of a little brilliance.

There are no star facets on the pavilion. A culet is often added when cutting a diamond, but is practically never placed on any other gem. When a culet is cut, the gem will have 58 facets instead of 57. The culet forms a "hole in the middle" which in a colored gem is noticably disfiguring. In a diamond, the culet is kept exceedingly small so that the "well" is actually a tiny, clear point. The usual reason given for cutting a culet is that a sharp point at the tip of the pavilion is easily chipped in the course of setting the diamond, which is avoided by cutting the culet.

The brilliant type of cut thus consists of a distinctive style of grouping the facets in three rows of facets encircling the crown; on the pavilion only two rows. This grouping applies to all stones whose girdles are curves, such as the round brilliant, the ellipse, the oval, and all the modifications and mixtures.

It is of interest and of importance that every facet in a round brilliant has its opposite on the other side of the stone, so that any ray of light which is internally reflected from a facet on one side of the pavilion to the other is squarely caught and reflected up toward the table. This is another reason why the perfect brilliant cut produces maximum life and sparkle in a gem stone.

Variations of the Brilliant Cut

There are a number of variations of the standard brilliant cut, such as the Lisbon cut, the Portuguese cut, the multifacet cut, the star cut, the split brilliant cut, the trap brilliant

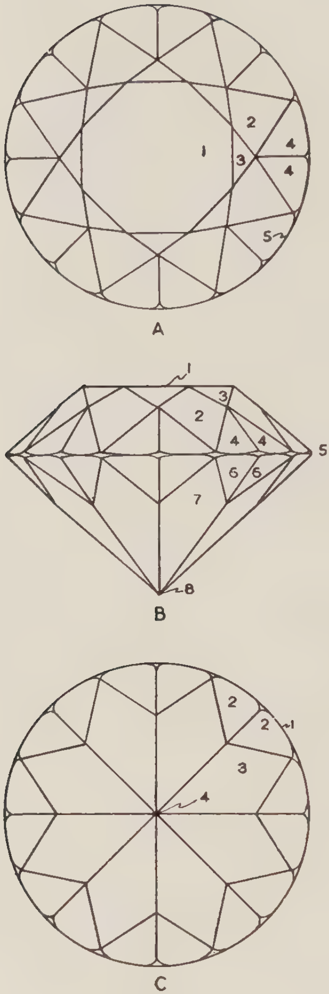


Fig. 49

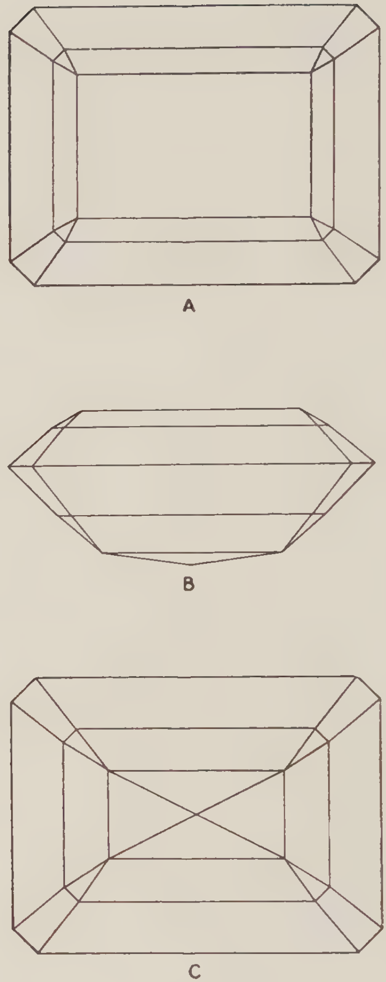


Fig. 50

Figure 49. The Brilliant Cut. A, top view; 1, table; 2, crown main facet; 3, star facet; 4, crown break facets; 5, girdle. B, side view; 1, table; 2, crown main facet; 3, star facet; 4, crown break facets; 5, girdle; 6, pavilion break facets; 7, pavilion main facet; 8, culet or point. C, back view; 1, girdle; 2, pavilion break facets; 3, pavilion main facet; 4, culet or point.
Figure 50. The step cut. A, top view; B, side view; C, back view.

cut, and the twentieth century cut. These are far too complicated for any ordinary cutter and will not be described here. They are not in common use. Many gemologists frown upon the use of some of these cuts, which, they say, do not add materially to the brilliance or the beauty of the gem, but are used merely to stimulate sales.

The Step Cut

The step cut is an entirely different style from the brilliant and is commonly used for stones whose girdles are straight lines. In addition, it is called the trap cut, and the name emerald cut is also applied to it. This name, step cut, is descriptive in itself and means simply that the facets are cut in the form of steps (Figure 50).

It will be apparent at once to the discriminating reader that the facets of a step-cut gem lie horizontally, making long, narrow, inclined planes all around the sides of the stone. From the sides, the longer facets run down to a line on the tip of the pavilion instead of a point — somewhat like the ridge of a roof turned upside down. If the cutter desires, however, the final end facets can be brought to a point (Figure 50-C). Since the facets run the full length of the sides and the ends of the gem, they must necessarily be fewer in number than in the brilliant cut. It is a style, therefore, that has different requirements and gives different results from those of the brilliant cut.

The step cut is especially adapted to gems of a rich and luscious color. It tends to enhance color while it plays down sparkle and life. It seems that the step cut was used principally on emeralds by ancient cutters, and they were right in so using it, since that style is most flattering to the stone.

It is not to be understood, however, that the step cut is used only for the square forms of stones. The step style is adaptable to both shapes, rounds as well as squares, but preferred for the latter.

The cutting of step facets is quite simple and needs very little description or exposition. This is further discussed in the chapter on cutting facets.

The most important consideration in cutting steps is the task of making the opposite sides absolutely parallel. This requires an accurate eye. The process must start at the girdle and end at the table, else the table will present a lopsided figure, which mars the perfection and symmetry of the finished stone.

Many cutters will be unable to make the roughed-out stone perfectly square without mechanical help. For them there are templets, a description of which can be found in the chapter on rough grinding of cabochons. These templets make it easy to make the sides parallel and the corners exactly 90 degrees.

In the classical step cut, the form is usually a cut-corner rectangle. On such a gem, two rows of facets are cut on the crown. The facet next to the girdle is the main facet and the important angles are figured between this facet and the girdle. The facet next to the table is cut quite flat and rather narrow and serves largely the purpose of flattening down the otherwise too sharp edge of the table. This makes it much less likely to chip along the table edge and to become dull when the stone is worn in jewelry (Figure 50).

Larger stones, usually those of ten carats or more, are often cut with three rows of facets on the crown.

The pavilion is cut in the same way, but it generally has three rows of facets where the crown has two. In this case, it is the last facet, the one at the tip of the pavilion, which must bear the correct angle to the girdle as discussed in the chapter on the optical properties of gems.

The relation of size of the facets on the pavilion is the same as on the crown. The widest facet is that which lies along the girdle, while the narrowest is at the tip of the pavilion. Nevertheless, in some stones it is very effective to cut the first and the last facets wide and the ones in between narrow.

It is common practice to cut the last pavilion facets to a point rather than a line (Figure 50) where the stone is not too long and narrow for this procedure. This makes triangles instead of quadrangles out of two of the last four facets.

The Scissors Cut

This style is a modification of the brilliant cut, with some features of the step cut added. It has also been called the square brilliant cut.

In this style, the stone is usually a rectangle, but any stone whose girdle is made up of straight lines is suitable. Such forms are triangles, cut-corner rectangles, baguettes, lozenges, pentagons, and hexagons.

The facets on each side and end are placed in groupings of four facets in three levels or rows. All the facets except the two terminal end facets on the pavilion are triangles lying in different planes. The points of all four triangles in each group touch in a single point. Each group consists of one main facet, two supporting facets, and one top facet. Study of Figure 51 will greatly clarify this discussion.

The Mixed Cut

The two basic styles of facet cutting are often mixed in a single gem. The crown may be cut in the classical brilliant style, while the pavilion can be cut step style. This is particularly adaptable to elliptical stones. In this way, both color and brilliance can be played up in a gem where both properties seem desirable.

The Buff-Top Cut

This style of cut is a variant from the standard cuts, and is popular for stones of deep colors, such as amethyst and cairngorm. The crown or table in this style is curved or cushion shaped, as in cabochon cuts, while the pavilion is step cut (Figure 52).

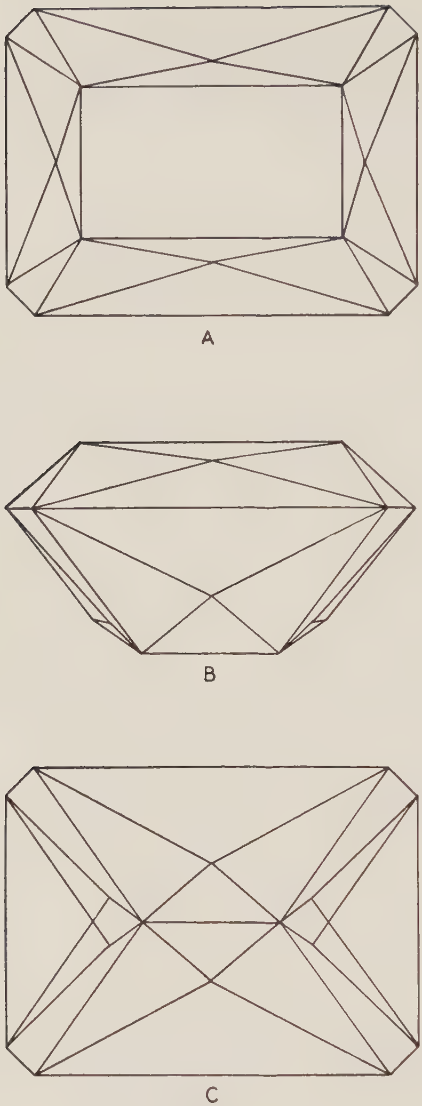


Fig. 51

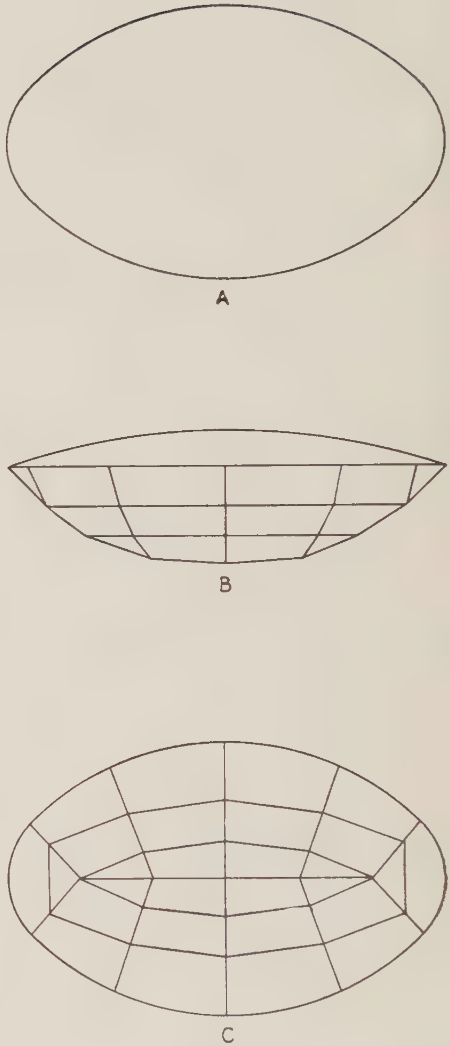


Fig. 52

Figure 51. The Scissors Cut. A, top view; B, side view; C, back view.
Figure 52. The Buff-Top Cut. A, top view; B, side view; C, back view.

The crown in this style is cut as low as possible, making it especially suitable for use when the rough material is insufficient in thickness for the usual crown.

Number of Facets to the Row

In the cutting of round girdled stones, eight facets to the horizontal row is the usual number. This may be doubled to sixteen. But in elliptical cuts, it is apparent that at the ends of the stone, where the arc of curvature is rather acute, the facets need more crowding. Therefore elliptical gems are cut with ten facets to each row instead of eight (Figure 52-C).

Occasionally, in larger stones, even twelve facets to the row can be used. The placing of twelve facets per row upon a stone with gentle curvatures calls for the greatest skill and the most accurate visual perception. This cut should not be attempted by anyone without adequate experience in the simpler standard cuts. Careful study of the arrangement of ten facets around the ellipse must precede the first attempt to cut them.

CHAPTER XIV

Preliminary Practice in Cutting Facets

LET NO ONE assume for the merest moment that the production of a facet cut gem is easy. And let no one start the job in a haphazard way if he wishes to attain a fair measure of success. And again let no one despair of the accomplishment of this art if he has tenacity of purpose.

Professional cutters serve an apprenticeship lasting years. To reach perfection may indeed be impossible for many who try ever so hard. Yet with some mechanical aptitude, infinite patience, a steady hand, an accurate eye, a love for that appealing beauty that only a sparkling gem delivers, and, last but not least, with the help of one of the many mechanical devices now available, many a rank amateur, like myself, can become proficient in this art.

Before taking the first step, the cutter must be completely familiar with the geometrical configuration and arrangement of the facets of at least the two classical styles of cuts — the step-cut rectangle, and the round brilliant. He must learn the number and the size of the facets, one row at a time. He must observe and remember the relationships of the facets to each other, and their exact positions on the stone when finished. He must memorize the angles. He must never forget the proportions of the perfect make.

When a beginner first takes a brilliant-cut gem stone in his hand and studies it, he is as apt to be as confused as he is fascinated. He will wonder where to start, where to end. Which facet comes first, and why? How can the cutting be made symmetrical? And he will have to find out. Here is an easy way to begin.

Learning to Cut Facets by Using Potatoes

When all of this seems difficult of accomplishment, get a few potatoes and a knife — and start cutting facets. First cut a flat surface and let that be the table. Then cut a rectangle around the table. The "gem" is now roughed out.

Next fix an imaginary girdle and cut from there at an angle upward along the side toward the table — and your first facet is done. Cut the next facet symmetrically opposite to the first one, on the opposite side, then finish the first row of four by cutting the two ends. Now the first row of crown facets is done. By cutting the second row all around, high and narrow, and next to the table, the crown will have its quota of regulation facets.

You need only to continue to cut downward from the girdle onto the pavilion and your faceted potato will be surprisingly real.

Practicing on Potatoes to Cut "Brilliant" Facets

To cut a set of brilliant facets on a potato requires much more skill. A careful observance of the sequence in which the various facets are cut is essential, or the cutter will soon become confused, if not completely lost.

First cut the table. Then rough out the round form. Follow this with placing the girdle by cutting the potato to the shape of two cones with their bases together forming the girdle; the upper cone is left truncated by the table. Your potato is now ready for placing the facets.

How this is done on a real gem crystal is shown in Figure 53.

There are fifty-six of these facets to be cut correctly in their places upon the stone. They must be cut in their proper sequence — building up the gem from its foundation, so to speak. In Figures 54 to 58, there are forty carefully drawn diagrams that should be rigidly adhered to when cutting. In this way, the beginner will find his way through what at

Figure 53. Roughing-Out a Brilliant From a Crystal. A, the rough, partly broken crystal; B, placing the table on the crystal; C, shaping the blank; D, placing the girdle.

first will look like a impossible maze. The first attempt may not be entirely successful. After that first attempt, the effort will become more successful, and may even become amazingly easy. The cutter will soon learn to see in his mind the proper angles and lines even before they are cut — just as the solving of picture puzzles with hidden figures becomes easy after the eye once catches the concealed puzzle figures.

Cut the first crown main facet from the girdle to the crown (Figure 54-A). Then cut the opposite facet, which is the fifth, symmetrically in the same way (Figure 54-B). Follow this by the other two main facets, the third and the seventh, to make the table a square, surrounded now by four main facets on the crown (Figure 54-C-D).

By the method of cutting the facets in opposites, the lines forming at the table can be made parallel, which will result in a perfect octagon when the table is finished.

These four facets which are cut first, as outlined above, are sometimes also referred to as the bezel facets.

Proceed now to cut the other four facets at the corners of the bezel facets, as shown in Figure 54-E to H, to make the table an octagon. You now have cut the eight main facets of the crown.

The last four of the crown main facets are sometimes also referred to as the corner facets.

Thus far, the process has been quite simple. But now you will have to go more carefully. Begin placing the star facets by cutting down the eight points of the table so that eight new small triangular facets are produced surrounding the table. When finished, these facets give the appearance of an eight-pointed star in the center of the top of the stone.

The base of each triangle, or star facet, should consist of exactly one half of each pair main facets, while the apex of the triangle points downward toward the girdle but reaches only one third of the distance from the table to the girdle (Figure 55-A to H).

In cutting the star facets, be sure to reduce the angle which the facets make with the girdle. For instance, if you started by placing the crown main facets at approximately an angle of 36 degrees to the plane of the girdle, then place the star facets at approximately an angle of 34 or 33 degrees, or even less.

If you have cut this row of facets correctly without getting confused and making an error, you will have an octagonal table all sides of which are equal and all opposites of which are parallel (Figure 55-H).

This constitutes one half the number of facets which you are to place on the crown of your potato, not taking into consideration the table as a facet. You are to cut the sixteen crown break facets next. This is perhaps the most difficult row of facets to cut in a brilliant.

These break facets are small triangles placed side by side or, more appropriately, back to back, and slanting from the apex of the star facet down to the center point of the main facet on the girdle. The object is thereby to make a kite-shaped facet out of the main facet. The angle of the break facets with the plane of the girdle is increased above that of the main facet by about 2 or more degrees, so that the angles between the break facets and the girdle is approximately 39 or 40 degrees.

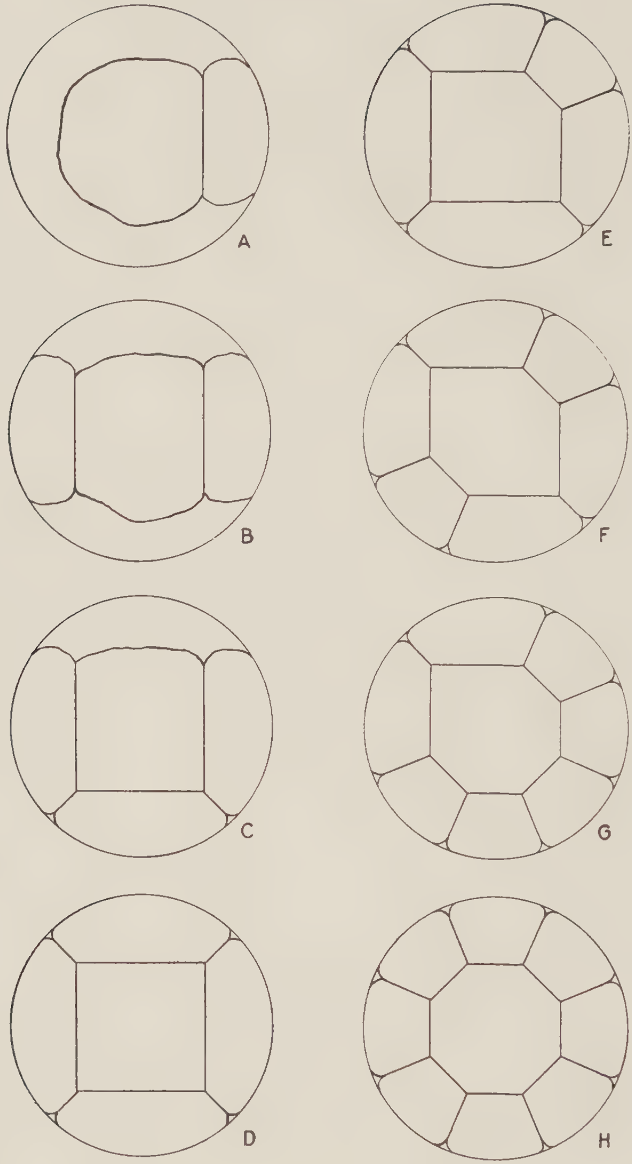


Figure 54. Cutting the Crown Main Facets of a Brilliant. A, first crown main facet; B, fifth crown main facet; C, third crown main facet; D, seventh crown main facet; E, eighth crown main facet; F, fourth crown main facet; G, second crown main facet; H, sixth crown main facet.

