Making Measurements and Using Testing Tools for Specific Properties of Gem Materials

Gemstones are very small and hold concentrated wealth. To correctly identify a cut gemstone may in some instances be much harder than trying to identify a piece of rough material. Many gemstone crystals in rough materials have characteristic crystal shape, cleavage, or fracture, but often you can't see these properties in cut materials — color, density, luster, reflectivity, heat conduction, magnification, and optical properties are ways to look at cut stones non-destructively and identify them.

In this lab we will work with some larger stones and make measurements, Such measurements will be applied to specific stones when we learn gems in a systematic way (as we did with minerals) doing individual groups in labs devoted to them. But for now our goal is to learn the instrumentation, including the names and the parts of the instruments. Importantly, we will learn how to handle the testing equipment in a consistent and practical way so as to avoid any damage to either gemstones or to the testing equipment.

Measuring gemstones includes their dimensions, weight (or mass), and describing their color, etc. It is sometimes important in their identification as well, a too heavy feeling gem may not be what it appears to be!

Weighing Gemstones

First 1 gram is 1/1000 (one one thousandth of a kilogram). The kilogram is defined by a piece of metal held in a laboratory in France. However, a gram is also defined as a milliliter of water at 4^{o}C. These measurement units are part of the International System of Units (abbreviated **SI** from French: Système international d'unités). The USA is one of the few countries in the world not formally adapted to this modern "metric system." It is very convenient to use because units are multiples of the number ten. The **SI** was established in 1960, based on the meter-kilogram-second system. Almost all science and much of engineering are done using the system.

Gemstone rough may be sold by the ounce, pound, gram, or kilogram, and sometimes by the metric carat. Most cut gemstones are sold by the metric carat (0.2 gm per carat; adopted in 1907). Older publications may not use the metric carat, so the values reported may vary by age and region of the world.

We will use carats or grams and you should us the chart at the back and convert between them (grams and carats) and use either a hand calculator or the computer calculator found in the accessories section on the start menu.

5 carats = 1 gram

Weighing Precious Metals

Precious metals are usually sold by the troy ounce, troy pound, or penny weight (dwt) or by metric weights such as the gram (g). Since we use these metals, you should become familiar with their measurement as well.

Precious metal weights	
1 gram (g)	= 0.643 dwt (penny weight) = 0.0032 oz troy = 0.035 oz av
1 pennyweight (dwt)	= 1.555 g = 0.05 oz t = 0.055 oz avoirdupois
1 troy ounce (oz t)	= 31.103 g = 20 dwt = 1.097 oz av
1 ounce avoirdupois (oz av)	= 28.3495 g = 18.229 dwt = 0.911 oz t

A Quick Coverage of Precious Metal Purity

Precious metals are sold in both pure form that may exceed 999.99 parts per thousand or may be sold in the karat system; 24 karat is pure gold.

999.9 is pure gold, 750 as you can see below (part of the “Normal European Stamping) has only 75% gold and 25% base metal.

A base metal is less expensive that the more valuable metal. Sometimes Gold, platinum (and related platinum group metals), and silver are called “**noble metals**.” Noble is a comparison to royalty. There, in the past, have been (and in some countries may still exist) laws against individuals owning precious metals.

Platinum group metals include: platinum, iridium, palladium, ruthenium, rhodium, and osmium.

Only gold is sold in the United States by the Karat system. Note that a carat with a “C” is a measure of weight not purity (as above). Both silver and platinum are sold by fineness, parts out of 1000. Silver of 92.5% or 925 out of 1000 parts is called “sterling silver.” It is abbreviated as ster, 925, or written out as “sterling.” Often copper is **alloyed (mixed with)** silver to harden it, because silver like gold it is very malleable and ductile.

GOLD PURITY			
Karat Gold	**Parts Gold**	**Percentage Gold**	**Normal European Stamping**
9 K	9 in 24	37.50%	375
10 K	10 in 24	41.67%	416
12 K	12 in 24	50%	500
14 K	14 in 24	58.33%	583 or 585
18 K	18 in 24	75%	750 (see question above)
22 K	22 in 24	91.67%	917
24 K	24 in 24	99.99%	999 or .99999

The color of precious metals is determined, in part, by the addition of base metals. Platinum and the related PGM metals are generally gray, but their luster varies. Gold can be colored by metals such as copper (red/pink), silver (paler gold/electrum), nickel, zinc, etc. (white gold) and so on. Thus **color is due to the alloy.**

