GEMSTONE FASHIONING

Preparing a gem for use in jewellery, or for display as an ornamental object, is known as fashioning. In certain cases *no fashioning* is done at all; the gem material is used just as it came from Nature. For example, attractively formed crystal specimens or metal nuggets are sometimes put on display stands, or mounted in jewellery as is.

Perhaps the most common example is pearls

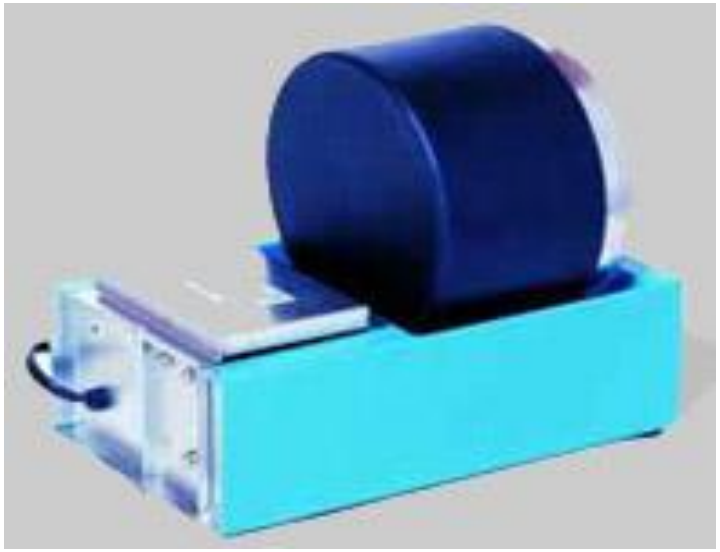
GEMSTONE FASHIONING

The art and craft of fashioning gemstones is called *lapidary* (or diamond cutting), and a practitioner is known as a lapidary, (sometimes lapidarist), or a diamond cutter

Lapidary Products

Tumbled stones: The simplest of way of fashioning gems is tumbling.

Accomplished by mixing the rough gems with water and a series of ever finer abrasives, and either tumbling them in a motorized, rotating rubber-lined barrel, or subjecting them to prolonged vibrations.



A rotary tumbler, a vibratory tumbler

Tumbled stones

Slabs and slices

- **Slabs and slices: Sawing, with the exception, perhaps, of tidying up a mineral specimen or slicing open a geode, is seldom an end in itself, but rather a preface to polishing or further lapidary work**

- **Lapidary saws come in a variety of sizes from tiny facetors' trim saws with four inch blades, to standard rock slicing saws of 8 - 18 inches, to giant behemoths used to cut boulders.**

Grinding and Polishing

Once a gem has been sawn into slices or trimmed into manageable size, it is then ground to smoothness and polished to a lustre. The grinding machines employ a metal, or in some cases resin, disk with its surface or edge covered with abrasives or polishes of various grit sizes and types. These disks come in two basic styles: flat "laps" which are used horizontally, and upright "wheels" which are used vertically.

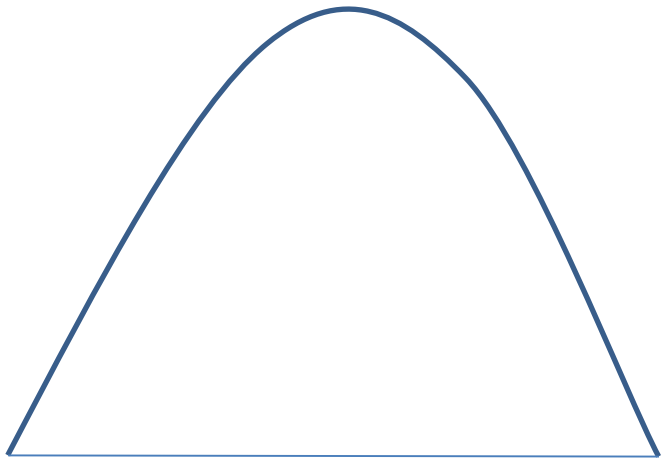
Grinding and Polishing

The basic idea here is the same as in tumbling, in that the gem is subjected to grits of increasing fineness as it is shaped and made smooth, then finally a polishing compound is applied which produces the finished shiny surface. The polishes are usually metal oxides or extremely fine grits of diamond. Various abrasives and polishes must be used to achieve success with different types of gem materials, based on their hardness and surface characteristics.