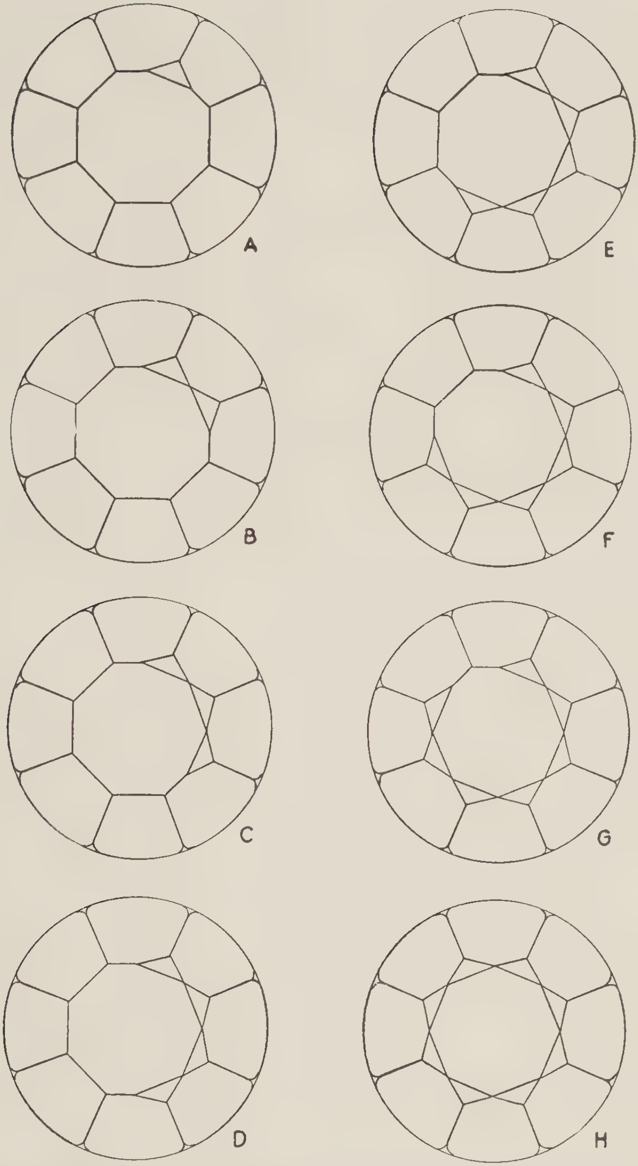


Figure 55. Cutting the Crown Star Facets of a Brilliant. A to H, the facets are cut in rotation in a clockwise direction, beginning with the upper right-hand corner.

Begin by shaving a thin triangular slice from each lower corner of the main facet, so that the main facet will assume the shape of a kite (Figure 56-A). Proceed thus with each main facet until all eight of them are completed (Figure 56-A to H).

The cutting of this row of sixteen facets is tricky and you may at first get lost as in a maze. If you are successful in one or two attempts, you are to be congratulated. If not, you will have to try again and keep on trying until you succeed. By repeatedly referring to Figures 54 to 56, you will eventually come out with a satisfactory set of facets.

You now have finished the crown of a brilliant and you are probably surprised how much simpler the job looks after it is done. Of course, you will need considerable practice before the job is perfect, or even anywhere near that state. Each time you go through the process, it will, fortunately, come easier and turn out better.

But the task is not done. Turn your potato over and start on the pavilion. The eight pavilion main facets are cut exactly as the crown main facets. The only difference is the absence of the table. The facets, instead of making an octagonal table, come to a sharp point (Figure 57-A to H). Then also the angles which the main facets make with the girdle plane are not 36 degrees but 41 or slightly more.

On the pavilion, no star facets are cut. So, after cutting the eight main facets, you proceed at once to cutting the pavilion break facets. This is done in the same manner as the crown break facets were cut. There is only one difference: The pavilion break facets can be made longer, even so long that they take up half of the distance between the girdle and the point at the pavilion. This will make of the main facets diamond-shaped figures instead of kites as on the crown. Opinion differs somewhat as to just how long the break facets should be, but from a third to a half will not be far wrong in any kind of stone (Figure 58).

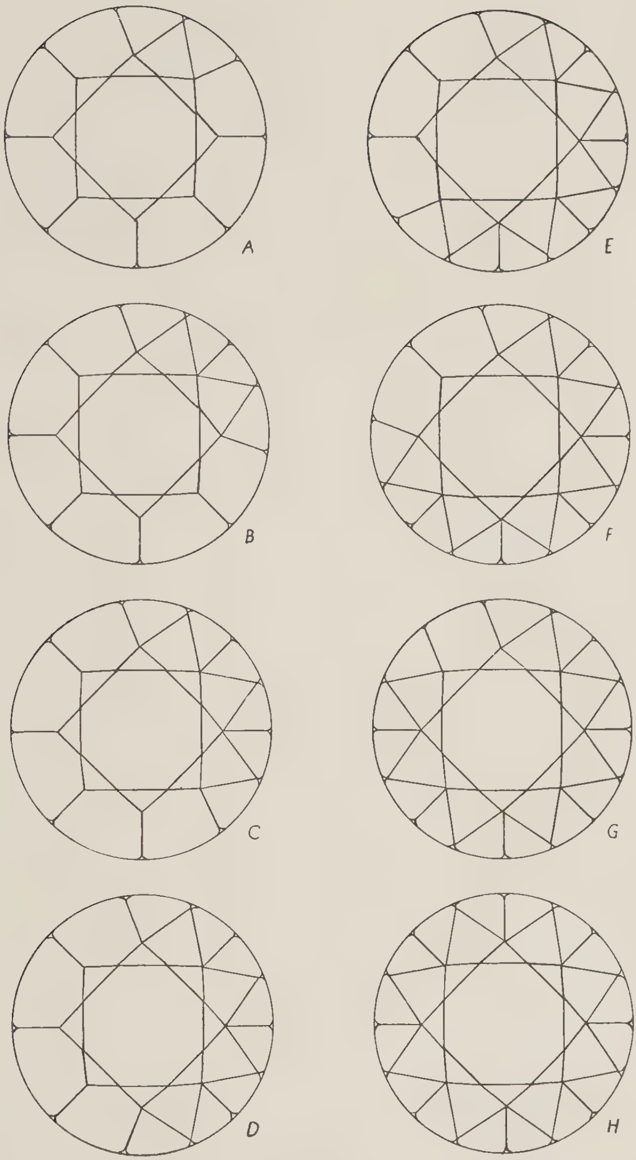


Figure 56. Cutting the Crown Break Facets of a Brilliant. A to H, two break facets are placed on the first main facet, converting it into the shape of a kite. This is continued all around the crown.

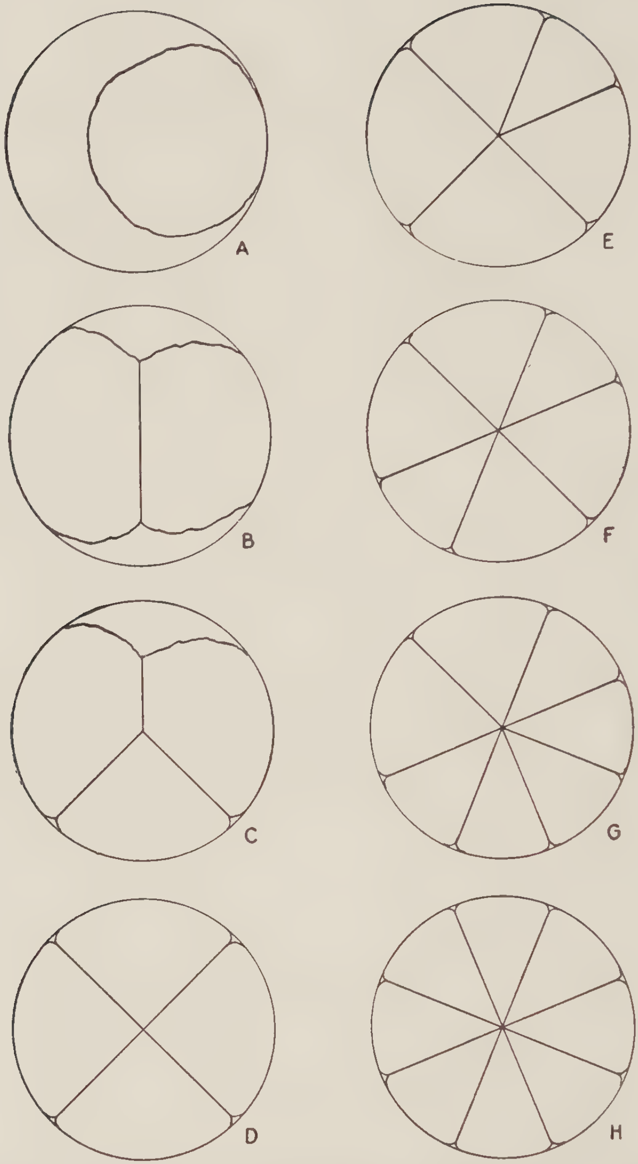


Figure 57. Cutting the Pavilion Main Facets of a Brilliant. A, cutting the first pavilion main facet; B, fifth pavilion main facet; C, third pavilion main facet; D, seventh pavilion main facet; E, eighth pavilion main facet; F, fourth pavilion main facet; G, second pavilion main facet; H, sixth pavilion main facet.

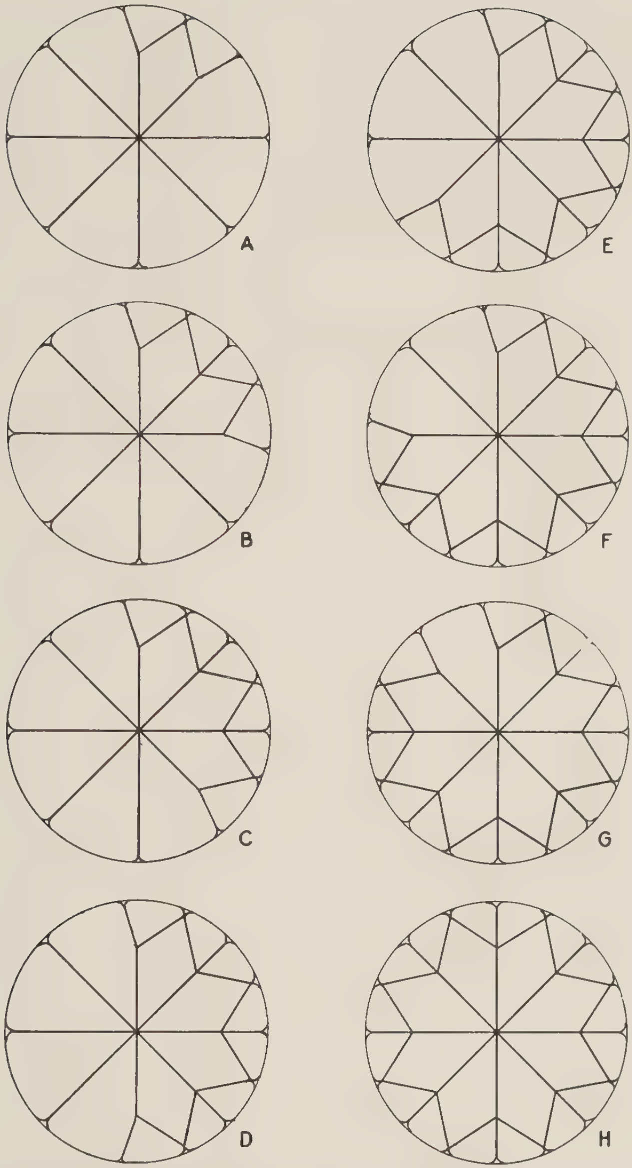


Figure 58. Cutting the Pavilion Break Facets of a Brilliant. A to H, two break facets are placed on the first main facet, converting it into the shape of a diamond. This is continued all around the pavilion.

The pavilion main facets should be carefully lined up with the crown main facets as accurately as possible. This is best done by cutting so close that the girdle is an exceedingly thin line or circle. A "knife-edge girdle" is the pride of every professional cutter. By running the facets both from the crown and the pavilion to such a narrow girdle, the facets can be accurately and easily matched. The reason for this, and the way it is done, is better discussed in a later chapter where the actual process of cutting the stone is dealt with.

You have now completed the two basic styles of cutting facets on potatoes. These styles are the standard rectangle step cut and the standard round brilliant cut. The rectangle has four facets to each row; the brilliant has eight or a multiple of eight.

Cutting the Elliptical Brilliant

There is one modification of the brilliant style that merits full description here. The reason for this is that this modification is especially appropriate for elliptical gem stones.

Elliptical stones do not lend themselves to rows of eight facets well. The sides of the ellipse would carry facets proportionately too large while the end facets would carry angles which would be too acute. The result of such cutting would be an unbalanced stone and a wavy and uneven girdle. By using ten facets to the row or, in larger stones, even twelve, a symmetrical, well-balanced gem results.

Elliptical stones are cut with ten facets to the row, or multiples of ten. To cut ten facets is slightly more difficult than to cut eight, because of the elongated form of the table. However, as in the standard round brilliant, each facet is parallel to the one exactly across the table on the other side of the stone.

As before, you should do preliminary cutting on potatoes so as to get familiar with the process. Start by cutting the flat surface for the table. Then rough out the elliptical form.

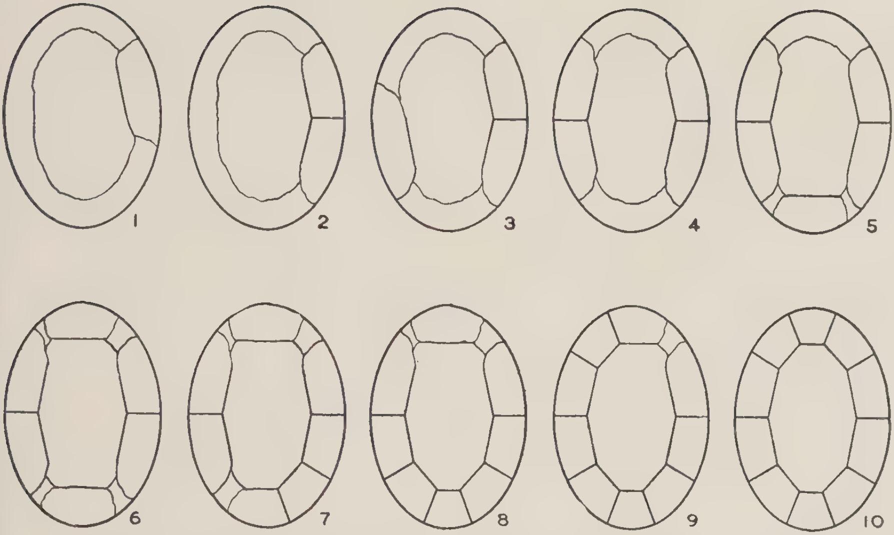


Figure 59. Cutting the Crown Main Facets of an Elliptical Brilliant. 1, first crown main facet; 2, second crown main facet; 3, sixth crown main facet; 4, seventh crown main facet; 5, fourth crown main facet; 6, ninth crown main facet; 7, third crown main facet; 8, fifth crown main facet; 9, eighth crown main facet; 10, tenth crown main facet.

Place the girdle by cutting a bevel away from the table. Likewise, cut a slope around the pavilion. To begin with, be sure to leave plenty of thickness for the girdle. Overcutting robs the stone of the extra material always needed for a margin of safety.

You are now ready to begin placing the first four facets — that is, the first, second, sixth, and seventh, the important ones on the sides of the stone. These four are considerably larger than the rest and are placed on the sides, meeting at the exact center of the side (Figure 59-1 to 4).

A minute discussion of the details of the cutting is not necessary if the reader has carefully studied the instructions for the standard round brilliant. By following the steps outlined in Figure 60-1 to 10, the process will be clearly understood.

CHAPTER XV

The Study of the Gem Crystal and Its Orientation for Cutting

THE PROCESS of cutting facets on a piece of gem material requires a number of steps which must be taken in their proper order. The raw material comes usually in the form of natural crystals, or in rough chunks or fragments which have been broken away from crystals. On such fragments there may be discernable one or more crystal faces which are important landmarks in laying out and orienting the gem. Often, however, no clue as to the original crystal form can be found.

Flaws and Imperfections in Gem Materials

A crystal of gem material requires study of all its parts under a good light in order to find the flaws and imperfections it contains. A good magnifying lens is also essential. A jeweler's loupe, or a spectacle loupe which can be snapped onto the ear piece of the spectacle frame, are excellent for the purpose. The magnification should be from four to ten times.

A glaring imperfection is often removed simply by sawing through it, making thereby two smaller stones out of a single larger one. Or, a flaw may be removed by grinding it away entirely in the process of cutting. Still another method is to cut the stone in such a manner that the flaw is placed near the girdle, or at least not directly beneath the table. This will hide the imperfection, making it blend more or less into the facets themselves so that it becomes less noticeable.

Flaws in a crystal of gem material consist of inclusions, cleavage cracks, prominent structure lines, feathers, and — rarely — bubbles.

INCLUSIONS. Many crystallized gem materials contain within their structure small crystals or masses of another mineral, much like a pebble is often frozen into a block of ice. When such inclusions add to the beauty of the gem, they are desirable. A case in point is the presence of rutile crystals in clear quartz, the rutilated quartz gem also called Venus' hairstone. When, however, an unsightly inclusion appears in a faceted gem, it detracts from its beauty as well as its value.

Inclusions are not limited to crystals of other minerals. The desirable as well as the undesirable animal and vegetable objects found in amber belong in this classification. Diamonds are notorious for carbon "spots."

CLEAVAGE CRACKS. Cleavage cracks are slight separations within the crystal, lying in the plane of the cleavage. From certain angles they may be exceedingly difficult to detect, while they become quite visible when the crystal is turned so that the light is reflected from the cleavage plane. Such cracks sometimes become enlarged during grinding.

STRUCTURE LINES. Structure lines, caused when crystals are formed, are said to be present in most gem materials, principally in corundum. They may be visible and even prominent in synthetic rubies and sapphires. By many gemologists, they are not considered flaws in the strict sense of the word. Associated with prominent structure lines, there may also be uneven distribution of color in the material.

FEATHERS. Minute cracks within the crystal may be short and feathery in appearance. They are referred to as feathers because of the resemblance. Feathers are quite easily detected, the larger ones with the naked eye, the smaller ones with the loupe.

BUBBLES. Small bubbles containing water are occasionally found in quartz crystals; quite rarely, gas bubbles.

Immersion Test for Flaws

Often a gem rough is so covered with irregularities or the surfaces are so "frosty" that the interior is not clearly visualized and the flaws are not detectable. Much help may often be gained by immersing the stone in a liquid which will render the interior clearer and easier to examine. A small white porcelain dish, found in every well-equipped chemical laboratory, is used. The stone should be completely covered and examined with a good lens, or, better still, under the microscope.

The effect of the liquid will be to render the stone more or less invisible, allowing the imperfections to stand out clearly against the white bottom of the dish.

The liquids used in this test are mineral oil, castor oil, cedarwood oil, clove oil, kerosene, glycerine, and Canada balsam. These various liquids have specific refractive indices and colors which approach those of many gem materials. The more nearly these two properties are matched with the same properties in the gem stone, the more clearly will flaws be shown when the gem is placed into the liquid.

"Opening a Stone" to Discover Flaws

Another method is to "open a stone" or to "cut a window" into it. This is done very simply by flattening a small spot in the most strategic area of the stone by holding it to the grinding wheel for a few moments, and then turning the stone around 180 degrees and holding it to the wheel again, to grind two small flats exactly opposite each other on the gem stone. These "windows" are then polished and the stone is "open." The interior will then be easier to examine and flaws may be quite easily discovered. If one set of windows is not enough to reveal the interior completely, another set may be placed elsewhere for better results. It is then often possible to make use of one window for the table of the gem by enlarging it.

Most gems need no further study or orientation than the outline above describes. However, certain stones require careful further study for other reasons than finding and eliminating flaws.

Cleavage in a Gem Material

Some gem materials have a distinct cleavage or grain. When cutting such a stone in a manner that allows the table to lie in the plane of the cleavage, the material may flake away and satisfactory cutting may not be possible. Again, by cutting such material with the table at right angles to the cleavage, the girdle is apt to chip and remain rough all around. Therefore such a stone should be cut with the table slightly more, or less, than 90 degrees from the cleavage. The best results call for an inclination of from 70 to 80 degrees of the table away from the cleavage or grain.

Among the gems which should be so treated are topaz, kunzite, hiddenite, and yellow spodumene.

In cutting a gem which is oriented along the lines just discussed above, there may appear during the polishing operation a facet which has been necessarily cut against the grain. Often such a facet will refuse to take a bright polish when its turn comes. The remedy is to undop the gem, turn it completely around, dop it again. The polishing wheel will then work on the gem the opposite way, or with the grain. A polish will then be acquired more easily.