To test for purity of metal acids are used. Only **aqua regia** completely dissolves gold and platinum. It is **a 50/50 mixture of concentrated hydrochloric (HCl) and nitric acid (HNO_3)**. It is very dangerous! We will not use it in lab. However, nitric acid dissolves the common base metals and can be used. By observing the reaction of tested metal on a **black streak plate**, called a "touch stone" we can compare the unknown tested metal to a known standard. **Standard test needles** are currently available for gold of various karats, but white gold, and platinum are tested using solutions without test needles. The purity of platinum is not easy to test, but density may be used in some cases. The standard gold needles are scratched on the black streak plate next to the unknown golden metal and acids are applied (see Figures 1 & 2). For platinum and white gold various websites give you some idea of the testing

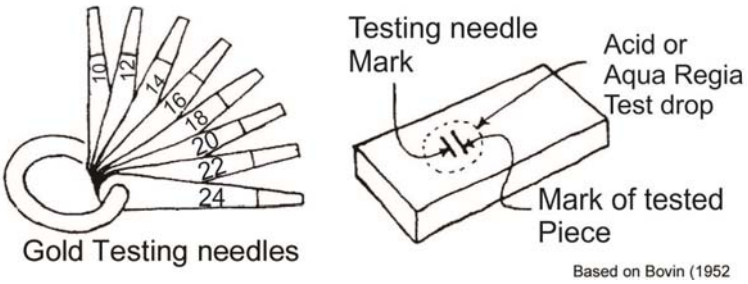


Figure 1. Gold testing using acid.

Figure 2. The acids used for testing. 1

methods, such as http://shorinternational.com/TestGoldScratch.htm.

Gold testing will not be done today, but is important from a business perspective, since anything of lower precious metal content, than represented to the buyer, could cause a serious loss in revenue.

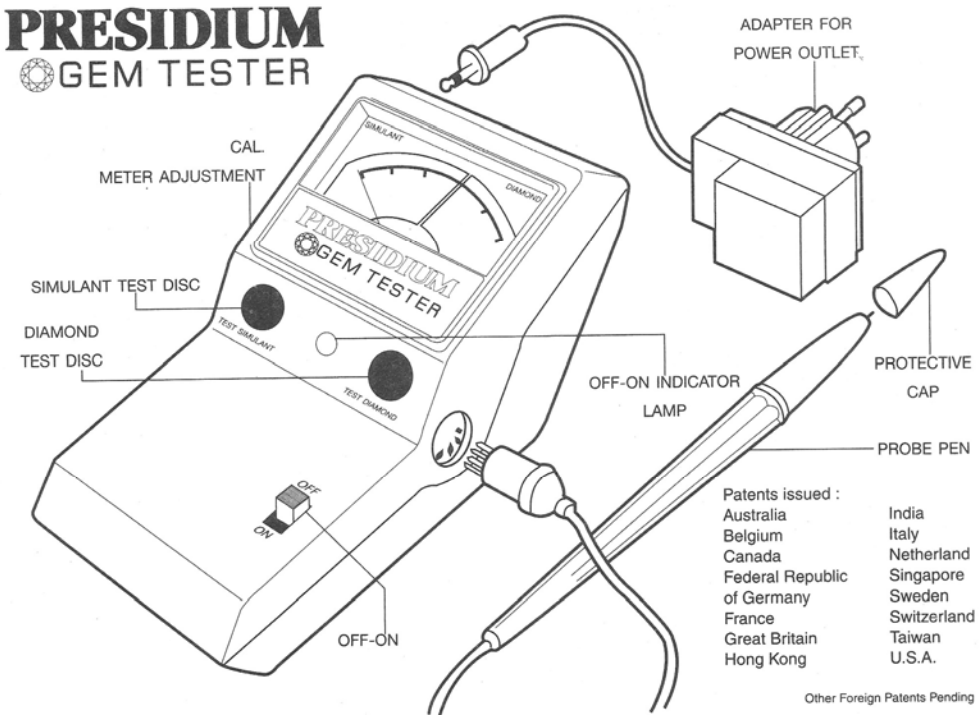
Various other test of heating and treating with acid can be used to test precious metal content, but will not be discussed here (See Bovin, 1952).

Testing Gemstones Using a Conductivity Meter

Mostly, we are talking about heat conduction. But in general, conduction means, "**a.** the transfer of heat between two parts of a stationary system, caused by a temperature difference between the parts, or **b.** transmission through a conductor (like electricity), or **c.** conductivity. As well it can mean the carrying of sound waves, electrons, heat, or nerve impulses by a nerves or other tissue.