Cabochons

Second only to faceted stones in familiarity as lapidary products, are cabochons (cabs for short). Most commonly cabs have flat bases and smoothly domed tops, and are fashioned from translucent to opaque materials.

The cabochon form is particularly good at emphasizing the patterning of a gem, or for displaying most types of optical phenomena



Cabochon

Cabochons

Cabochons

They are usually produced with a slightly bevelled bottom edge which makes for easier and more secure setting in jewellery. Sizes range from tiny accent gems to large pieces appropriate for use as belt buckles or in bola ties. Standard shapes such as ovals and rounds are commonly produced in "calibrated" sizes that fit exactly into commercial mountings. In other cases, particularly with rare or valuable material, or those intended for designer jewellery, the sizes aren't standard, and the shapes may be freeform

Beads

Beads are one of the most ancient types of fashioned gems, and are enjoying an enormous resurgence in popularity today.

Beads can be virtually any shape: round, oblong, tubular, flattened circles (rondells), briolettes, fancy or baroque.

Beads

Beads are simply gems with holes in them. The fashioning of a round or other symmetrically shaped bead can be done by hand with cabbing equipment, but in commercial operations is usually done with a device called a "bead mill". Sawn slabs are cut into cubes (for a round bead) and fed into the mill which has grindstones that operate at angles to the cube removing its edges until it is uniform. Most mass produced beads then go into a tumbler to be polished and are drilled with a lapidary drill press, using diamond tipped drill bits.

Engraved and Carved Gems

Engraving and carving gems is, like bead making, a very early form of lapidary

Gems fashioned by engraving are incised, so that a design is cut (shallow or deep) into their surface, whereas carved gems are fully three-dimensional.

Engraving and carving should be considered lapidary *arts* rather than crafts, as the vast majority of styles and pieces can only be done *well* if the maker has some degree of artistic talent, an ability not required of those doing tumbling, cabbing, or bead making

With such a long history, it is not surprising that a large number of different carving styles, as described below, have been developed and made popular.

1) **Intaglio:** In these gems, a design is cut *into* the gem, so that it lies below the rest of the gem's surface. Historically they were worn in a ring which was also used to form a signature seal. Intaglios have always been most popular in men's jewelry.

2) Cameo: Cameos are essentially the reverse of the intaglio idea, in which by cutting *away* the material around it, the design is raised above the level of the base. The most common subject matter was (and still is) beautiful ladies or historical or religious figures in profile, and the materials used frequently have differently colored layers which can be strategically revealed in forming or embellishing the image. Historically, shell and agate were two of the most commonly used cameo materials, although there have been bursts of popularity of a great many other materials like jet, coral, and even lava!

3) Scrimshaw: In this technique a design is shallowly engraved into the ***surface of horn, bone or ivory then inked, or painted to provide contrast or color.*** Scrimshanders have a long history, particularly among those peoples who traditionally hunt either marine mammals, elephants, or other herbivores with antlers, horns or sizeable teeth or tusks.

4) Surface engraving/carving: In this technique a cabochon is decorated with designs carved into it (front, back or all round). Highly transparent material is sometimes "reverse" carved where the design, usually left unpolished, is cut into the back to create a picture visible from the front. The three dimensional scenes which result require great skill to accomplish, and can be stunningly beautiful.

5) True Carving: When the cutting or engraving work encompasses all sides of the piece so that it's truly three dimensional, it is said to be a carving. The four most common styles for carvings are hololith, representational, stylized, and abstract.