Polarization

Tourmaline is a gem material which occurs in long triangular crystals. When the crystal is looked at from the side, it is clear and shows its color to fine advantage. But when one tries to look through the crystal from end to end, the crystal is much darker and may indeed be completely opaque. This is due to the fact that tourmaline polarizes the light passing through the long axis of the crystal, absorbing more or less completely the polarized rays. For this reason, the gem should be so oriented that the table is parallel, or very nearly so, to one of the three sides of the crystal. Having the table across the end of such a crystal will produce a gem which will suffer greatly in brilliance as well as in color.

Unequal Color Distribution

Many gem materials do not have their color distributed evenly throughout. Among these, the outstanding examples are amethyst and sapphire. A small lump of material may show a deeper color in a spot near one edge. If it is possible to orient the gem so that the best color will appear exactly at the culet, or the point of the pavilion, the color effect of the entire stone will be greatly heightened. The small spot of color at the tip of the pavilion will flood most of the rest of the gem.

Color vs. Brilliance

As mentioned in a previous chapter, all crystal gems can be cut to play up either their color or their brilliance. Usually it is customary to cut all clear or colorless stones for maximum brilliance. Those stones which have very light colors may well be cut the same way. Among these are the pale beryls — aquamarine, green beryl, pink beryl; also the quartz stones which carry faint colors — pale amethyst, smoky quartz just off the white, and light citrines. And there are others.

On the other hand, the stones of deeper colors are often cut to play up the color, even to the extent of completely sacrificing all life and brilliance in favor of purity of color in the finished gem. The emerald is the outstanding example of this class of gem.

To obtain maximum beauty from a gem, the rules of proper make, as discussed in a previous chapter, must be carefully followed. This refers especially to the proportions of the various dimensions to each other. The deeper the gem and the longer the pathway of the light ray in the substance of the gem stone, the more intense will be the color. At the same time, there will be life and sparkle from at least one of the rows of pavilion facets if not from all of them. Maximum life and sparkle are obtained when all of the pavilion facets return all of the light that enters the gem from above, back upward through the table. This is called total internal reflection.

Maximum purity of color, at the sacrifice of sparkle, is obtained by cutting the gem thin. This refers to making both the crown and the pavilion lesser in their dimensions, but still preserving the proper proportions between the two. The thinner the stone, the lighter and clearer the color.

There comes a point in this consideration when care must be taken not to have one row of pavilion facets too steep and the others too flat. If this happens, the result when looking down into the table will be a ring of brilliance around the girdle area and complete absence of any brilliance in the middle. This is an exaggeration of the "well" or the "hole in the middle" already described in a previous chapter. The most satisfactory method of cutting is to cut all facets according to the scientifically determined angles as shown in Table VI in Chapter XI.

Adequate time spent in the study and orientation of a valuable gem crystal before attempting to cut it will pay off in heavy dividends in the form of more flawless, more perfectly faceted gems, and far fewer "seconds."

CHAPTER XVI

Sawing and Roughing-Out the Gem Crystal for Facet Cutting

In Chapter IV, there has already been discussed in detail the process of sawing the rough chunk of gem material into suitable slabs, and these in turn into blanks, for cabochon gems. The same saws and the same methods can be used for sawing the crystal for facet cutting. By a crystal, in this sense, is meant any piece of clear gem material suitable for facet cutting whether it is a perfectly formed crystal in the natural state, or a chunk or fragment of such crystal, or a waterworn pebble.

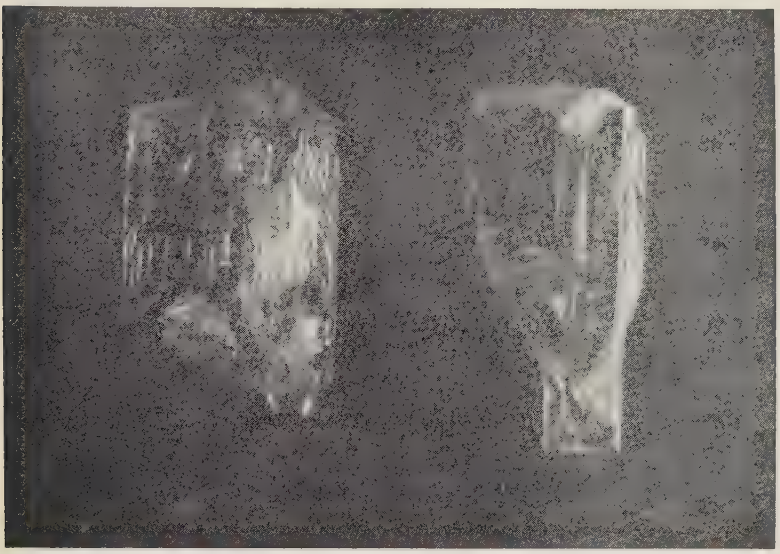
It is a fact that much of the precious rough crystal material is likely to come in rather small chunks or crystals. Such small pieces are not suitable for the large 12-inch saw and are thus usually sawed by the smaller cut-off saw. The smaller saw blade is thinner, and therefore the material wasted by the saw cut is less.

Some pieces will not need any sawing at all. They may be roughed-out directly from the original crystal.

Many crystals, especially those of the finer gems, are clear and smooth in the natural state. These may require only a single sawing to prepare them for cutting. It is a simple matter to mark such a rough at the exact place planned and then saw along the mark.

All valuable gem crystals should be carefully studied before sawing, even if they are clear and completely flawless, with a view of preserving as much as possible of the weight and size and obtaining as large a gem as can be made, keep-

A GROUP of twelve photographs showing rough, natural gem crystals, the operations by which they are cut into faceted stones, and a few representative gems from the author's collection.



Cut 1. Two Gem Crystals of Finest Quality. This photograph, taken with the aid of a polaroid filter, presents a somewhat dramatic view of two top-grade crystals of kunzite. These crystals, together with a number of others, were discovered in July, 1951, by Mr. George Ashley in one of his gem mines in San Diego County, California. They are the first known kunzite crystals of a rich and brilliant purple color. The usual colors of kunzite are exceptionally delicate and range from pink and lavender to lilac and rose shades. Mineralogically kunzite is spodumene, a lithium-aluminum silicate, which also comes in emerald green, called hiddenite, and in pale yellow and in colorless white. A few blue crystals have been found in Brazil.

The crystal on the left (above), weighs 170 carats, and measures 42 x 25 x 16 millimeters in its three greatest dimensions; the one on the right weighs 125 carats, and its dimensions are 48 x 23 x 16 millimeters.

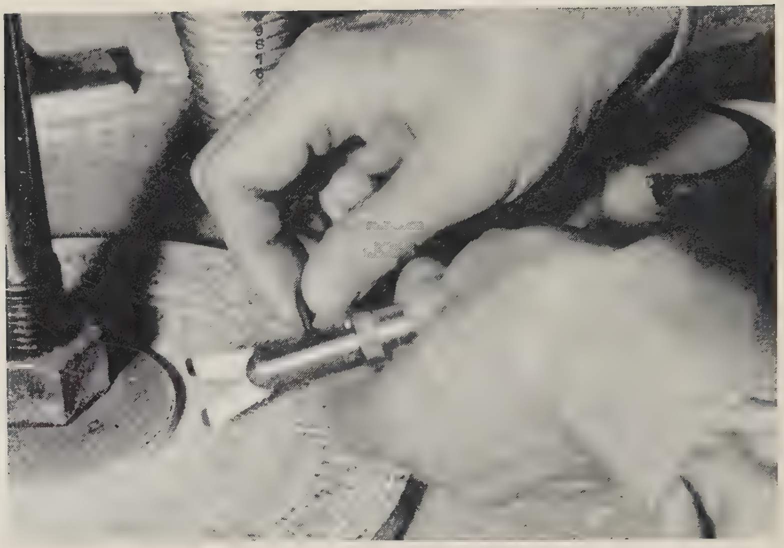
The lovely delicate colors of kunzite and its strong dichroism are so appealing to the gem lover that every cutter sooner or later wishes to attempt the task of cutting a gem out of a crystal. But it takes extensive experience and the most gentle handling to cut this material, because of the great possibility of splitting, due to its highly prismatic cleavage.

Cut 2. When cutting facets the table is the first facet to be cut, as shown here. The wheel is bell metal bronze impregnated with diamond dust.

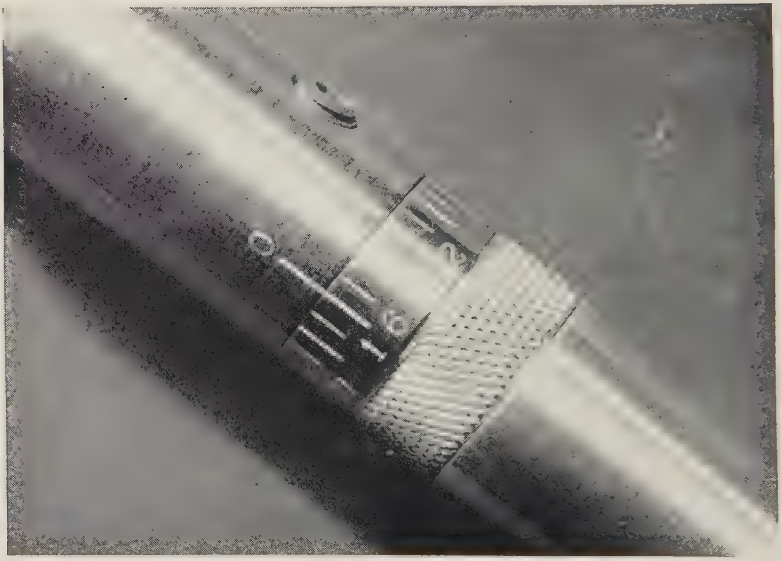
Cut 3. After the table is cut and polished, the stone is shaped and then dopped for cutting the remaining facets.

Cut 4. The dopped stone on the faceting device is next made "square" and reduced to its exact dimensions by placing the fishtail blades of the device on a horizontal base and cutting the girdle on the diamond lap to absolute "squareness."

Cut 5. This view shows the stone being polished on a pewter lap.

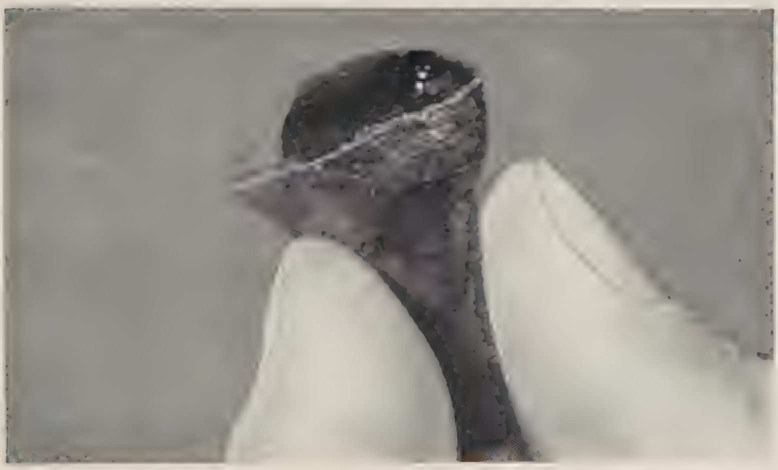


Cut 6. Resetting the scale on the device for the next facet.

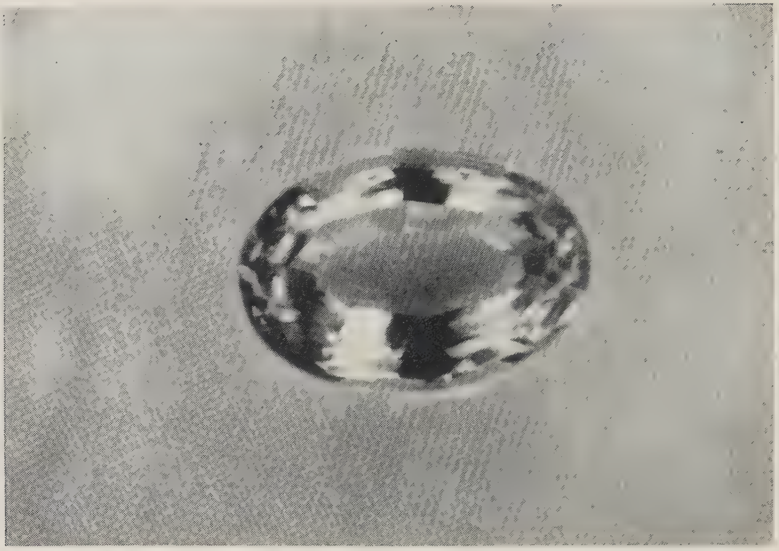


Cut 7. A close-up view of the scale of the faceting device. Scale rings are made in 30, 32, 36, and 48 divisions.

Cut 8. Inspecting the progress of polishing. Shown here is the correct manner of holding the device—the tips of the thumb and forefinger next to the stone, the other three on the device.



Cut 9. A close-up of the facets of the pavilion. The stone is turned in all directions and viewed from all angles to discover imperfections.



Cut 10. A large elliptical citrine of fine golden color and great brilliance. This combination of balanced brilliance and richness of color has been attained by cutting the crown in the brilliant style and the pavilion in the step-cut style. There are twelve facets in each tier or row around the stone. The table is 12-sided. The total number of facets is 105. The gem weighs 36.57 carats and its dimensions are 25 x 17 x 13 millimeters. A large and beautiful gem like this can be cut by almost any amateur after he has acquired a thorough familiarity with facet arrangement and some experience in both styles of faceting.

Cut 11. This view represents the "pay-off." The cutter has produced a group of gems—30 faceted and two cabochon—and is now inspecting, criticising, weighing, measuring, classifying, and evaluating them. Some will go into that collection reserved for the choicest; some into jewelry or a class for demonstration and instruction, and some, regretfully, into the discard.

This view shows the manner of holding and handling fine faceted stones by means of metal tweezers especially made for that purpose. The gem is kept clean of grease and dirt from the fingers, and can be turned to the examining light in all directions. The maximum beauty is thus revealed unobstructed.

Cut 12. A HANDFUL OF GEMS in all shapes and sizes, and variety and depth of colors. From the author's collection.

ing in mind always the proper make. No unnecessary waste should occur. Careful marking and subsequent sawing will often preserve an extra half carat for a fine stone and make it just that much more valuable.

Preforming the Facet-cut Gem

After sawing through a crystal, or cutting it into the pieces desired, the next step is to rough-out the stone. This process has already been completely described for cabochon gems in Chapter V. The same methods used for roughing-out cabochons are satisfactory for facet preforms. The same grinding heads and the same wheels will do quite well.

On the whole, the gems for faceting will be considerably smaller and far more delicate. Therefore it is often not wise to use the coarse silicon-carbide wheel at all, but do the entire roughing-out job on the finishing, or finer, wheel.

In roughing-out a crystal for faceting, it is important to remember that the finished gem will not have the same shape as a cabochon. The cab has a curved top and a flat surface for the back. The faceted gem has for its uppermost part the table, a flat surface, and for its lowermost part the point of the pavilion. The flat part of the facet-cut gem is thus not on the back but on the top. This must be remembered and proper allowances made when preforming the stone.

The usual method is to begin by grinding a flat surface at that spot on the rough where the table is to be placed. This is done by holding the rough against the side of the grinding wheel. By using the side of the wheel instead of the periphery, the grinding will be much smoother and gentler. Also, it will take more time.

After the table has been placed, the crystal is ground in the usual way to give it the outline already decided upon. This may be round, rectangular, oval, or any one of several other shapes.

Next, the position of the girdle is determined. It must be

Plate V. At work on the cut-off saw dividing a valuable gem crystal.

decided how much thickness is to be allowed for the crown and how much for the pavilion. The crown portion is then beveled down somewhat, leaving plenty of material intact so that later the table will not turn out to be too small. It is important right at this point that the cutting is not overdone. An overcut stone does not allow rough material for adequate flattening and polishing of the facets later on.

Likewise, the pavilion is beveled down somewhat in the same way as described for the crown (Figure 62-A-B-C).

Two things have now been accomplished: The crystal

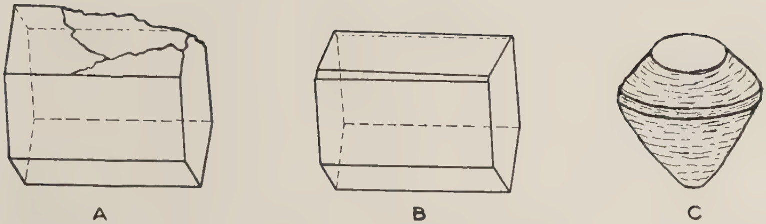


Figure 62. Preforming a Crystal For Facet Cutting. A, a rough, partly broken crystal; B, cutting the table aslant to the crystal face; C, shaping the stone.

has been roughed-out, and the first facet, the table, has been cut. But the process is not yet complete.

Polishing the Table

Before the roughing-out job is finished, the table should be polished. This, as well as the preceding work, is done by hand, without mounting the stone on a dop.

Polishing the table at once after preforming the gem gives the opportunity of opening up the stone to have another last scrutiny for flaws inside the crystal. Should any flaw be found, there is still time to deal with it by grinding it away entirely or by altering the size or the shape of the gem so that the flaw can either be eliminated or hidden as already discussed in detail in a previous chapter.

The manner of polishing the table will not be further discussed here, as it rightfully belongs to the chapter on polishing.

Some cutters, of course, do not polish the table at this point but perform that process later, after the facets have all been cut and just before polishing them. The matter is optional with the individual cutter. The method this author uses has prevented many a disappointment which comes when a bad flaw turns up suddenly and unexpectedly either immediately after polishing the table or after about half the facets have been cut. Another cause for disaster is the fact that the large facet, the table, contains the largest and longest and deepest cutting lines or scratches. It takes considerable material away from the table when these are polished out. The star facets, if they are already cut, will then lose a large portion of their size and may even have to be cut over again. For these reasons, the table should be polished first, before any of the other facets are cut.

DON'TS FOR SAWING AND ROUGHING-OUT THE GEM CRYSTAL

(1) Don't forget to study the crystal piece and to orient it according to its requirements before you saw it.

(2) Don't forget that more than half the flaws in gem stones can be eliminated by clever use of the saw.

(3) Don't saw the precious crystal material on a large saw which has a heavy gauge blade; it is too wasteful to saw away a thick layer.

(4) Don't be in a hurry to cut up a particularly fine piece. If in doubt, study it again — and again. Better ideas may come to your mind.

(5) Don't cut until you have a clear and complete picture in your mind what the finished gem will be like. Do as the architect does in his line.

CHAPTER XVII

The Traditional and the Modern Dopping and Holding Devices

THE GEM CRYSTAL has been preformed in preparation for cutting the facets. This preformed gem must be mounted on a dop stick or holding device so that the facets can be cut accurately. Devices for holding are generally referred to as faceting devices or faceting heads.

A study of the foregoing chapters has clearly demonstrated the marked differences which exist between the rather simple procedure of cutting a gem cabochon style and the highly skilled art of cutting facets. In the former, the gem is dopped for the purpose of more easily rounding the crown by constantly turning and rotating it against the wheels; but in the latter the problem is practically the reverse — the dopping is for the purpose of holding the gem perfectly steady against the cutting and polishing wheels. As a consequence, the devices used for dopping the facet-cut stone must be adapted to this requirement.

Types of Dopping and Holding Devices

The devices used for dopping and holding the gem stone for facet cutting range from the simple dop stick used for many generations past to the more complicated modern instruments which make the job of cutting a matter of setting the device according to a scale and allowing the cutting to proceed more or less automatically.

With such a modern mechanical device, almost no individual skill is needed — the instrument does the work. Certain standard cuts can be made with almost machinelike precision, and the beginner, the amateur, and the professional alike can perform first-class facet cutting on round stones, four-sided stones, and eight-sided stones.

It is not possible, however, to cut many of the more elaborate forms, such as ellipses, triangles, hexagons, pear shapes, and many others. The usual instrument is so constructed that it has 32 notches around the circle, the distances between them being equal. Not more than 32 positions, or angles, can be cut. There is no opportunity to vary the angles from those 32 divisions on the instrument.

With the older jamb-peg method, using a simple wooden dop stick, any conceivable angle can be given to the facet, and, therefore, any conceivable shape of stone can be cut. But this simpler, older device requires far greater skill than the newer mechanical devices.

The Dop Stick and Jamb Peg Method

The method used for many generations and handed down from master to apprentice requires two remarkably simple wooden implements: (1) the dop stick (Figure 63), and (2) the jamb peg (Figure 64).

The dop stick is made preferably of boxwood. Cherrywood is also used. Boxwood is compact, hard, and evenly grained. This makes it easy for the cutter to feel in his fingers the tiny vibrations produced by the cutting and transmitted by the cutting wheel to the stone.