Faceted Gems

The most popular fashioning style for transparent gem material is the faceted gem. Because colored stones and diamonds are cut by different methods, and graded and marketed separately, we'll look at each in turn, although some of what is covered below applies to both.

Colored stones

When discussing a faceted stone, the first distinction that is often made is shape (face up outline). As is also true of diamonds, colored stones are either *rounds* or *fancy cuts*. So ovals, pears, freeforms, etc. are all "fancy". Going beyond the outline shape, one might next look at the cutting style. *There are three traditional basic styles (brilliant cut, step cut and mixed cut), with many old and new variations upon them.*

Colored stones

The brilliant cut which is especially suited for producing light return to the eye (brilliance), has triangular and kite shaped facets. The step cut, which is more suited for emphasizing color in a gem, has tiers of rectangular to square facets. Mixed cuts usually have a brilliant style crown with a step cut pavilion, but the opposite arrangement can be seen as well. Occasional variants include faceted gems with an apex rather than a flat table, and those whose crown is formed of rows of parallel facets (opposed bar cut) or a field of intersecting squares or diamonds (checkerboard cut).

The Faceting Process

Raw gem material (run of mine) = rough material

Faceting is the newest of the major lapidary crafts. Historically, we don't find the first faceted gems until the 14th century and faceted diamonds don't make an appearance until the 16th century. The earliest cuts were done by hand, and had just a few facets. An example of an early, but still occasionally used cut, is the rose cut which was often chosen for early diamond jewelry. The rose cut has a flat bottom like a cabochon, with a series of facets rising to form a dome or apex.

Several hundred years ago the *jamb peg faceting machine* came into use, and faceting, as we recognize it today, began. In order to cut facets on a gem in an organized manner that results in a precise arrangement, three factors must be controlled:

1) the angle of the cut
2) the depth of the cut and
3) the radial placement of the cut.

Although modern highly engineered faceting machines have replaced jamb pegs in much of the world, these older systems are still widely used, and a substantial proportion of the gems in commerce today have been cut by them.

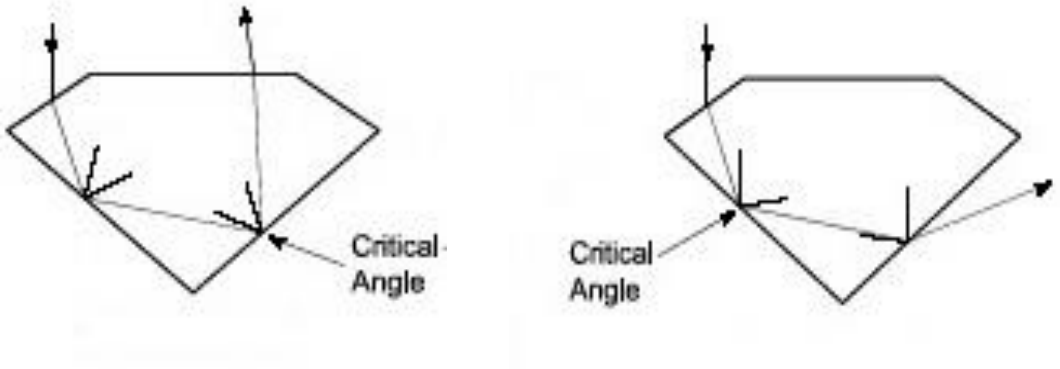
Background Information on Faceting

Pavilion and Crown: In the faceted gem, the pavilion and crown have different *functions*. The crown acts as a window or lens to collect the light which strikes it, and direct or focus it into the pavilion of the gem, whereas the pavilion must act as a mirror to reflect that light around the pavilion, and then *back to our eyes* through the crown. If the pavilion fails to do so, the gem lacks brilliance and is lifeless. Crown angles are much less crucial to the optical performance of a gem than are those of the pavilion, and can vary substantially from stone to stone without severely affecting a gem's brilliance. The crown and pavilion are cut in two separate sequences of operations. The gem is initially adhered to the "dop stick" until one side is finished, then removed, turned exactly 180 degrees, and attached to a new dop, to go through corresponding operations for the other side.

The Critical Angle: Each gem species, depending (with an inverse relationship) on its refractive index, has a pavilion faceting angle below which it loses brilliance.

Think for a moment of skipping flat stones on water. What controls whether the stone will skim and bounce along the surface, or go kerplunk into the depths?.....The angle at which it hits the water! So it is with light that enters a gem and strikes the pavilion facets. When that beam hits outside the crtical angle it will be reflected to another facet and/or to the crown, but if it hits inside the critical angle it will not reflect, but pass right out through the side or bottom of the gem, not to return to our eye, the gem loses brilliance.

In the graphics below we see two gems cut to the same proportions (pavilion main angles at 38 degrees) one is a diamond (RI = 2.42), the other is a fluorite (RI = 1.43). The critical angle for diamond is about 24 degrees, that of fluorite is 44 degrees. At 38 degrees on the pavilion facets much of the light hitting the fluorite is lost, whereas almost all that which hits the diamond is reflected. The diamond would appear bright and the fluorite lifeless, especially in the center: we would say it has a "window". If, instead, we were to cut the fluorite to a pavilion angle of 45 degrees or above, we would then eliminate the window and it would be brilliant, and conversely we would get a lifeless diamond if we were to cut its pavilion at 20 degrees or below.



Reflection when the pavilion angle is above the critical angle, lack of reflection "windowing"when it is not: Graphic courtesy of Joe Mirsky

Yield vs Brilliance, Clarity and Color:

Faceting is a series of compromises. The yield, that is the carat weight, of the finished stone versus the carat weight of the rough, can be as high as 40 - 50% or as low as 1-2% depending on a mix of the attributes of the rough, and of decisions that are deliberately made by the facetor.

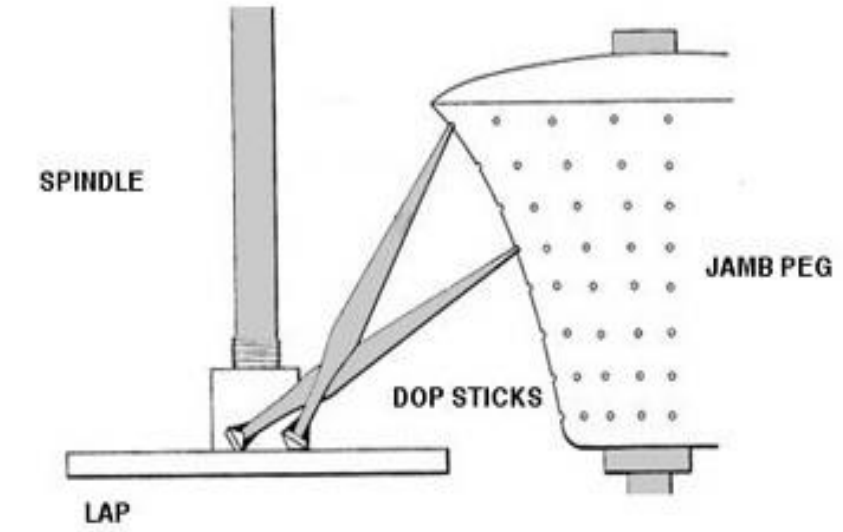
For example:

1) The shallower the pavilion angles, the greater the yield (but the less the brilliance).
2) Included rough can be oriented (with loss of yield) to eliminate or minimize the appearance of inclusions.
3) Pleochroic stones will give different colors and different yields depending on how the stone is oriented for cutting.
4) Rough that happens to be somewhat "gem shaped" yields more than thin and flat, or highly asymmetrical rough.

Given a moderately well shaped, clean piece of rough, which is cut to correct pavilion angles, the average yield is about 20%. To put it another way: start with gem rough = 5 ct, end up with finished gem = 1 ct.