This is exceedingly important. By the sense of touch, these vibrations will tell the cutter how the cutting is progressing. He will learn by experience to tell from the "feel" when the cutting goes rapidly or slowly; he will know if the facet lies perfectly flat on the wheel or if it is slightly off.

When a facet is not flat on the wheel but tilts over on one of its edges or corners, the cutting will immediately go askew and the facet is spoiled. Often one spoiled facet spoils

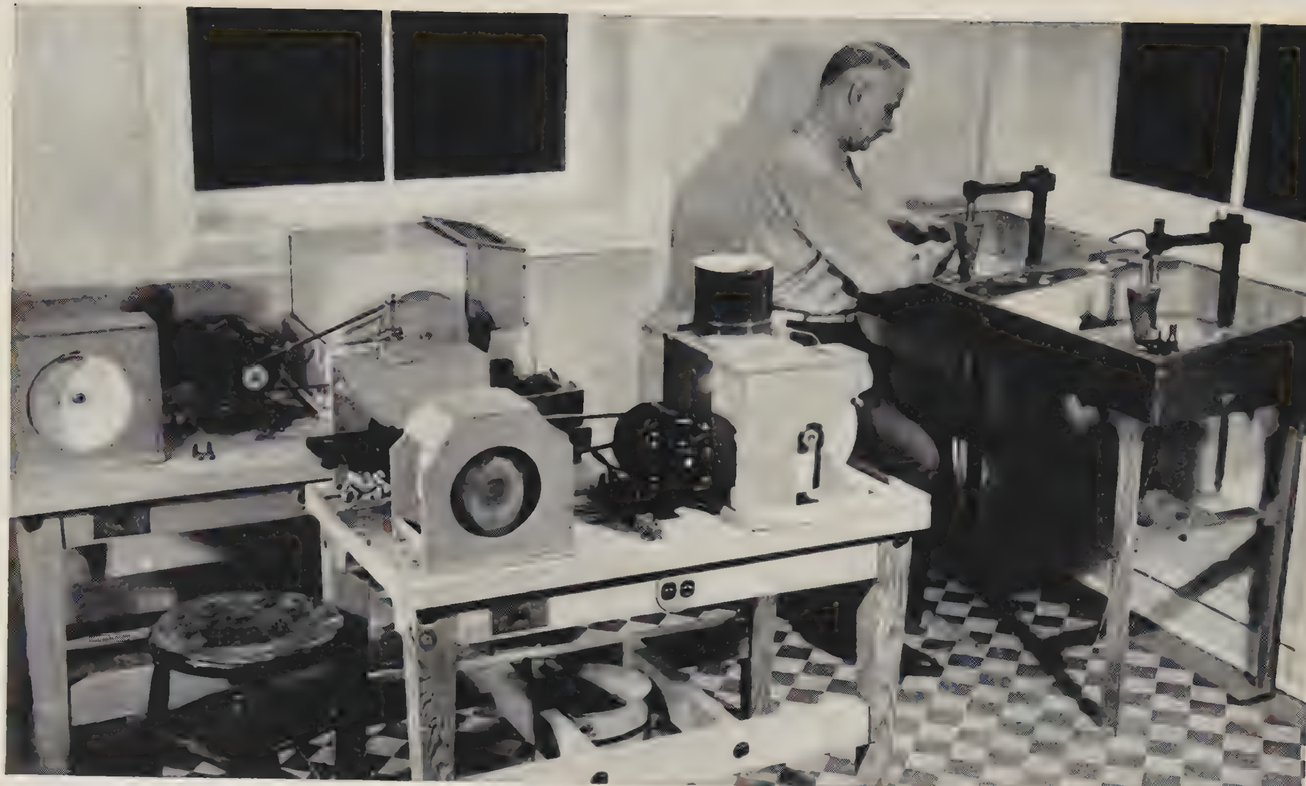


Plate VI. At work on the faceting bench. At left are the two work tables with the equipment shown in Plates I to IV.

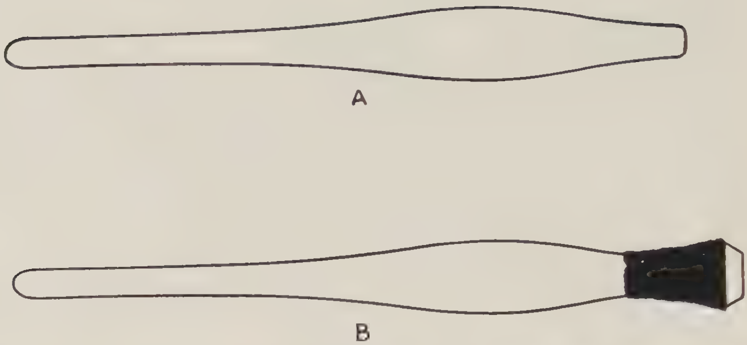


Figure 63. The Dop Stick For Facet Cutting. A, simple stick, made of boxwood and shaped to fit the hand; B, stick with properly mounted, preformed gem.

the entire group of facets and the process of cutting must begin all over again.

The most delicate sense of touch is gradually developed by the artistic cutter as he becomes more and more adept at holding the gem stone perfectly flat upon the wheel by means of the dop stick.

The dop stick is 4¾ inches long; ⅜ inch in diameter at the lower, rounded tip; ¼ inch in diameter at the upper, squared end; and ½ inch in diameter at the bulge or belly.

The thickest part of the bulge is placed 3¾ inches from the longer, thinner end (Figure 63).

A dop stick of this size and shape fits naturally into the cutter's hand for proper holding. This will be discussed more fully in the chapter dealing with the technique of facet cutting.

The jamb peg is made of hardwood, such as maple or walnut. The best pegs are made out of broken or discarded bowling pins. They will not expand or split, as pegs sometimes do when they get soaked and dried out alternately (Figure 64).

Jamb pegs are turned down on a lathe to the proper dimensions, and then shallow holes or notches are sunk into

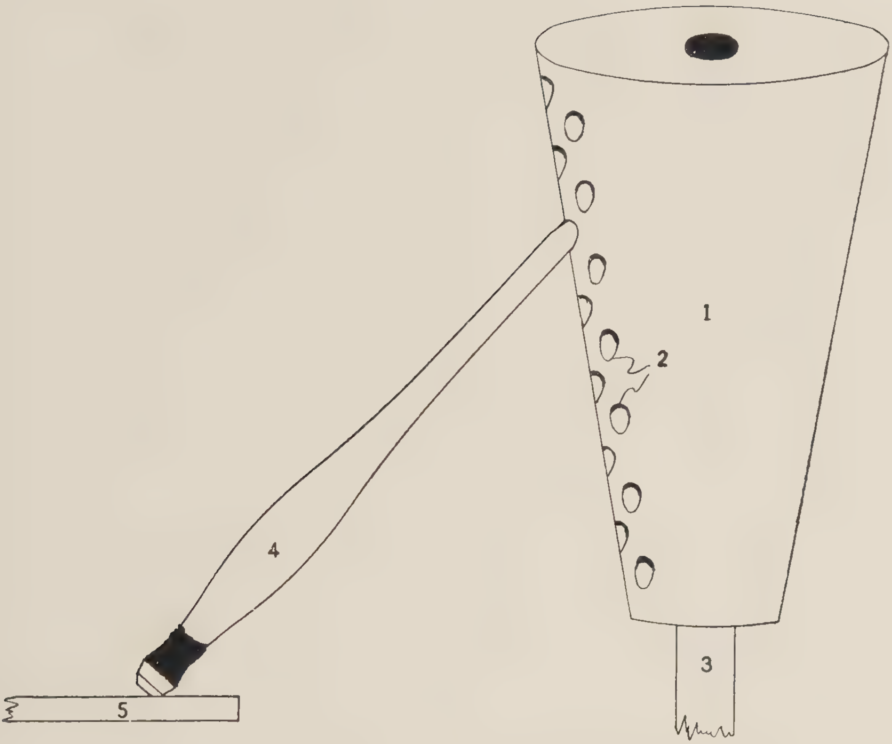


Figure 64. The Jamb Peg For Facet Cutting. 1, jamb peg; 2, holes for insertion of stick; 3, stand rod; 4, dop stick with mounted stone; 5, cutting wheel.

the entire length. These holes are ¼ inch in diameter and about ¼ inch deep. They are burned into the wood by means of a red-hot iron rod. The business end of the rod should be smoothly rounded so as to produce a smooth, rounded hole. This will allow for proper seating of the rounded end of the dop stick.

The holes in the jam peg are staggered but kept rather closely grouped together. The vertical distance from the center of one hole to the next should not be more than ¼ inch.

When burning the holes, the iron rod must be carefully directed into the wooden jamb peg in the correct way. At the lower, smaller end of the jamb peg, the rod is directed almost crosswise to the center axis of the peg. At the upper, wider end, the direction is almost parallel to the axis. In this way, the holes will have the same direction as when the dop stick is in the cutting position. For more clarity, the student should study Figure 64.

Through the mid axis of the jamb peg a hole is drilled to accommodate the stand rod by which it is mounted on the cutting bench. The hole may be ⅝ inch in diameter, but in no case should it be less than ½ inch. The jamb peg must stand rigidly firm. Facets will not be flat when the jamb peg can be forced over out of true by hard pressure against it during the cutting.

The jamb peg is conical in shape. The large end is 3 inches in diameter; the small end, 1¼ inches. The length is 5 inches. It is mounted vertically with the small end down, just above the level of the cutting wheel and close to its periphery.

The use of the dop stick and jamb peg requires long training and advanced skill. After all, it is this method that professional cutters have learned the long and hard way, and have jealously guarded for centuries. It has been handed down from father to son, or carefully taught by master to apprentice.

To the beginner and the amateur, this method is not recommended. He should use the mechanical method until, by gradually acquired technical skill, infinite patience, a steady hand, an accurate eye, and sheer tenacity of purpose, he can graduate to the dop-stick method of the professional.

The Mechanical Index Method

This is a modern method which is used widely by amateurs and by some professionals. The mechanical device works practically automatically and what skill is essential is acquired quite readily.

Mechanical faceting heads of this type are obtainable from dealers in lapidary equipment. They are also sometimes called facetors or gem makers.

Some of these devices are quite simply constructed, while others are large and complicated. They all have in common the basic principle of the index and vernier. Both of these are marked off into divisions so that the cutter can set the device according to the scales — and then the cutting proceeds. The machine holds the gem stone at the set angles and the cutter needs little or no skill.

From a flat circular base rises a stand rod. The base is screwed or bolted to the top of the cutting table, or bench, close to the horizontal cutting wheel.

The stand rod carries a crosshead which slides up and down on the rod, so that it can be firmly fixed at any height by means of a setscrew. The height of the crosshead determines the angle which the facets will make with the girdle of the gem stone.

The crosshead carries the dop stick, which is attached by a simple hinge device. The stick is of metal and carries at its upper end an index wheel with 32 notches equally spaced all around the wheel. A spring-steel locking device falls into the notches holding the dop stick in any one of the thirty-two positions. The notches thus determine the number of facets that can be cut in one row around the gem stone.

Attached to the dop stick as an extension of the hinge is a vernier scale which shows the angles of inclination at which the cutting is to be done. The scale is set indirectly by raising or lowering the crosshead on the stand rod (Figure 65).

This faceting device will cut four, eight, sixteen or thirty-two facets to each horizontal row around the gem. It will not cut three, six, ten, twelve or twenty; or any odd number. That is the great disadvantage of this type of device.

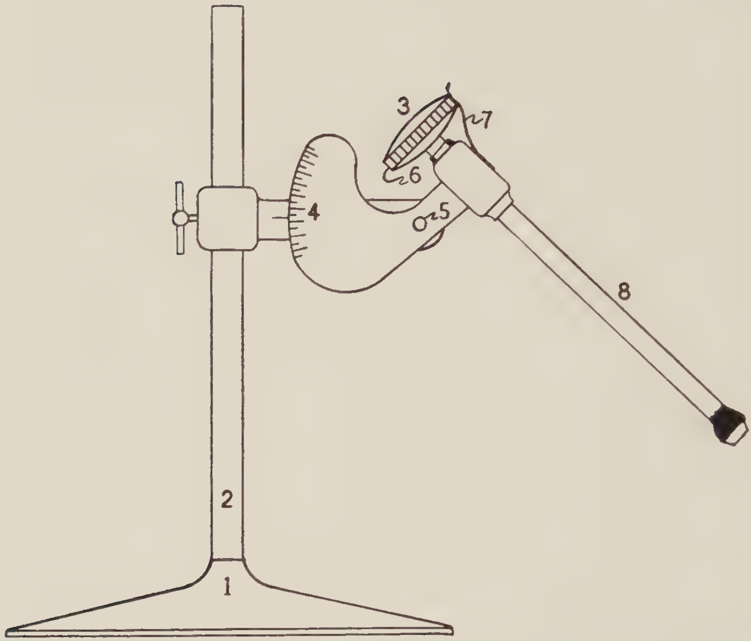


Figure 65. Mechanical Dopping and Holding Device For Facet Cutting. 1, base; 2, stand rod; 3, notched wheel; 4, vernier scale; 5, hinge; 6, index scale; 7, locking spring; 8, dop stick.

By the use of this apparatus the beginner should have practically no trouble cutting facets from the start. He will, of course, have to be thoroughly familiar with the arrangement of the facets, their vertical angles of inclination from the girdle, and their horizontal angles of rotation around the central axis of the gem stones. Without this knowledge, he cannot properly set the two scales on the device.

CHAPTER XVIII

The Willems Faceting Device

THE DIFFICULTIES inherent in the use of the professional wooden dop stick of ancient design, and the limitations of the modern faceting heads described in the previous chapter, led this author to invent a simplified device which combines the basic principles of the two and has none of the limitations. It carries the name "Willems Faceting Device" and is obtainable from The Gem Exchange, Bayfield, Colorado.

This device is adaptable to any standard lapidary machine with horizontal cutting wheel. It consists of (1) a conical jamb peg (which is furnished with grooves instead of holes) and (2) a dop stick assembly of metal (Figure 66-A-B).

The Jamb Peg

The jamb peg is the regulation professional peg. It is 5 inches in length, 3 inches in diameter at the upper, larger end, and 1¼ inches in diameter at the lower, smaller end.

Preferably, the wood is maple; maple is sufficiently hard and close grained. It stands up well under long use. There is also the distinct advantage that the figures identifying the grooves stand out boldly black against the light wood. These figures are sunk into the wood with dies and then blackened.

There are eighteen grooves cut all around the jamb peg ¼ inch apart. These are cut at precise angles. The upper lip of the groove is horizontal so that the fishtail of the device will have a level surface to rest against while cutting. The lower lip is considerably wider and slants downward at an angle of about 60 degrees.

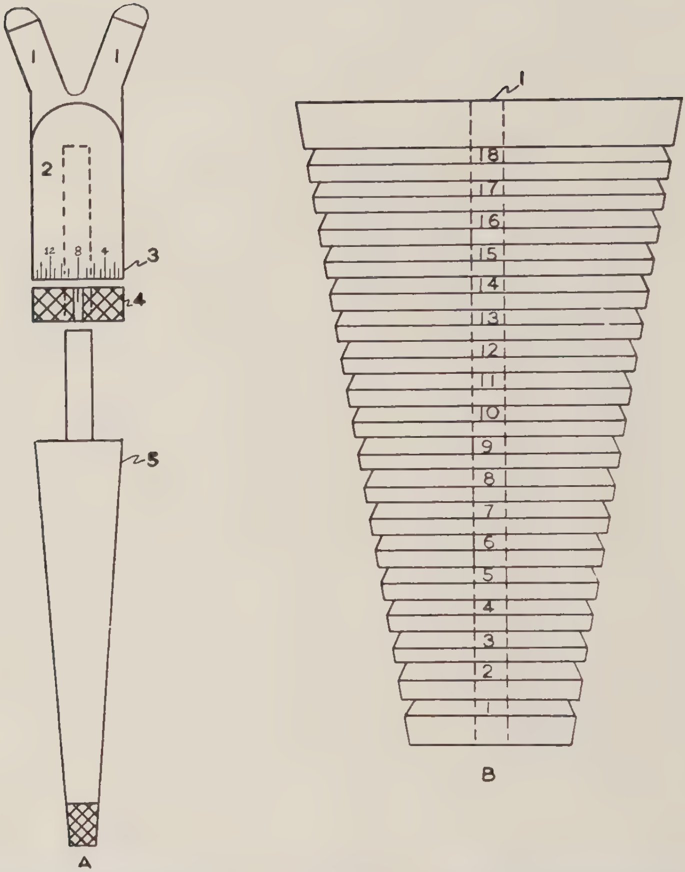


Figure 66. The Willems Faceting Device. A, faceting device disassembled; 1, fishtail blades; 2, handpiece; 3, index scale; 4, correction ring; 5, adapter. B, jamb peg; 1, center hole.

The center hole running the full length of the peg is a half inch in diameter.

As a last treatment, the jamb peg is dipped into shellac to fill the pores. This helps to prevent swelling, buckling, and splitting and gives the peg many years of usability.

The Faceting Device

The Willems faceting device consists of an assembly of

PLATE VII. The Willems faceting device.

three separate parts: (1) the handpiece with its fishtail, (2) the correction ring, and (3) the adapter (Figure 66-A).

When assembled properly, the device has the general form and size of the ancient wooden dop stick and is, in fact, used almost exactly in the same way (Figure 67-A-B-C).

The handpiece. The handpiece consists of a short rod of steel 1⅜ inches long and ⅝ inch in diameter. The upper end is rounded like a dome into which there is attached the fishtail, ⅞ inch long and spreading to a width of 1 inch. The fishtail terminates in two blades, or thinned-out sharp edges, which engage the grooves in the jamb peg during the process of cutting. The blades are turned down slightly for better seating into the grooves.

The lower end of the handpiece is squared across and is given an accurate scale of thirty-two divisions. The placement of this scale with a high degree of accuracy around the handpiece is the most difficult process in the manufacture of the device. It requires the work of an expert machinist (Figure 66-A).

A small, countersunk setscrew on the side of the handpiece serves for attaching the adapter.

The correction ring. The correction ring is made of steel, ⅝ inch in diameter and ¼ inch wide. The surface is knurled to make it easy to handle. The ring fits accurately between the two other parts and is marked for lining it up accurately with the scale on the handpiece. There is also a small, sunken setscrew to set it to the adapter.

The correction ring is used only for zero-ing the facets on the crown and the pavilion, making it easy to line up the facets exactly above and below the girdle (Figure 66-A. Also Figure 67-A-B-C).

Zero-ing with the Correction Ring

For the uninitiated, this process of zero-ing needs further explanation. For the purpose of this description, it will be

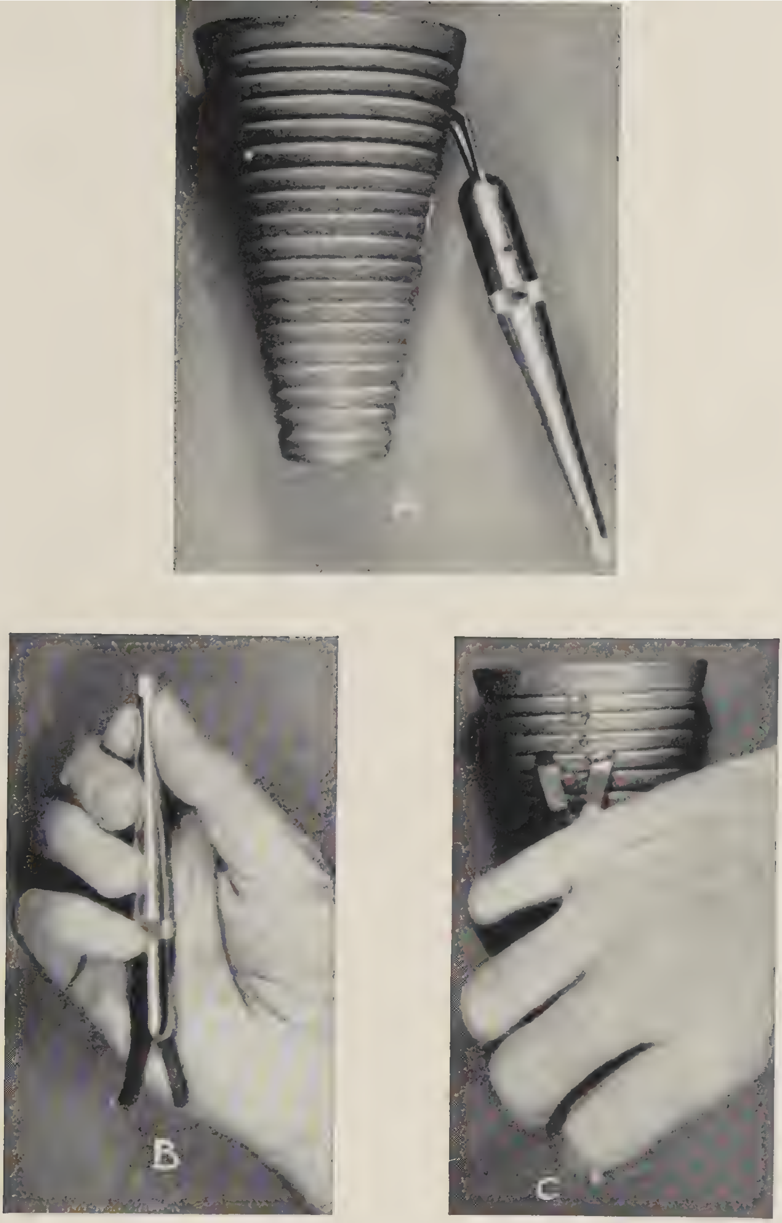


Figure 67. The Correct Position of the Willems Faceting Device, and Jamb Peg. A, blades of device inserted into groove of jamb peg; B, correct manner of grasping, with all finger tips in contact with the device; C, correct position when cutting.

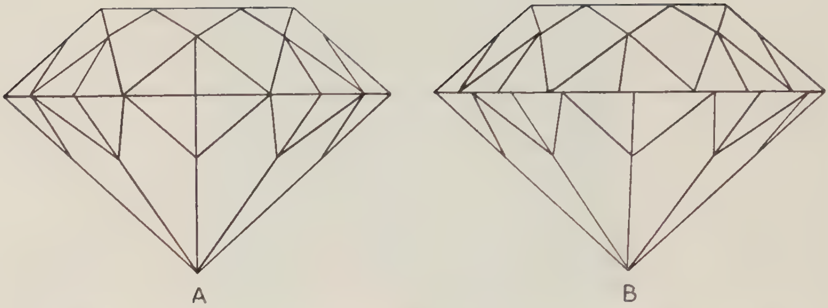


Figure 68. Lining Up the Pavilion Facets With the Crown Facets. A, facets accurately lined up above and below the girdle; B, facets improperly placed, not lined up.

assumed that the cutter is working on a standard brilliant and that he has finished cutting and polishing the thirty-three facets in the crown. The gem must then be removed from the adapter, turned over, crown down, and redopped with the pavilion up. The cutting of the eight pavilion main facets is the next procedure. These eight facets must line up exactly with the main facets of the crown. Failure to accomplish this will result in the loss of much life and sparkle in the finished gem (Figure 68-A-B).

This lining up process is difficult. Here is where the correction ring comes in. Without the ring, the cutter would be obliged to redop the gem squarely across the mark on the adapter. The human eye is hardly accurate enough to accomplish this. There seems always to be a slight discrepancy. And then, because the dopping is slightly off, the correction must be allowed for by subtracting the correct amount from the scale at each resetting for a new facet. In other words, the mark on the adapter cannot be set with 100 per cent exactitude on zero (or any other division) but a fraction of a division will have to be subtracted each time the adapter is rotated for a new facet. For complete understanding, of course, one must use the instrument, since it was not made just to be read about.

The correction ring makes this subtraction to the zero mark necessary only on the first facet to be cut on the pavilion. It is then tightened down on the adapter. It is now zeroed. No further corrections are necessary. The marks will always be in line.

The Adapter

The adapter is really the dop stick. It is made of aluminum to keep the device as light as possible. The lighter the device the more nearly it will approximate the boxwood dop stick.

The adapter is 3 1/8 inches long. At the upper end where it rests against the correction ring, the diameter is 5/8 inch. It tapers down to 3/8 inch in diameter at the tip. Another size of adapter, used for smaller gem stones, tapers to 3/16 inch. By means of these two sizes, gem stones from one carat to 50 carats, and even larger, can be accommodated.

At the upper end, the adapter carries a steel pin which goes through the correction ring and is inserted into the handpiece, where it is fixed by the setscrew.

At the lower end, the tip, the adapter is deeply etched with heavy knurling. This aids in making the dopping cement adhere adequately.

It should be apparent to the reader that the Willems faceting device is used in the same way as the professional boxwood stick is used. There is the same jamb peg — it has grooves instead of holes. There is the same dop stick — to it is added an index scale by means of which the horizontal angles of rotation of the facets can be accurately placed; and the fishtail fitting against the upper lip of the groove makes it a simple matter to keep the facets in line, which otherwise is the most difficult part of facet cutting.

CHAPTER XIX

The Technique of Dopping for Cutting Facets

In Chapter XVI, the technique of sawing and roughing-out the gem crystal was carried out. The gem stone is now in the preformed facet stage. The next step is to dop the stone for the purpose of cutting.

In the two foregoing chapters, three different methods of dopping and holding the stone have been described. In all three of them, the actual method of affixing the stone to the dop stick is essentially the same. Furthermore, it is the same basic method that is described in an early chapter for dopping cabochon gem stones. A few points of additional information and of caution should be added.

The preformed gem is warmed over an alcohol flame, the end of the dop stick is prepared with a mass of warm, soft dopping cement, and the stone is placed on the cement. The stone is then pressed into the mass so that it rests firmly against the end of the dop stick. Next, the cement is worked with the fingers smoothly around the pavilion up to the girdle.

It is important to have the gem true, the table exactly at right angles to the long axis of the dop stick. Otherwise, the facets will come out atilt and uneven.

When using one of the mechanical faceting heads, dopping is done in the same way. A removable rod is disconnected and used as the dop stick. The rod is then replaced with the dopped gem stone in position.

The Willems faceting device uses aluminum in the adapter which serves as the dop stick. The adapter is tapered toward the business end. This combination, taper and aluminum, makes it a little difficult to make the dopping cement adhere promptly.

When the cement is first applied to the adapter, the metal and the cement should be heated to the same temperature. The cement should be soft but not quite dripping. In this condition, the cement should be rolled on the rolling block (as described in Chapter VI) with firm pressure so that the knurling on the adapter will take a firm hold on the cement. Once a good mass of cement is made to adhere tenaciously, no more trouble will be encountered.

After dopping, the adapter should be stood upright for cooling. The dopping is then complete and the gem is ready for cutting.

DON'TS FOR DOPPING PREFORMED FACET GEMS

(1) Don't forget that it takes a considerably larger mass of cement to hold the facet gem than a cabochon gem.

(2) Don't forget that cement does not adhere readily to cold metal; the metal must be well heated when the cement is first applied.

(3) Don't fail to dop gems for facet cutting true.

(4) Don't depend on your eye for truing the gem on the dop unless you are exceptionally accurate; use a small square for truing.

(5) Don't burn your fingers with cement that is too hot; keep the fingers wet when working the cement.

CHAPTER XX

The Technique of Facet Cutting

FACET CUTTING LAPS. Faceting gem stones is done on a horizontal-running wheel. Such a wheel is called a lap. A lap is a wheel or disc of metal, wood, or other substance which is charged with cutting powder or polishing powder. In the diamond-cutting industry, the wheel is slightly different and is referred to as a skeif. Laps are made of various metals. Skeifs are made of a porous cast iron. The best skeifs are made in Belgium of a special grade of iron. Skeifs are not used by lapidaries, only by diamond cutters.

Some gem cutters prefer a lap of cast iron similar to a skeif, and then apply diamond dust or some other cutting powder to the wheel with a small brush. The powder is first mixed with olive oil to give it a pastelike consistency. But the professional lap is not usually made of iron, and the diamond powder is imbedded in the metal more or less permanently by "charging" the wheel. This gives excellent results and has the advantage that it cuts fast. A well-made, true-running, properly charged lap will last for many years and will need no attention except periodic recharging. A little later in this chapter, the various laps will be more fully discussed.

The gem stone has now been roughed-out and dopped on a Willems faceting device, or on one of the two other devices — the mechanical faceting head or the professional boxwood dop stick. The stone has been carefully centered on the end of the dop and the table placed at right angles to the long axis of the stick.

PLATE VIII. Cutting facets.

Proper Way of Holding the Professional Wooden Dop Stick

The manner of holding the stick is important. For a wheel running clockwise, the right hand is used for the operation of cutting. Perhaps this should be stated the other way around — for a right-handed cutter, the wheel should be running clockwise. Essentially the operation consists of holding the dopped gem to the revolving wheel at the proper angles so that the facets are produced by the action of the lap.

The dop stick is taken in the right hand by grasping the business end of the stick between the tips of the index finger and thumb. The other three fingers are then placed over the

PLATE IX. Detail of Plate VIII.

belly of the stick. The pointed end of the stick is allowed to emerge from the partly closed palm near the base of the small finger. Thus the stick lies diagonally across the palm and all five finger tips are in contact with it (Figure 67-B, p. 161).

Everything in this description of the stick and jamb-peg method applies equally well to the Willems faceting device.

Vibrations from the cutting or polishing process are transmitted to the fingertips, especially those of the index and thumb. These vibrations, even if ever so minute, are a guide to the cutter. Experience will soon teach him that when a facet does not lie perfectly flat upon the wheel the vibrations transmitted to the fingers convey the information to him at once. The stick must be held firmly and the pressure against the lap must be even and steady.

Cutting the First Facet of a Brilliant

The hand holding the stick as described above is now turned palm down, the pointed end of the stick is inserted into the proper hole in the jamb peg, and the stone is brought down upon the revolving wheel. The palm of the hand is down and the elbow extends to the right (Figure 67-C). The right hand is now in position for the cutting to begin.

When the gem stone is held to the diamond lap in this way, a small flat surface appears at once on the stone at the point of cutting. This is the new facet. The cutter lifts the stick from the cutting position every few seconds, turning the palm upward for inspection of the newly forming facet. Not being finished, or not having quite the right angle, the dop stick is replaced and the facet is brought down upon the lap for more cutting or for correction of the cut already started.

Right here it becomes apparent to the cutter that the greatest skill is essential to place that tiny facet back upon the revolving lap in exactly the same positon that it was in when he lifted it off for inspection. Should he replace the stone so that the facet touches at one edge only, instead of the whole surface of the entire facet falling accurately upon the lap, then the cut will immediately go off to one side. This always spoils that particular facet, and that is frequently enough to ruin the entire gem. To say the least, the facet will lose its table flatness.

For a facet cutter to produce facets which are not perfectly flat is considered unpardonable. Worse than that, cutting offside or cutting facets that have a bulge interferes with the ability of the gem to reflect the light properly, and a second-rate gem is the result where a first-class stone should be possible. Therefore the requirement — all facets must be perfectly flat.

It is thus clear that there are certain rules for the facet cutter to adhere to in order to produce flat facets with the

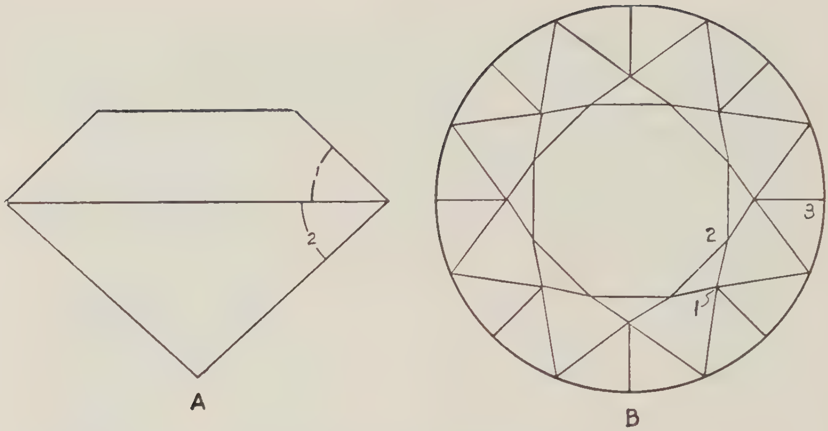


Figure 69. The Angles of Inclination and of Rotation of the Facets in a Brilliant. A, the angles of inclination of the main facets of the crown and the pavilion; 1, between crown and girdle; 2, between pavilion and girdle. B, the angles of rotation as made by one facet with the next in the same row around the crown; 1, the angle between adjacent main facets; 2, the angle between adjacent star facets; 3, the angle between adjacent break facets.

old-time wooden dop stick. These will be thoroughly discussed in the following paragraphs.

THE ANGLES OF THE FACETS. Two different angles are always to be considered when cutting facets: (1) the angle of inclination, which is the angle that the facets make with the plane of the girdle, and (2) the angle of rotation, which is the angle that the facets make with each other as they encircle the gem.

The angles of inclination. There are three rows of facets around the crown of a standard brilliant and therefore three different angles of inclination — one for each row. The angle of inclination of the main facets is the important one (Figure 69-A).

The angle of inclination is correctly obtained by finding the appropriate notch, or groove, in the jamb peg which will give the right inclination to the dop stick when in the cutting position (Figure 67-C). For the row of star facets the inclination changes, and the dop stick naturally goes up into a higher hole in the jamb peg. Likewise for the angle of inclination of the break facets, the dop stick goes lower on the jamb peg.

The angles of rotation. The second angle to consider may be called the angle of rotation. This is the angle which each facet in the same row makes with the adjacent facet. In a brilliant, there are eight main facets. When the facets are properly placed, the angle between each adjoining pair will be the same all around the row (Figure 69-B).

The angle of rotation is obtained by rotating the dopped gem for each succeeding facet the exact number of degrees required so that the angle between adjacent facets will be exactly the same for the row of facets all around the gem. This number is 135 degrees.

It is now clear that the act of holding the gem stone in the exact position for cutting the facets with the correct angles of rotation is the most delicate manipulation of the process of cutting. To rotate the gem to exactly 135 degrees is much more difficult than to cut the second facet directly on the opposite side of the stone. This simply makes the second facet parallel to the first facet, the accomplishment of which is not too difficult. And so on through the other six main facets. This method has been described in more detail in the chapter on preliminary practice in cutting facets. With the Willems faceting device, each of the angles can be set on the scale, thereby eliminating this most delicate adjustment from the realm of guesswork and making it a certainty. No estimating or measuring or guessing is necessary; it is done simply and correctly by the device.

THE NECESSITY OF MAINTAINING A FIRM AND CONSTANT GRIP. The cutting of the first main facet on the crown has already been started. The cutter holds the boxwood dop stick in his grasp without allowing the slightest movement, or slipping, or rotation of the stick between the index finger and the thumb. The stick, once it is set correctly in this grasp, is held there until the facet is finished. Every now and then the stick is lifted off the lap and the hand is turned palm up so that the facet can be inspected. But the stick is held tightly in the exact grasp, without slipping or relaxing. The hand is then turned down again, the pointed end of the stick is replaced into its notch in the jamb peg — and the cutting goes on.

By maintaining a grip, once it is correct, the cutter can remove the dopped gem from the lap many times and at once replace it in the exact position, thereby "finding" the facet at once. A facet that is "lost" is bound to go astray.

How FAR TO CUT A FACET. Gradually the facet will take shape as the cutting proceeds. The time to stop cutting that first facet is when the line of contact between facet and table has reached the right point. Care should be taken to allow ample area for the table so that it will not turn out too small when finished. Remember, when the cutting is finished there is still the polishing to be done. That takes away a small amount of material, making the facet larger and the table smaller. Make ample allowance for this.

Cutting the Second Facet

When the first crown main facet is done, turn the stick around 180 degrees and replace the tip of the dop stick in the same hole in the jamb peg as before. Now the second, really the fifth, crown main facet will appear. This should be exactly opposite the first facet. The sharp edges of the facets with the table should be parallel.

The second (fifth) facet should be the same size as the first one. This is one way of telling when to stop cutting the second facet. Another way of determining this is to cut until the lower edge of the facet is exactly as far down as the first one. These two points on opposite sides of the stone are then the first two marks which determine at what level the girdle shall encircle the gem. As the remaining six facets are cut, these two points will be joined and the girdle is thereby completely outlined.

Cutting the Remaining Bezel Facets

After the first two facets have been cut, the next two, the third and seventh, are cut in the same way. This will make the table a square. If the square is imperfect, then the cutting has not been accurate. Any imperfection should be carefully corrected before the four corner facets are cut.

Cutting the Corner Facets

The cutter proceeds in the same way with the four crown corner facets. When all the eight main facets are finished, the table should be a symmetrical octagon with all sides and all angles equal. Also the girdle should now have taken definite shape.

Cutting the Star Facets

Next, the row of star facets around the table should be cut. The stick is now placed one or two notches higher in the jamb peg and thereby the angle of inclination is decreased. The dop stick is held between the index finger and thumb so that the corner between two main facets and the table is exactly centered in the grasp, and when the gem stone is brought down onto the lap the corner will be cut away, forming the first triangular star facet.

This is a critical operation and requires careful handling. Usually one or two light touches of the gem to the diamond lap is all that is required to produce the star facet. The greatest restraint must be exercised not to overcut.

Cutting the Break Facets

When the eight star facets have been cut, the cutter proceeds to the next row. This row contains the sixteen crown break facets just above the girdle. This time the point of the dop stick is placed several holes lower on the jamb peg, which increases the angle of inclination, making it greater than that of the main facets.

Again it is necessary to hold the dopped stone in the exact position required and touch it lightly to the wheel. This may at first be difficult for the beginner, but practice will produce results.

The gem has now been cut to give it the full set of facets on the crown. The cutter proceeds at once to the polishing of these thirty-two facets before he cuts the pavilion. The polishing technique is the subject of the next chapter, where it will be described in detail.

Polishing is done by means of a polishing lap. If the cutter is fortunate enough to have a double faceting bench, he merely moves over to the polishing compartment. If, however, he has only one spindle, he will have to remove the cutting lap and replace it with the polishing lap to finish his job.

All the descriptive directions up to this point deal only with the use of the right hand and arm in the operation of cutting. But the left also has a job to do. It is used for wetting and preparing the cutting surface of the running lap.

Warning Against "Dry" Cutting

The cutting wheel must be kept constantly wet with plain water. Cutting with a dry lap will cause heating of the stone and that may give rise to expansion and breaking. A gem may actually crack into pieces. Or simple fractures may occur.

Dry cutting may also cause "burns." This is a small area of cracking from a central point in a radiating manner so that minute flakes are produced which come away and leave ugly depressions.

All cutting with a diamond wheel will leave on the surface of the gem a series of fine parallel scratches. When the lap has not been kept adequately wet, these scratches will be much deeper and rougher, often amounting to actual tears.

All types of gems will be ruined by cutting too dry. Among those which require especially careful handling in this respect are hiddenite, kunzite, emerald, and garnet.

Wetting the Cutting Lap

The wetting of the lap is done with the left hand. This may prove to be a little tricky at first — somewhat like the trick that school children demonstrate when they pat the top of the head with one hand while they rub the chest with the other. The motions of the left hand are different and independent from those of the right. A little practice is necessary to perfect the separate motions of the two hands.

The wetting plug. Wetting the lap is done with a cloth wetting plug. This plug is made by tearing a strip of cotton cloth $1\frac{1}{2}$ inches wide and about 14 inches long. This strip is then rolled into a plug and tied with a string or a rubber band. The lower end of the plug should be fairly flat (Figure 70).

The plug will wear down rather rapidly. It is time saving to make several plugs at one time so as to have a fresh one handy when it is needed in the middle of a cutting job.

When this plug is dipped into water, it will carry just the right amount to the revolving wheel. A sponge would carry too much and water and mud would fly off the lap all over the place. A piece of felt would not carry enough. A brush is not firm enough to use pressure to scrape the mud which has gradually collected while cutting off the wheel.

Assembly for watering the lap. In the lower left-hand corner of the cutting bench near the lap are assembled three objects necessary for watering the lap (Figure 70): (1) a dish or bowl for the water — an oval birdbath obtainable from a dime store does quite well, (2) a block of wood, rubber,

Figure 70. Assembly for Watering the Diamond Lap (view from above). 1, cutting lap; 2, water receptacle; 3, cloth wetting plug; 4, base for plug when not in actual use.

or plastic for placing the plug on a clean base when not in actual use — a rubber furniture caster turned upside down is highly satisfactory, and (3) a cloth plug, as described above.

Using the watering assembly. The wetting is done by holding the plug in the left hand. Before the gem is brought down on the lap with the right hand, the left picks up the plug, dips the flat end into the water, and then touches the wet end of the plug to the revolving wheel, leaving the surface freshly wet. Then the right hand brings the gem down into actual contact for cutting at the place where the lap is wet. The left hand is always ready to bring more water to the lap so that it is never quite dry. In between times, when the lap does not need to be watered, the plug is allowed to stand on its lower flat end on the block. The block serves to keep the lower end of the plug free from contamination.