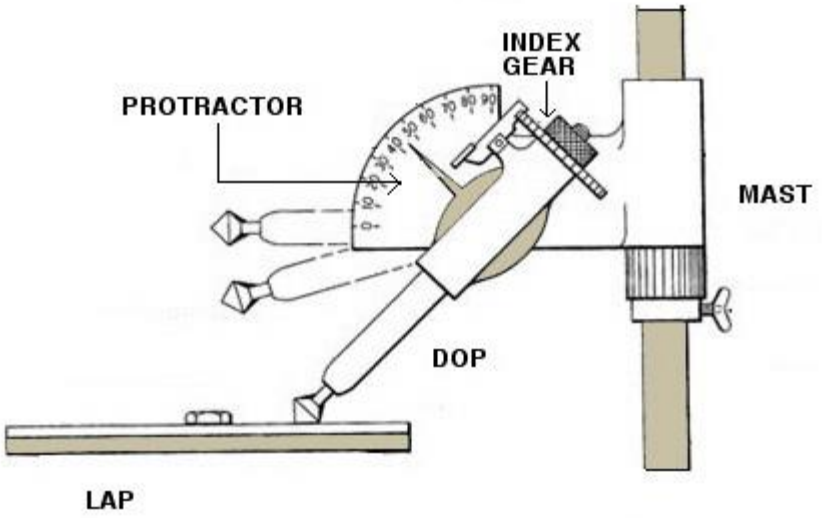
Faceting Tools

In the figure below you can see the basic set up of a traditional jamb peg faceter. The spinning lap provides the grinding and polishing surface, the wooden "dop" sticks to which the rough is adhered, serve to hold the stone in position as various cuts are made. The angle of the cut is controlled by placing the dop stick in a particular hole, the depth of cut is controlled by the amount of time the piece spends in contact with the lap and how hard the facetor presses down on it, and the radial position is controlled by removing, slightly rotating, and reinserting the dopstick in its hole as each different cut is made. Most stones that are cut on such equipment are referred to as "native cut".



A jamb peg faceting machine

A modern, highly engineered faceting machine is seen below: such machines accomplish the same three goals (angle, depth, and radial position of facets), but do so with great accuracy. In machines of this type the dop stick with the gem attached to it, is fitted into a "quill" which can be postioned at various precise angles via the "protractor". The quill moves up and down on the mast, which gives great control over the depth of cut, and a slotted index gear gives accurate control over the radial placement of facets. Stones cut on such equipment are usually described as "custom cut".



A typical modern faceting machine: Image courtesy of Ultra Tec, the main working parts of a faceting machine

Native cut gems: These are generally cut by eye, usually in Asia, Africa or S. America, on a lap, or more often a jamb peg or similar machine. The cuts are typically oval to cushion shaped with windows, low crowns and bellied pavilions. The "make" (proportions and finish) is "inferior" in that the table sizes, crown heights, pavilion depths, facet meets and degree of polish are not to custom standards.

Such cuts give high yield from gem rough, and due to the increased volume/mass of the pavilion tend to deepen and emphasize color. For these reasons the majority of the high value colored gem rough (ruby, sapphire, emerald, Imperial topaz, etc) is still cut this way-->even though the cutters could make smaller, brighter stones with the equipment they have. Frequently native cutters are paid by yield, another factor which perpetuates the native style of cutting.

Custom cut gems: These are usually produced on some type of precision engineered faceting machine (there are many brands), usually in N. America or Europe, using magnification. Cuts can be any shape, but are characterized by "superior make". The gems are usually fully brilliant with no windows and pleasing crown to pavilion proportions. The level of polish, and the precision of facet meets is very fine.

Such cutting sacrifices yield, and may lighten the color tone of gem material. On the other hand custom cut stones are generally easier to set in commercial mountings, and extremely beautiful due to their brilliance and symmetry.