It must be mentioned here that the watering is likewise done on the polishing lap. This procedure is slightly more complicated and will be described more adequately in the chapter on polishing.

The point has now been reached where the crown facets have all been cut and polished. The gem is completely finished above the girdle. But the girdle itself and the entire pavilion below it are still in the preformed stage.

Redopping the Gem Stone

The gem is next removed from the dop and then turned over and redopped on the same stick or device. The crown is down and the cement comes up to the edge of the girdle but does not cover it up. Care should be exercised to line up the facets on the pavilion with those on the crown, as has already been explained before and as illustrated in Figure 68, p. 162.

Cutting the Pavilion

The cutting of the pavilion is done exactly as the crown. There is this difference only — there is no table on the pavilion; hence the eight main facets come to a point instead of terminating at the table. In cutting diamonds, it is customary to cut a minute facet where the table would appear. This is called the culet, as previously explained. On colored gems, a culet is not generally cut. It is considered more desirable to preserve the color of the stone at the point of the pavilion, rather than have a "hole in the middle."

The cutting is now finished and the polishing of the same facets on the pavilion begins. The polishing takes the facets in rotation exactly as in cutting.

Cutting a Step-Cut Gem Stone

Step-cut gems are practically always rectangles. Other forms lend themselves quite well to this style of cutting, however, including elliptical and round stones. In all forms, the method of cutting steps is the same.

The requirements for the step cut, also called trap cut, are much less exacting than for the brilliant. It is relatively easy to take the roughed-out gem, dop it in the usual way, insert the point of the dop stick into the proper notch on the jamb peg and cut one of the long side crown facets. Then proceed by cutting the opposite facet in the same way, observing the rules as in cutting the brilliant.

By adding the end facets, the first row is completed. The next row is cut and the crown is finished. This makes eight facets on the crown in a rectangular stone when cut this style, as compared to thirty-two in a brilliant. If the corners are also cut, then there are sixteen facets on the crown. In larger stones, three rows are the rule, and some cutters put even more rows on the crown, making the facets very narrow and long.

The pavilion is cut in the same way. No full description of the procedure is necessary here.

The Cutting Laps

Gem cutting laps, other than skeifs used for cutting diamonds, are not always made of iron, as said previously in this chapter.

The professional lap is made of bell metal, although certain other materials, principally copper, are also used. Bell metal is a bronze consisting of 22 per cent tin and 78 per cent copper. Bell metal is chiefly used for casting large bells because the composition is notably uniform, compact, and fine grained. These qualities make it desirable also for a diamond-charged lap.

The lap should be 10 inches in diameter and $\frac{3}{16}$ to $\frac{1}{4}$ inch thick. The center hole for the spindle is 1 inch in diameter. A smaller lap can be used if desirable. The lap must

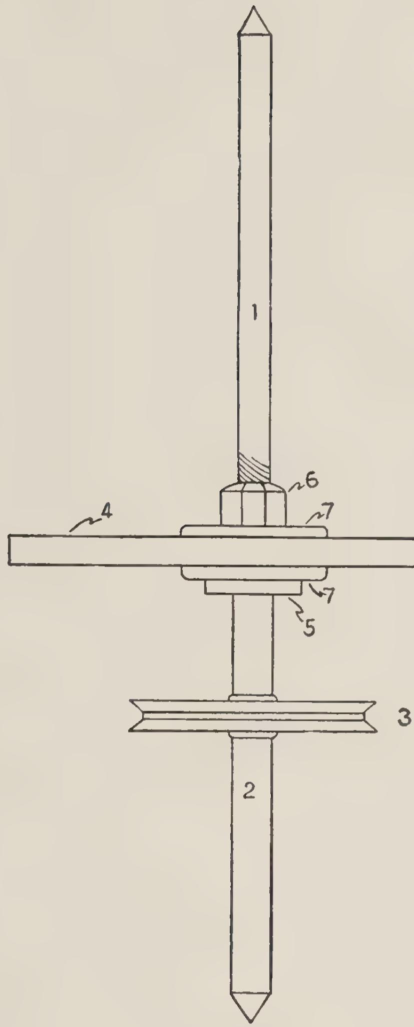


Figure 71. Professional Style Lap For Facet Cutting. 1, upper, narrower part of spindle; 2, lower, wider part of spindle; 3, grooved traction pulley; 4, lap; 5, collar rest; 6, nut; 7, flanges.

be carefully and accurately machined so that the surface is free from grooves, depressions, or rough spots. It must be true running.

The lap is mounted on a spindle 21 inches long from end to end. The lower end, from the tip to the undersurface of the lap, is 12½ inches. A collar for the lap to rest upon is placed at this level and securely tightened. The thickness of the collar does not matter, but the flange between collar and lap must be of such thickness that the lower surface of the lap just clears the table top of the lapidary bench.

The lap is fixed between two flanges and tightened down from above by a heavy nut. The thread should be left handed because the lap will run in a clockwise direction (Figure 71).

The lower part of the spindle is 1 inch in diameter. That is the part from the lower tip to the beginning of the thread. In its upper part, the diameter is ⅞ inch.

The spindle has conical ends which run in small blocks or hardwood bearings. Lignum vitae is highly satisfactory for this purpose. A small section sawed from a broom handle will do for such a bearing. This arrangement will make it possible to adjust the spindle so that the lap runs free and easy without the slightest play.

Below the lap at the proper level, the spindle carries a grooved pulley 5 inches in diameter for the power belt of the motor.

Other Types of Laps

Laps for cutting facets are made in many cases of other metals than bronze. Copper is sometimes used. Cast iron is a favorite with some cutters. These laps are not given the permanent charge with diamond dust. They are charged while cutting, by brushing on the diamond-dust, olive-oil mixture with a small paintbrush. Other grits are also used instead of diamond dust. Among these are emery, silicon carbide, and boron carbide. The grit paste may be made with

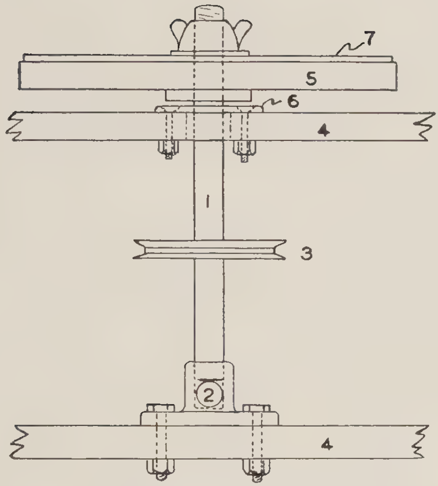


Figure 72. Master Lap With Interchangeable Discs For Cutting or Polishing. 1, spindle; 2, ball-bearing; 3, traction pulley; 4, section of lapidary bench; 5, master lap; 6, bearing; 7, interchangeable disc.

plain water. Some cutters add a bit of clay flour to give the mix body and tenacity.

Master Lap with Interchangeable Cutting Discs

Another type of lap is made to run on a ball bearing at the lower end of its spindle. The master lap rides on the upper end of the spindle and is tightened down by a wing nut. Upon this cast-iron master lap, interchangeable thin discs are placed for cutting or for polishing. Various metal discs may be used according to the work to be performed (Figure 72).

The Diamond Charge of the Bell-Metal Lap

The bell-metal professional lap is charged with diamond dust of 200 or 300 grit. The dust is also called bort. The coarser dust will cut faster but will also leave deeper scratches on the gem to be polished out later. The finer grit cuts a little slower. For small stones of one to five carats, this is no disadvantage. For larger gems of fifteen or more carats, the facets have a much larger surface and take much more time in cutting. The ideal would be to have two laps, one with a 200-grit charge, the other with a 300-grit charge. But if only one lap is desired let the charge be 300 grit.

How to Charge a Bell-Metal Lap with Diamond Dust

To charge a wheel with diamond dust, remove the wheel and spindle from the cutting bench and place the lap on your knees while sitting comfortably in a chair or stool, and allow the lower end of the spindle to extend down between the lower legs; then proceed as follows:

(1) Scrape the entire surface of the wheel with a small flat piece of carborundum, such as the flat side of a piece of broken grinding wheel. Scrape in all directions, but principally in the direction of spokes in a wheel. This will produce numerous minute scratches in the surface of the metal where the fine diamond dust particles can be imbedded.

(2) Wash the lap clean with a rag and water to remove all carborundum particles. Then dry the surface with a clean rag.

(3) In a watch glass, mix two-thirds of a carat of diamond dust (for a 10-inch lap) with eight to ten drops of heavy oil. Machine oil will do, but olive oil seems to be better. The mixing is done with the tip of the little finger, using a rotary motion. The finger is not wiped in order not to lose any diamond dust adhering to it. The mixing is carried on until the dark gray bort is evenly distributed throughout the oil in the watch glass.

(4) The little-finger tip now carries the mixture to the lap. One blob of oil is placed at one side of the wheel and another of equal size is placed at the opposite side. This is carried on until there are eight equal blobs around the lap. Any oil mixture remaining is placed as equal but smaller blobs between the larger ones. Great care must be taken

to avoid uneven amounts of the mix to be collected in certain spots on the wheel. Next, with circular motion, the same little finger enlarges each blob until the entire lap is evenly smeared over with the oil-diamond mixture.

(5) With a small steel hammer, the entire surface is gone over with gentle taps, driving the diamond particles into the tiny scratches in the lap. The oil will hold the particles in place for tapping. It will be easy to see the dust particles lying on the wheel in the thin layer of oil. The tapping should go on until all the particles have disappeared into the metal. It may be necesasry to go over the entire lap several times in order to pound all loose particles of the bort into the metal.

(6) The excess oil is now removed with a cloth by wiping. The lap is replaced in the lapidary bench, and, next, the cloth is held to the lap while it is running. All the oil should be removed, using several changes of cloth if necessary.

(7) With a flat piece of agate, the entire surface of the wheel is rubbed, at first lightly, then vigorously, to roll around and drive in any remaining particles of bort. At last, run the lap a few turns and apply the flat agate to the lap gently. Be sure to wet the lap when doing this.

(8) The lap is now ready for cutting.

It takes about three hours to charge a professional diamond lap properly. In a good charge, the bort is distributed evenly over the entire lapping surface. The wheel will cut smoothly without ripping or tearing the inner half of the facet. Such a charge is adequate for cutting up to a thousand carats of gem stones.

Running Speed of the Cutting Lap

The speed of the diamond-cutting lap should not be too fast. Little or no harm will result from overheating if the lap is adequately watered at all times. But if run too fast, the cutting of a small facet will be done so quickly, with one or two touches to the wheel, that the inexperienced cutter will ruin good stones before he even gets really started.

A speed of 700 revolutions per minute for a 10-inch lap is satisfactory for cutting as well as polishing. That is the speed used by professional cutters. However, the speeds advocated by various cutters range from 100 r.p.m. to 1000 r.p.m. It is the experience of this author that speeds of 500 to 650 r.p.m. are satisfactory and fast enough to cut rapidly and still smoothly and safely.

How to obtain the desired speed from a motor of known revolutions is fully discussed in Chapters IV and V.

The Lapidary Bench

The spindles with their laps are mounted on a heavy lapidary bench with a table top at least 1½ inches thick. All around the top, a guard rail is fixed. This will keep the water and the mud from flying away by centrifugal force and spattering everything in the vicinity, including the exposed parts of the cutter.

The lapidary bench can very profitably be made double so that one compartment is used for cutting while the other is used for polishing. In between them is a double division to keep the grit and diamond dust in the cutting compartment from entering the polishing compartment. A single particle of diamond dust, if it should get onto the polishing wheel, will be quickly imbedded in the soft metal and will keep tearing scratches into a gem until the grit is found and dug out — which is an almost hopeless task.

Another desirable feature of the double lapidary bench is the fact that one electric motor can be used for both operations.

The lapidary bench is 31 inches high from the floor to the table top. The table top is 22 inches wide and 48 inches long. The four legs are 3 x 3 inches at the upper extremity

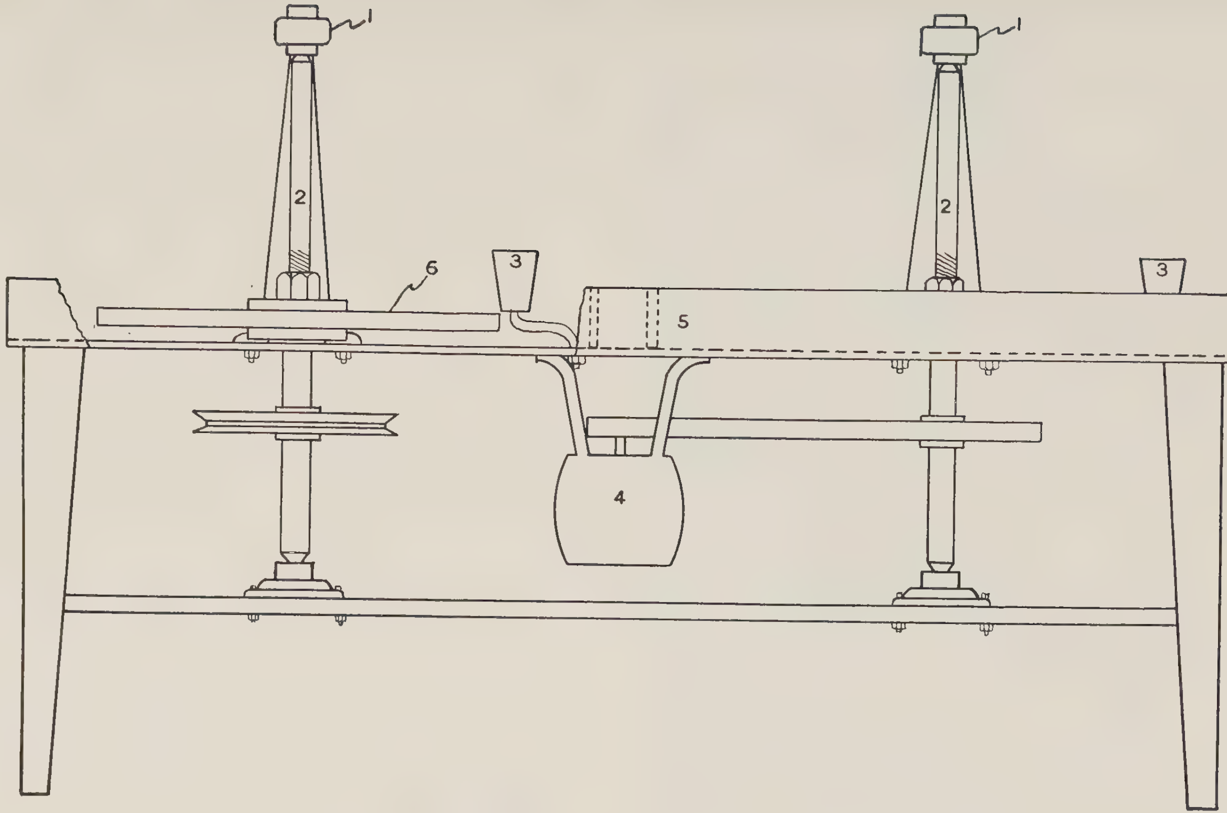


Figure 73. Double-Facet-Cutting Bench, Professional Style (side view). 1, upper arm and bearing; 2, spindle; 3, jamb peg; 4, motor; 5, guard rail; 6, lap.

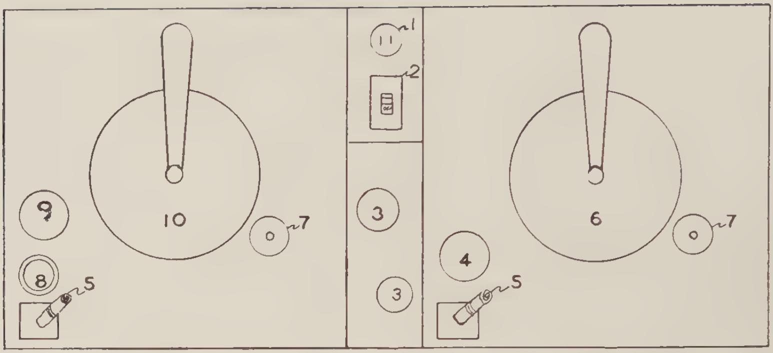


Figure 74. Double-Facet-Cutting Bench, Professional Style (viewed from above). 1, electric plug; 2, switch; 3, jars of polishing agent in center compartment; 4, water receptacle in cutting compartment; 5, wetting plug; 6, diamond-cutting lap in cutting compartment; 7, jamb peg; 8, polishing agent; 9, water receptacle in polishing compartment; 10, polishing lap.

and tapered somewhat toward the feet. All around the table top is a guard rail extending 3½ inches above the table top (Figure 73).

The table top is partitioned off into two compartments, 20 by 22 inches each. Two boards like those of the sides of the guardrail extend from front to back across the table top 6½ inches apart. This space between the compartments is utilized for holding cleaning rags, extra watering plugs, jars of polishing powder, etc. The electric switch for the motor, which is mounted beneath the table top, is also placed in this compartment (Figures 74 and 75).

Eighteen inches from the floor two 2 x 4 crossbars are firmly fastened between the front and back legs of the bench. This means 18 inches from the floor to the top of the bar. Running from one of these crossbars to the other, the full length of the bench, is a steel bar or strong angle iron, for the purpose of supporting the two laps and their spindles (Figure 73). A heavy 3 x 4-inch wooden bar would do.

The two spindles carrying the cutting lap and the polishing lap are mounted upright on this bar. The conical ends

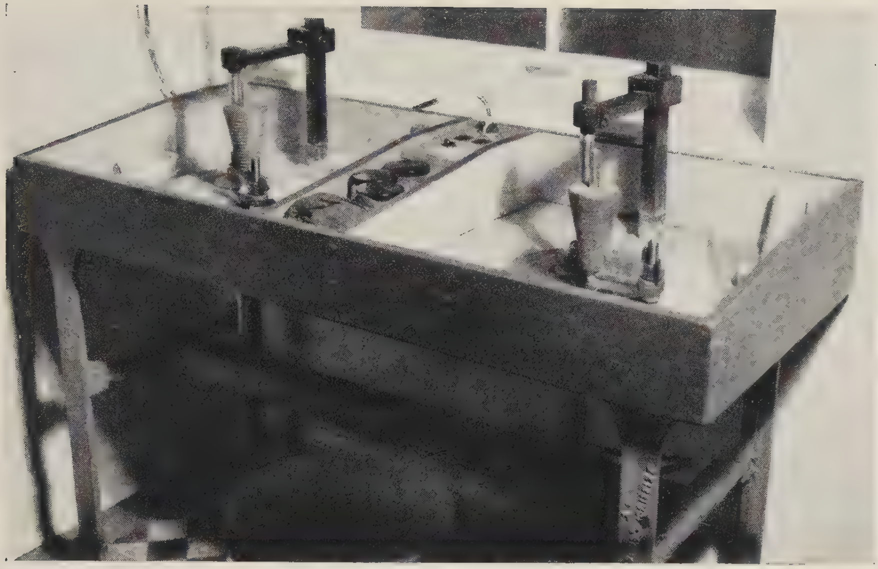


Figure 75. Double-Facet-Cutting Bench, Professional Style.

of the spindles are made to run in bearings containing short sticks of lignum vitae (Figures 76 and 77). The lower bearing is bolted directly to the long bar. The upper bearing is in the form of a bracket or curved arm with its base bolted to the top of the bench. The bracket may be of a design which has two separate pieces joined at right angles, or it may be in the form of an arm.

Both bearings, the lower and the upper, are mounted so that the spindle and lap are located in the center of the cutting and polishing compartments, respectively, of the bench. A hole 5½ inches in diameter is necessary in the proper spot in the table top to allow the pulley of the spindle to pass through when mounting the laps.

The spindles should be adjusted vertically so that the laps run absolutely true horizontally. The lower surface of the lap is so close to the table top that it just barely clears.

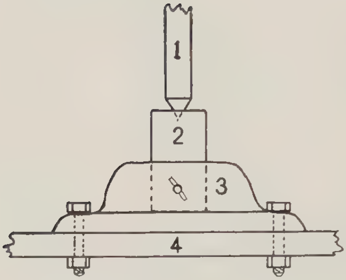


Fig. 76

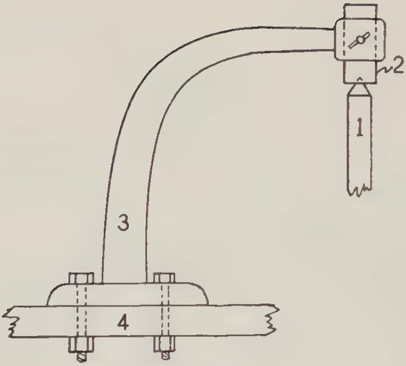


Fig. 77

Figure 76. Detail of Lower Bearing For Lap. 1, spindle; 2, lignum-vitae bearing; 3, adjustable socket; 4, cross bar. Figure 77. Detail of Upper Bearing for Lap. 1, spindle; 2, lignum-vitae bearing; 3, bearing arm; 4, table top.

The motor for the lapidary bench. The electric motor for driving the laps is mounted underneath the bench top. The motor should be one that is designed to run in the upside-down position. One-fourth horsepower is desirable. The motor is mounted halfway between the two pulleys and as far back on the bench as possible to get it out of the way of the cutter's knees when he sits at the bench. The most satisfactory motor is one which can be mounted on end with the traction pulley for the belt up close underneath the table top. Such motors are used in certain automatic furnaces for homes. They are made to run noiselessly. A washing-machine motor is also highly adaptable for this purpose.

Mounting the jamb peg. In the lower right-hand corner of each compartment, there is mounted the jamb peg. It is firmly fixed to the bench close to the periphery of the lap. The simplest method is to use an iron stand rod, bolting it to the bench. The ordinary jamb peg must be twisted and turned up or down when the cutter wishes to raise or lower it to set

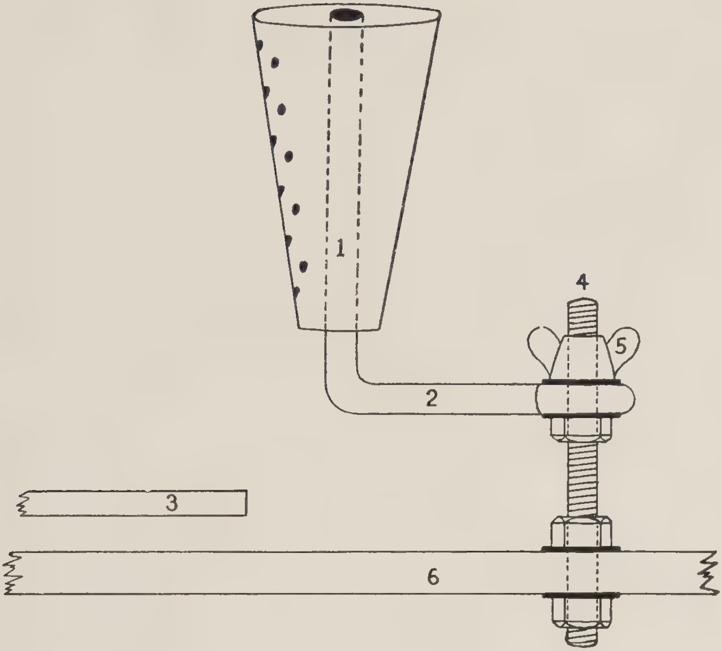


Figure 78. Jamb-Peg Assembly, Professional Style. 1, jamb peg; 2, right-angled carrying rod; 3, lap; 4, threaded stand rod; 5, wing nut; 6, bench top.

the exact position for the angle of inclination. This often takes a highly accurate adjusting.

A more delicate and refined method of adjustment makes use of a stand rod with a wing nut and thread. The entire rod is threaded and fastened firmly to the table top. A rod end is then drilled through the flat part to fit over the threaded rod. The rod end is bent at right angles and the jamb peg is fixed to it in an upright position (Figure 78).

This method allows the jamb peg to be adjusted up or down on the threaded rod to the slightest variations with accuracy.

The hardwood jamb peg has been described in greater detail in a previous chapter.

The machine described here can be built in any good machine shop with the help of a little woodworking. But it is by no means the only type of lapidary bench available. There are several models on the market, assembled and ready for cutting. Most of these are smaller than the professional bench described here and are fitted with only one spindle. The cutting and polishing laps are alternated or changed as desired. These smaller machines are quite satisfactory, but the full-sized professional bench will cut faster, especially when working with the harder stones such as ruby and sapphire. And it is built so sturdy that it will last a lifetime when properly cared for.

DON'TS FOR FACET CUTTING

(1) Don't overcut.

(2) Don't run the lap dry, even for a moment.

(3) Don't use force or too much pressure on the gem.

(4) Don't wait too long before recharging the wheel; grooves will appear when all the bort is gone.

(5) Don't work grooves into the lap; keep it absolutely flat.

(6) Don't cut constantly on one area of the lap; move the gem back and forth fanwise over the wheel while cutting.

(7) Don't allow the jamb peg or the stand rod to work loose; it must be rigidly firm.

(8) Don't run the lap too fast; adapt your speed to your individual requirements.

(9) Don't try to "get by" with an inadequate set-up; later you will regret that you did not invest a bit more to begin with.

(10) Don't fail to keep the lap true running.

(11) Don't try to do the "impossible" with the oldstyle dop stick of the professional.

CHAPTER XXI

The Technique of Polishing Facets

POLISHING the facets on a fine gem is perhaps the most important of all the operations to be performed. A good, clean, flat, highly polished facet with sharp corners will reflect light well and thereby give the gem its life and sparkle — in other words, its beauty. All gems, with one exception, must be cut and polished to perfect their beauty. That one exception is the pearl.

Polishing is done by means of a polishing lap and a polishing agent.

Metal Polishing Laps

The metal polishing lap is similar to the metal cutting lap. It is a horizontal wheel, running clockwise on the same kind of spindle, in the same machine. The usual professional cutting and polishing bench has a separate compartment for each operation (Figure 75). This bench and its moving parts have been described in the previous chapter.

Polishing laps are 10 inches in diameter and ⅝ inch thick. An 8-inch lap can be used when larger laps are not available. Some cutters do good work even with 6-inch laps.

A series of metal laps should be kept on hand so as to have a lap for each requirement. For the quartz gems, the beryls, the feldspars, tourmaline, and a number of others, a lap consisting of 33⅓ per cent tin and 66⅔ per cent lead is most satisfactory. For the harder gems like spinel, topaz, zircon, and chrysoberyl, a lap of 50 per cent tin and 50 per cent lead is better. For the softer stones such as apatite, fluorite, and obsidian, the proportions should be 25 per cent tin and 75 per cent lead; or pure lead may be used. For the corundum gems, the lap should be pure tin or even pure copper.

Such a collection of six laps runs into quite a bit of expense. For the professional and also for the amateur who can afford it, a good variety is highly desirable. But the beginner will probably limit himself to one polishing lap for quite a while. To fill that requirement, it is suggested that a tin-lead lap of one part tin and two parts lead will go farthest. He will have a minimum of trouble with certain gem materials, but the lap will polish a larger variety than any other and will do a satisfactory job on the remaining ones.

A tin-lead lap alloy is not too difficult to make. The metals melt at temperatures which are moderately high but can be attained without resorting to electric furnaces. The writer knows of one professional who melts and casts these metals in an iron frying pan and obtains good results.

The polishing lap must be machined to a perfectly flat surface, free from depressions and grooves into which the smallest facet could sink. It must be capable of producing a truly flat facet. The composition of the alloy must be uniform throughout. The lap must be balanced so that it runs true. Such a lap mounted on a spindle described in the previous chapter will run smoothly and almost noiselessly.

Scoring the lap. A lap with a smooth surface will not polish well. That is because it does not carry the polishing powder properly. The wheel should therefore be carefully prepared with narrow, fairly deep scratches made with a sharp knife blade, or the point of a small file sharpened to knife edge. This is called scoring the lap. These scratches are made all around the wheel in the arrangement of spokes in a wheel. The scratching, or scoring, must be repeated every few hours on the softer laps. Those of pure tin or copper will run much longer (Figure 79).

To score a lap, take a sharp knife and run it from the hub of the lap straight down to the periphery like a spoke in

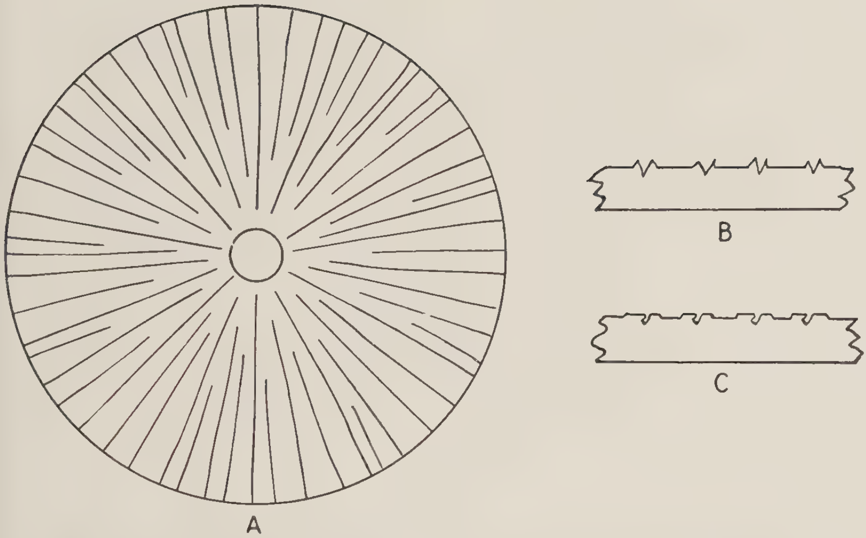


Figure 79. Scoring the Polishing Lap. A, view of freshly scored lap from above; B, cross-section of fresh knife scratches (exaggerated); C, cross-section of properly prepared scorings (exaggerated for emphasis).

a wheel. Apply fairly firm pressure to the blade. Make the scores quite close together. Around the outer part of the wheel, make shorter scratches in order that the distance between the scratches will be even on all parts of the lap. Move the wheel slowly around while scoring until the entire surface has been covered.

Another way of scoring a lap produces small pits all over the surface of the wheel instead of long scratches. These pits are deeper and somewhat wider than scratches. Consequently, this type of scoring will last much longer.

To score a lap by this method, use an ordinary pocketknife with a good-sized blade. Open the blade and hold the knife by the far extremity of the handle, bring the widest part of the knife blade, the belly, squarely in contact with the surface of the wheel. While holding it not too firmly in this position start the wheel running at full speed. Small chips of metal will fly off the wheel as the knife bounces around on the lap. The knife will have a chopping action. Keep this up until you have the entire surface of the lap covered with closely set pits. This type of scoring is highly satisfactory (Figure 80).

After the scoring has been finished, a smooth, flat piece of agate or similar stone should be held gently to the lap, a quantity of polishing powder should be applied in the form of paste or mud, and the wheel allowed to run for a few seconds. This will partly smooth down the sharp ridges made by the knife cuts and yet leave scorings for holding and carrying the polishing powder (Figure 79-B-C).

Special laps. In addition to the laps just described, there are special varieties for special work. Many cutters have become accustomed to some special type of lap and they can do practically every kind of polishing job with it. In fact polishing is much like shooting: although a good shot can usually hit the target with his favorite gun, another man cannot use it nearly as well. A good cutter can always get a good polish out of a lap which he knows just how to use. He has learned the knack of making the lap "grip" and "pull," which is the secret of getting a fine polish on the facets.

Special laps consist of pewter (20 per cent tin, 80 per cent lead), type metal, plastics ("lucite," "plexiglass"), pitch, mehinite, and — believe it or not — phonograph records. This author knows of at least one cutter who does highly creditable facet cutting using only discarded phonograph records, both for cutting and for polishing laps. And he claims no advantage for Toscanini's conducting over the recorded efforts of Spike Jones!

After the lap has been scored, it is ready to mount in the bench and to be used for polishing.

Notice carefully that the scoring is in such a direction that the scratches will move across the gem; the stone cannot sink into the scratches or pits.

The Polishing Agents

The polishing agents needed are usually only three in number. Only one agent at a time is used on a gem. Other agents are used if the polishing is not successfully accomplished. When one agent fails, wash it off and try the next one. Do not mix them.

The polishing powders in general use are: (1) tripoli, (2) tin oxide, and (3) Damascus ruby powder. However, various other agents are preferred by some cutters.

Tripoli is an exceedingly fine-grained silica. It is the most widely used polishing agent for facet cutting. It is available at small cost from dealers in lapidary supplies. A pound of it will last a month or longer. Tripoli is used in the form of a buff-colored powder; or those who prefer it can have it as chunks or bricks.

TABLE VIII

Gem	Polishing Agent	Polishing Lap
Benitoite	Tripoli	100% Lead
Beryl	Tripoli	33⅓% Tin; 66⅔% Lead
Corundum	Fine Diamond Dust	Copper
	Tripoli	100% Tin
Feldspar	Tripoli	33⅓% Tin; 66⅔% Lead
Garnet	Ruby Powder	50% Tin; 50% Lead
	Tripoli	
Peridot	Ruby Powder	Pewter
	Tin Oxide	50% Tin; 50% Lead
Quartz	Tripoli	33⅓% Tin; 66⅔% Lead
Spinel	Tripoli	50% Tin; 50% Lead
	Ruby Powder	
Spodumene	Tin Oxide	100% Lead
	Tripoli	
Topaz	Ruby Powder	Pewter
		50% Tin; 50% Lead
Tourmaline	Tripoli	33⅓% Tin; 66⅔% Lead
Zircon	Ruby Powder	Pewter
		100% Tin
		50% Tin; 50% Lead

Tin oxide is stannic oxide, with the formula SnO_2. It is a white or slightly yellowish powder which is also called putty powder when slightly impure.

Damascus-ruby powder is a preparation of secret formula imported from France. It is high in price and not always easily obtainable. A small quantity, however, will last a long time, so that the total cost is not excessive. Every lapidary shop should have an ounce or so on hand. When tripoli and tin oxide have failed, wash the lap clean and apply ruby powder. The results will justify the cost and the effort.

Most facet-cut gems, by far, will yield to tripoli, but in certain cases the gem material should be submitted to some other polishing agent for better polishing. When one agent fails, one of the others will usually bring results. Table VIII gives a list of gem stones opposite the polishing powder and the lap which are considered best suited for the purpose.

Applying the Polishing Agent

The application of the polishing powder to the running wheel is a trick that will take a little time and practice before it is mastered. In the lower left-hand corner of the polishing compartment there are placed three things for this operation: (1) a block with a cotton cloth watering plug, (2) a large watch glass containing the polishing agent, (3) a vessel filled with clean water. The description of the operation of watering the cutting lap in the previous chapter applies here and the reader is referred there for complete directions (Figure 80).

The operation is to dip the plug into the water, using the left hand, then touch the end of the plug to the dry powder, picking up just the right amount, and applying this to the running lap. Too much water will allow the soft, sloppy mix to be thrown off the wheel. Too little water will allow the powder to remain dry enough to fly off as powder, or to cake up under the gem. The right proportions will make a soft, mudlike mix which will fill the scorings on the lap and give it

Figure 80. Polishing-Agent and Wetting-Plug Assembly. 1, polishing lap; 2, guard rail; 3, block with wetting plug; 4, polishing agent; 5, water. (Notice that this lap is scored with pits instead of lines).

a certain feel already referred to as the "pull" or the "grip."

The left hand does the watering and mixing and then applies the mix to the wheel, just as it did the watering job while cutting. Watering is begun before the polishing is begun so as to have the lap coated with the mix at the proper consistency before laying the gem on the lap. It will take a few seconds to get the preparations just right. The cotton plug in the left hand travels automatically back and forth between water, polishing agent, and lap after a little practice.

When Failure Threatens

There will come a time when the full polish cannot be brought out in a gem. The cutter who has conscientiously followed the instructions on polishing as outlined in this chapter will nevertheless surely find, sooner or later, that everything he has learned fails. In such event let him use white vinegar instead of water. The results may be surprising. Peridot is a gem stone that may polish quite well with tripoli and water. And then again it may remain unaffected. White vinegar and ruby powder then may do the trick.

Inspection of the Work While Polishing

A good light hooded by a good shade and placed near the point of operation is essential to good polishing. The work is inspected every few seconds by turning the facet up against the light so that the light is reflected to the eye. The shape, the flatness, and the angles of the facet are easily and critically examined in this way. Scratches also are at once detected.

A hand lens of moderately high magnifying power is an excellent aid to inspection. Minute scratches can be reliably detected in this way only. A jeweler's loupe is most satisfactory.

Polishing the Crown

Before the polishing job begins, the cutter scrubs his hands, the gem stone and dop, and he changes his apron. This is to avoid contaminating the polishing laps with grit.

The polishing begins with the crown just as soon as its cutting has been finished. First the eight main facets are polished, then the eight star facets around the table, and last the sixteen break facets around the girdle.

The dop stick is held in the right hand and placed down upon the lap the same as in cutting. The upper end is inserted into the notches or grooves of the jamb peg, being careful to make use of the same notches for polishing that were used for cutting. In this way, the same angles will be preserved in polishing that were established by cutting.

Redopping the Gem Stone

When the crown has been finished, the gem is removed from the dop and "turned over." This is done by gently heating the gem and the cement together high over an alcohol flame. As the cement gradually warms up and softens, a knife blade is used to peel back the cement from the stone all around. Soon the gem can be separated and lifted off with the fingers.

The stone is then grasped by a pair of forceps, heated over the alcohol flame to the proper temperature, and dopped again on the same stick with the crown down, pavilion up. The procedure of dopping is more fully described in Chapter VI. Due care must be given to placing the stone so that the plane of the girdle is squarely across the top of the dop stick, at right angles to the long axis of the stick. The stick with the dopped gem is then set aside for ten or fifteen minutes for cooling and hardening.

Cutting the Pavilion

The dopped gem is now ready for cutting the pavilion. The cutter does not need to scrub the hand or the stone; but he must put away the apron used for polishing and don the one for cutting.

There is no essential difference from the cutting already described in the previous chapter. The cutter is by this time fully aware of the arrangement, the size, the angles, and the relation of the facets to each other. It is then a matter of applying this knowledge to the process of actually cutting the facets.

The eight main pavilion facets are cut first. Great care must be taken that these main facets are lined up exactly with the main facets of the crown. (Refer to Figure 68). This can be done by leaving a tiny margin of the crown exposed around the girdle so that the bases of the crown facets which rest on the girdle can all be clearly seen.

When the main facets are cut on the pavilion, their bases are brought down by cutting close to the girdle. A "knife-edge" girdle should be produced. A sharp, smooth, regular girdle is the mark and pride of every accomplished cutter. No good cutter will be satisfied with less than that.

After the main facets are cut, the sixteen pavilion break facets are cut — and the cutting is all done.

Polishing the Pavilion

The dopped stone and the cutter's hands are now thoroughly scrubbed, the apron is again changed, and the polishing of the pavilion begins.

Polishing of the pavilion facets is less exacting than polishing the crown facets. The process needs no further description — the cutter by this time will know exactly how to proceed.

Polishing the Girdle

The last act of polishing, when all the facets are done, pertains to the girdle. The girdle should be as carefully polished as the other parts of the stone. True, there are some cutters who leave the girdle unpolished. But unpolished, to this cutter, means unfinished. The cutter has not got everything out of his gem if he has not polished every part of its surface, including the girdle.

The girdle is polished by rotating it flatly on the polishing lap near its periphery. The manipulation is delicate. The cutter should try to avoid cutting a groove into the soft metal of the wheel. The gem is held diagonally at several different angles to the lap. Thus the trick is soon acquired.

Removing and Cleaning the Finished Gem

The gem stone is now completely faceted, the girdle is polished, and the final step is to remove it from the dop stick and clean it of all adhering cement or wax. Removal and cleaning have been given a complete discussion in Chapter X.

The finished gem will be an enduring thing of beauty if all the requisites of cutting and polishing have been fulfilled. Should the first gem not come up to the artistic expectations of the cutter, let him not be dismayed. Constant repetition approaches perfection.

DON'TS FOR POLISHING

(1) Don't forget to scrub off the grit from the dopped gem before polishing.

(2) Don't forget to scrub your hands and change your apron before polishing.

(3) Don't run the soft metal laps after grooves have appeared in them; get them machined flat, and keep them true.

(4) Don't run the polishing lap dry.

(5) Don't allow facets to become rounded or bulging; they reflect light poorly.

(6) Don't be satisfied with anything but flat, clean facets with sharp corners.

(7) Don't overlook the advantages of polishing the girdle.

(8) Don't expect your first gem stone to be perfect; yours would be the only one so produced.

(9) Don't give up trying; if you cannot satisfy yourself, get help or instruction from an experienced cutter. Others have succeeded; so can you.