Faceting Paraphernalia:

Various adhesives are used in faceting, such as epoxy resin, cyanoacrilate "Super Glue", and faceting wax. Different gem cuts require different index gears, the one below has 96 slots and can cut gems with 3, 4, 6, 8, 12 and 16-fold symmetries (other indices would be used for gems with 5 or 7-fold symmetries). The dops are commonly made of brass and come in a large variety of sizes.

The laps used for cutting and polishing come in a variety of materials and sizes. The first picture below shows two diamond-surfaced cutting laps: the one on the left has a coarse diamond grit embedded into its metal surface, it would be used to lay in the basic shapes of the facets, the other one has finer grit and would be used to smooth the facets and prepare them for polishing. The second picture shows a polishing lap which is made of a plastic resin with fine metal particles embedded in it, very fine grit diamonds (in solution) are sprayed onto the lap surface for polishing the gem. Metal oxide slurries or sprays (such as cerium or aluminum oxides) can also be used for some gem materials

Diamond cutting: Considerably more talent and expertise is necessary for diamond cutting than that required of the colored stone facetor. In order to successfully cut diamonds one must be able to look at a piece of rough and determine its crystallographic axes. This knowledge is then used in choosing the best cut to use, as well as in orienting and cutting the various facets, which must be ground in different directions on the lap, depending on their variable hardness.

The cutters must be adept at getting maximum yield while still retaining good brilliance. A 1-2% difference in yield would be small potatoes for most colored gem cutters, but in the case of a diamond, many dollars could hinge on it.

Although there certainly are "master" cutters who can start with a piece of diamond rough, and go through all the steps to produce a finished gem; in the commerical world of diamond production, the process is usually divided into stages, each of which is accomplished by a specialist in that part of cutting.

1) Marking: The "marker" studies and then marks the rough to direct the removal of inclusions, and indicate how the piece should be cleaved or sawn. For large, extremely valuable pieces, this stage may take weeks or months.

2) Cleaving and/or sawing: Although most of us can picture that tense moment when the "cleaver" swings his mallet and strikes the wedge that will separate a diamond along its cleavage plane, in reality, few diamonds are cleaved today. The average piece of rough is sawn (by diamond blade or laser) into suitably sized and shaped pieces by the "sawyer". Cleaving is still important with large rough however.

3) Bruting: The job of the "bruter" is to create the face up outline of the gem: round, oval, marquis, etc. The time honored technique for doing this involves using one diamond to grind another and is done mostly by eye using a lathe-like apparatus. When bruting is done with too much force, or too much heat is allowed to build up, tiny whisker-like feathers can be seen around the girdle of the stone. This is a blemish called a "bearded girdle".

4 & 5) Blocking & Brillianteering: The "blocker's" job is to create the basic shape and proportions of the gem by cutting the table and culet as well as the crown and pavilion main facets. The "brillianteer" (the cutting superstar), traditionally puts in the stars, and the crown and pavilion bezel facets, each one of which may require subtle adjustments of angle, direction and size, depending on the grain pattern of the individual stone, its inclusions, and the desired cut.

1): If the gems being tumbled together are not all of approximately the same hardness, the softer ones will not only be worn down by the abrasive grit in the barrel, but also by contact with the harder stones in the mix. In my own first tumbling effort many years ago, when I did not know this, I opened the barrel after a couple of weeks, to find some of the gems (the harder ones) just barely worn, and some of the softer ones almost gone!

2): Aggregate materials like jasper, agate, chalcedony and especially the jades: nephrite and jadeite, are very tough, which means that they will not easily break when the forces of the carvers' tools are used to make and/or separate relatively thin areas. This is particularly true for interlinked forms which require a lot of force on a small "thread"of material attaching one piece to another. Single crystal materials, being less tough, break much more easily.

3: In order for a gem to have a good polish the surface must be made absolutely uniform, and smooth to a microscopic degree. Polishing a curved surface to this level, is much more difficult and time consuming than doing the same with a flat one. Picture as in woodworking, for example, trying to sand a flat table top, versus sanding a curving table leg and trying to get each of them perfectly, and uniformly, smooth.