CHAPTER XXII

Special Lapidary Techniques

In this chapter, there will be briefly taken up a number of subjects that are specialized branches of gem cutting. This work requires special equipment and tools in most cases, as well as special ability and training on the part of the cutter.

Sphere Cutting

Balls or spheres are not readily adaptable to setting into metal as jewelry, and therefore this procedure does not belong, in a strict sense, in the same class with gem cutting. Not much special training is needed for sphere cutting, and the cutter has the choice of at least two types of apparatus.

Spheres serve ornamental as well as useful purposes. Agate marbles are highly desired articles of trade. They were formerly cut in Germany and had a wide market. Whether this industry is again to be revived remains to be seen. Larger spheres made of clear quartz have been the stock in trade of crystal gazers for many generations. Spheres of colorful jasper, rhodonite, satin spar, and of many other minerals have enjoyed great popularity as ornamental objects.

Sphere cutting starts much as cabochon cutting does. The material is first sawed roughly into cubes. These are then reduced into rough spheres by grinding on the silicon carbide wheels as previously described for cutting cabochons. Next they are further treated with the special equipment for that purpose.

The simplest equipment for sphere cutting consists of two lengths of iron or brass pipe, each 2 to 3 inches long. One of these, the shorter one, is mounted on a spindle and joined

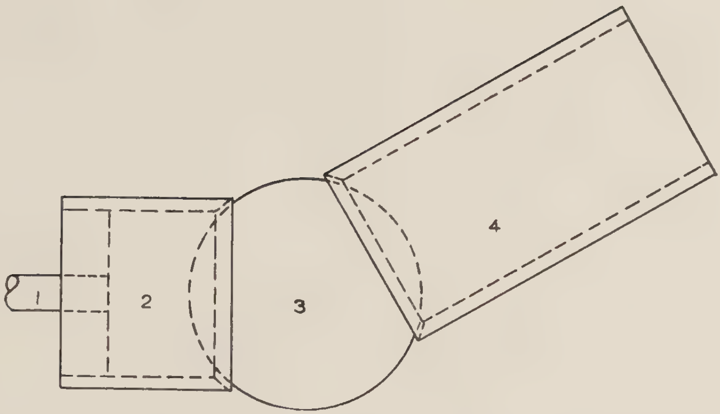


Figure 81. Equipment For Sphere Cutting. 1, spindle; 2, pipe attached to spindle; 3, sphere; 4, pipe held by hand.

to a motor and rotates with it. The other length of pipe is held in the cutter's hand. The sphere is placed between the pipe ends, and abrasive grit and water are applied directly with a brush. The cutter's hand holding the short end of the pipe manipulates the sphere by turning and rotating in all directions (Figure 81).

Some cutters plug the deep end of the pipe attached to the motor, leaving a well of about 1 inch deep. Into this they place the abrasive mix. The rapid rotation of the pipe will bring the abrasive into contact with the sphere.

The business ends of the pipe ends should be beveled so as to provide as much thickness of the pipe possible for grinding surfaces. The ball will roll rapidly in all directions from its own contact with the rotating pipe, while the other pipe in the cutter's hand will guide the stone, making it possible to produce a perfectly spherical surface on the stone.

For each size of sphere, there should be a proportionate size of pipe diameter. The pipes must be slightly smaller in diameter than the ball to be cut.

After grinding, the sphere should be polished on a hard

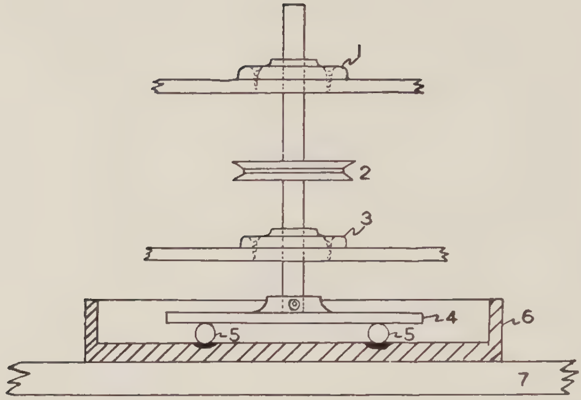


Figure 82. Ball Mill For Cutting Multiple Spheres. 1, upper bearing; 2, traction pulley for V belt; 3, lower bearing; 4, rotating disc; 5, spheres; 6, cast-iron tub with shallow circular groove. To the circular groove is fed the abrasive grit with water as the balls roll around in it; 7, section of table top.

felt wheel just as a cabochon gem is polished. A small sphere may have to be mounted on a dop stick for polishing, but those of adequate size can be polished by holding them against the wheel by hand.

Another method of cutting spheres is by means of a ball mill. This is illustrated in Figure 82, which shows the general principles involved. This method is useful for cutting many spheres at one time, and it has the added advantage that all spheres in the mill at the same time will be cut exactly the same size.

Sphere cutting is sometimes profitable when cutting asteriated gem stones such as star quartz, star sapphire, star ruby, and star garnet. By producing a sphere, the star may be brought out on two opposing points of the ball. Then by cutting it squarely in two between these points, two asteriated gem stones are produced, each developing the star in the most desirable location, the zenith of the dome. Their rareness makes genuine star rubies and sapphires highly prized.

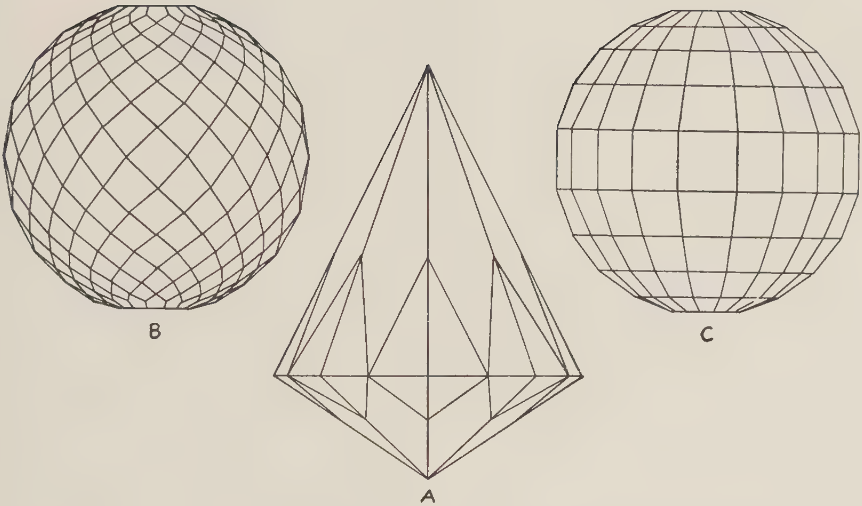


Figure 83. Types of Faceted Beads. A, pendeloque; B, faceted round bead; C, stepped round bead.

Bead Cutting

Beads often are spheres with a hole drilled through them for stringing, but they may be of other forms. Beads come in different forms: elongated, flattened at the ends, cylindrical, pear shaped, and in others. In some forms the holes are drilled lengthwise, in others crosswise, usually near the small end.

The beads may be given cabochon surfaces or they may be faceted.

Cabochon beads are often produced by first making spheres and then flattening or elongating them by further grinding.

Faceted beads require a particular skill to produce. The number of facets on a bead of good size may run up into the hundreds and their arrangement must be symmetrical both as to the equator and the poles. The facets are of various types: (1) diamond shaped; (2) triangular, and (3) rectangular (Figure 83-A-B-C). The angles of the facets are

Figure 84. Cutting a Bead With Breastplate and Stick. Cutting wheel, bead, stick with cupped end, and breastplate.

dependent only on the curvature of the surface and need not be cut according to optical principles.

Beads are faceted by holding them with the thumb and index finger against the wheel. A stick with a cupped end is held against the bead to press it firmly and steadily against the wheel. At the other end of the stick a small flat breastplate, much like that in a breast drill, serves the purpose of applying the necessary pressure (Figure 84).

Drilling

Drilling beads or gems or other forms of ornamental objects for personal adornment has been practiced for many thousands of years. The early Egyptians drilled their scarabs with bow drills; the Babylonians drilled their cylinder seals six thousand years ago; vases were hollowed out by hand drills using the principle of worm gears.

Modern drilling is done with metal drills, either solid rods or hollow tubes. Into the drill points, diamond particles may be set, or diamond dust may be driven into the metal. Silicon-carbide and boron-carbide grit may be used in place of diamond dust.

For drilling small holes, the solid rods are suitable but for larger holes the tube drills are more satisfactory.

Drills ready for use can be bought from lapidary-supply houses, or they may be made by the cutter himself if he has the inclination and the time to do so.

The drill points are used in a drill press of suitable size. Drill presses can be obtained at hardware stores or from the various well-known mail-order houses.

Carving and Engraving

These two terms are often applied to the same processes although strictly speaking there is a difference between carving and engraving. Carving refers to the production of forms or figures by cutting, while by engraving is meant the cutting of letters and designs.

This art was practiced nearly six thousand years ago by the Babylonians, who engraved their cylinder seals with characters and then strung them to wear as bracelets on the arm. The Egyptians carved their scarabs out of various minerals and then endowed them with engravings.

Probably the most remarkable example of gem engraving is found in the Shah, one of the great diamonds of the world. This renowned diamond, which long reposed in an Indian Rajah's treasury, contains three engravings which tell a large part of its history. A diamond obviously can be engraved only by another diamond, and then only by cutting the surface to be engraved with the grain and across the grain but never against the grain.

Gem stones are commonly engraved with letters, monograms, and symbols or crests, as well as designs associated with

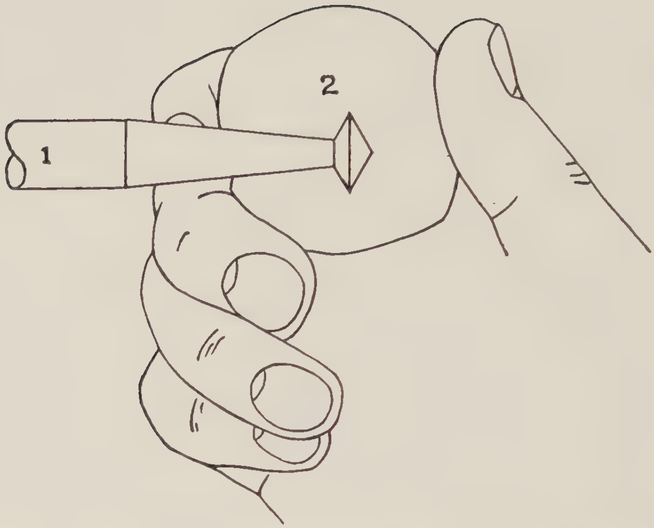


Figure 85. Method for Engraving Cameos. 1, lathe; 2, gem stone.

secret societies or lodges. Gold leaf often is used to embellish the engraving and to set it off against the background.

Carving has been extensively practiced by the Chinese, who have produced for many centuries exquisite examples of jade carvings of the finest workmanship. Cameos, intaglios, and cuvettes present the highest form of this art, since the cutter is truly a sculptor as well as a cutter. Not only profiles are produced but also front views in gem materials most difficult to cut.

Engraving and carving require great skill. The cutting is done by means of a small lathe fixed to a table or bench. The stone to be worked is held in the fingers and freely manipulated against the revolving cutting tool on the lathe.

Cameo carving at present is extensively practiced in Italy. The materials most used are shell and coral, but agate and tiger's-eye have long retained their popularity, due to the fact that a well-executed portrait on one of these hard gem stones is durable for a lifetime.

CHAPTER XXIII

Diamond Cutting

DIAMOND cutting differs considerably from the methods used for cutting the colored gem stones. In cutting and polishing the diamond, forceful pressure is brought to bear to press the diamond against the lap; but, in the cutting of colored stones, a great delicacy of touch is essential and only slight pressure is used. It develops, therefore, that the skill of the diamond cutter is of a different kind, but nevertheless fully as exacting as that of the colored-gem cutter, or lapidary.

Likewise, the apparatus used is not the same in the two operations. The diamond-cutting equipment is, generally speaking, built on the same broad principles but it is much heavier and sturdier.

The process of diamond cutting involves five different procedures: (1) cleaving, (2) sawing, (3) bruting, (4) soldering, and (5) polishing.

Cleaving

Cleaving means the splitting of the rough diamond along the lines of cleavage. The diamond crystal has four cleavages or planes along which the crystal can be split. In this respect it can be compared to wood which has a grain — not in four planes, however, but in two only. Just as wood will split with great accuracy along the grain if appropriately attacked, so the diamond will split along predetermined lines when cleft. Cleaving is done only on larger stones, for the purpose of dividing them into two or more smaller ones. This method will get more weight in carats out of the sum total of all the final stones cut than if the entire rough is cut to produce only one gem. By the expedient of cleaving, flaws are usually more profitably removed by cleaving through them than if they were ground away.

Cleaving is done by first scratching a groove into the surface of the diamond crystal along the cleavage plane at that point where the cutter wishes the stone to split. Then a blade similar to that of a knife is placed in the groove and a sharp tap with a small hammer on the blade will cause the diamond crystal to fall apart. This sounds much easier than it really is, for, should the cleaver make a mistake with a million-dollar diamond crystal, he most likely would find no more customers.

Sawing

Sawing of diamonds is not necessary on the smaller stones. It is really an adjunct to cleaving and is used where considerable portions are to be removed from the rough crystal which cannot be cleft off because the line of sawing and line of cleavage do not coincide. The sawing is done with a disc of phosphor bronze from 3 to 5 inches in diameter, and from .0003 to .0010 of an inch thick. This disc is run at a speed of six thousand revolutions per minute. The edge of this saw is charged with diamond dust in olive oil to begin with, but will continuously recharge itself with the dust that it removes from the diamond, provided the cutting edge is frequently treated with olive oil. It has been said that a diamond that has been sawed lacks brilliance in the polished state when compared to one that has been cleft from the same crystal.

Bruting

Bruting of diamonds is the operation of rubbing two rough crystals together with pressure and force, so as to wear away the rough and protruding parts and thereby gradually give to both the shape desired. This corresponds to the roughing-out discussed in Chapter V. For the purpose of bruting, the diamonds are dopped on sticks large enough for easy handling — much larger and longer than the lapidary's dop stick. Bruting to the diamond cutter is "cutting," although this latter term is not used in connection with the bruting operation but may be used in connection with the polishing operation. Bruting is carried on until the diamond has assumed the rough outline and shape desired.

Bruting is sometimes carried out by mounting one of the dopped stones in a lathe and using the other as a cutting tool. In this operation, the diamond which is mounted in the revolving dop is the one to be cut into shape.

Soldering

Soldering is similar to dopping as described in Chapter VI. It consists of mounting the bruted diamond in a conical mass of metal, called solder, made up of 33⅓ per cent tin and 66⅔ per cent lead. This alloy is heated to a mushy, semi-molten state and the diamond is then carefully set into the peak of the cone with a pair of tweezers. The hot metal is then worked and molded around the diamond, often with the bare fingers. The solder dop while still hot is then plunged into cold water. The sudden contraction of the solder firmly fixes the stone in the dop. In recent years, mechanical dops made of metal have been devised which clamp the diamond with forklike jaws, locking the stone firmly into position so that only a small portion remains exposed for polishing. The adjustment of all the dopping or holding devices to the correct angle for polishing is an extremely delicate procedure.

Polishing

Polishing of diamonds means the wearing away of the surface of the stone into small faces called facets. When the operation of polishing is complete, it has accomplished in one operation what it took two operations to do in cutting colored stones. Thus polishing, when speaking of diamonds, means the cutting of the facets as well as polishing them.

Polishing is done on a skeif, a horizontal running wheel twelve inches in diameter. It is made of a highly porous cast iron usually obtained from Belgium. As the abrasive agent, and also as the polishing agent, diamond dust in olive oil is applied to the skeif. The skeif in the diamond cutter's language may sometimes be called a wheel, but never a lap. The skeif rotates 2500 times per minute. Around the skeif are placed from four to eight clamping devices called tongs, or tangs, which hold the solder dop clamped in position for polishing at one end, and are long and heavy enough to rest on the polishing bench near the edge of the turning skeif at the other end. The tongs are held automatically in place by tong plates which are fastened securely to the bench. Thus from four to eight tongs, each holding a soldered diamond, can be managed by a single polisher at one time. While he lifts one tong to examine the progress of polishing, the others are in place being polished. He inspects each in turn, replacing it on the skeif in its position. When one facet is finished, he readjusts the solder dop in the tong and starts on the next one.

The upper surface of the tong is flattened to allow lead blocks or lead plates to be placed upon it for the purpose of exerting pressure of the diamond to the wheel. The various facet angles are produced by the most accurate adjusting of the solder dop in the tong.

There are now in use in some establishments semiautomatic machines for polishing diamonds. Such a machine makes it unnecessary for the operator to have the highest technical skill. At the same time, the machine is limited to one or two forms of stones. Any complicated or special form or shape can be produced by the hand method only.

CHAPTER XXIV

Absolute Minimum Requirements for a Beginner's Shop

THIS CHAPTER is written for the beginner who must be slightly bewildered and discouraged by this time — if he has read a sizable portion of this book. The writer hopes that the reader who has followed him through to this point has been led into a responsive interest in the fascinating activity of collecting and cutting gem stones. There is every likely probability that he will get greater satisfaction and reward out of it than out of any other avocation.

Gems are universally appreciated by all classes of people. They are the most enduring of all material things; they are the purest of all luxuries; they retain their values beyond all other investments. Gems do not fade, or age, or ever change. They give of themselves to all alike, in all seasons, and they unerringly stir the higher sensibilities of all who love beauty.

And, believe it or not, the cost is no more than that of a host of other pleasures, and less than most of them. To master the art is not difficult for those who have patience and perseverance.

How to begin? Here's how:

First, get some rough gem material. A dozen or two of the commoner gem stones found almost underfoot, so to speak, will do. Agates and jaspers will answer quite well. Try to find them and pick them up yourself. If you cannot do that, buy them from one of the many reliable dealers. The cost will be small.

Second, study your material. Get on the subscription list of one or more of the semitechnical journals. Go to the library and get what books you can find on the subject and study them. Learn to know your material, its appearance, its colors, its hardness, its abundance or scarcity, its qualities, and its origin. Don't be satisfied until you recognize at least agates and jaspers when you find them.

Third, make a little room in a corner of your basement or your garage for a few pieces of equipment. Get the electricity ready to plug in, build a bench or table out of a few planks. If you wish to sit down at your work, build it low; if you prefer to stand, make it higher.

Fourth, obtain a grinding arbor from a hardware store, or from one of the well-known mail-order houses, or from a lapidary supply firm. An arbor with a ⅞-inch shaft and ¾-inch spindles will do exceedingly well and cost a little over five dollars. Set the arbor up on your bench.

For a splash pan, use an old cafeteria tray or an old piece of tin or galvanized iron. Bend the edges up ¾ inch to form a rim. Put a hole in one corner for drainage and cleaning. Under the hole, hang a small pail or attach a rubber tube.

Fifth, obtain a ¼ horsepower electric motor and put it into place on the bench. If you simply cannot afford a motor or have no electricity available, rig up an old sewing-machine treadle and use your feet. It has been done more than once.

Sixth, on the right-hand spindle mount a grinding wheel of 180 grit with K bond, 1 inch thick and 8 inches in diameter, with a ¾-inch arbor hole. Cost, between four and five dollars. You can get along with one wheel for the grinding by using this medium grit. It will be a little slow, but it will do. You can make your own splash guard easily with a little resourcefulness. Above the wheel upon the guard mount a 1-gallon can with a spigot for feeding water to the wheel.

Seventh, obtain a bit of plain sealing wax and a skewer, one of those round wooden sticks with a point, such as a butcher uses to pin up his roasts. Use it for dopping the stone. The wax you heat over the flame in your stove.

Eighth, pick up a piece of carborundum cloth of 220 grit and cut it into pieces about 4 x 5 inches. Place a piece into the flat of your left hand and rub the dopped stone on the abrasive with the right. It is slow and laborious business to sand a stone this way but it can be done, and the results are highly satisfactory. The cost is practically nil.

Ninth, on the left-hand spindle, mount a hard felt wheel 1 inch thick and 6 inches in diameter, with a ¾-inch arbor hole. Cost, about $3.75. Protect this carefully against grit with a splash pan and guard.

Tenth, get a half pound of tin oxide at a cost of about seventy-five cents. This is the best all-around polishing agent.

Now go to work. You will be surprised what you can accomplish.

To these ten items can be added any number of additional ones from time to time, as the cutter sees fit to enlarge. With this equipment, which may seem crude and inadequate, a patient but resourceful cutter will be able to produce fully creditable cabochons. He then can take on more complicated cutting as he develops his skill.

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