Some gem materials and metals, such as diamonds and silver, are excellent conductors of heat. Computers use these substances to get heat off of computer chips so that they do not burn out too quickly. Synthetic diamonds can be made especially for this purpose, rather than as gems. But some are repurposed gemstones.

A thermal probe is usually attached at one end of the gem tester or may be a separate pen. We will use the "Presidium Gem Tester." It uses a probe connected to a meter (Figure 3 below).



After plugging in the meter and turning it on at the top, a red light turns on when it is ready. The probe tip is uncovered (remove black plastic). The needle exposed should not be touched with the hand. It is pushed into a clean part of the stone, within a few seconds the needle will rise on the dial to indicate the gem's identity.

Diamonds

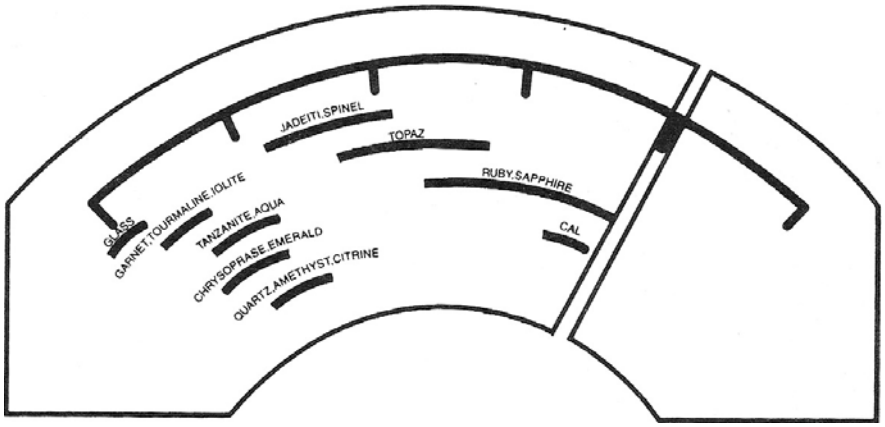
For diamonds it goes into the red portion of the meter. This indicates a diamond, you can use the metallic button to press the meter's probe into and it indicates diamond.

Colored Stone

In this case we mean anything other than a diamond. The needle is pressed into the stone. There may be overlaps and the overlaps must be tested by another method.

Try a red stone.

Try a blue stone.



Indicate whether the red stone is a ruby or perhaps glass, or garnet.

What if the gems overlap on the scale, what can you do?

Specific gravity and Weight

As we learned last week, specific gravity is the preferred method of testing a stone's overall heft. Since the stone may be small compared to a piece of rough, you may have trouble feeling its heft. Thus an accurate balance is quite important.

If we have a stone's overall weight to perhaps, 0.001 gms (or 0.0002 carats), we can calculate a specific gravity by weighing it in water.

Today, you will have access to such an instrument, record the specific gravity of your test stones.

Carat balances are a solution for the weighing of unmounted stones, but if the gem is mounted in a piece of jewelry, other methods must be used to arrive at its weight.

These methods are only approximations, but they may be very close if the stone is close to its **ideal cut**. Diamonds particularly, since 1920, are cut using the **American Standard Cut** also known as the **American Ideal Cut (or just ideal cut)**, which is the diamond-cutting benchmark in North America. It was derived from mathematical calculations that considered both brilliance and fire of the stone as recommended by Marcel Tolkowsky in 1919. He found that if a diamond was cut too deep or shallow then light would escape out the sides or bottom of the diamond resulting in a loss of **brilliance** and **fire** (brilliance, the light reflected back through the top of a diamond mounted in a ring; fire, the rainbow of colors created by dispersion as light goes through the diamond).

Older diamonds cut using the older brilliant cut, old miner cut, old European cut, rose cut, etc. must be weighed to get an accurate weight as their volume and proportions may vary.

The Hole Gauge

The simplest alternative to the weighing of a stone is to estimate its weight by a hole gauge. The hole gauge in Figure 4 can estimate the weight of a diamond in carats (cts) or pearl in grains (4 grains per cts or 0.05 grams per grain) This is a flat plate of plastic or metal which is punched with a series of holes that are used to measure diameters (width of a circle) of round brilliant ideal cut. The hole gauge estimates weight based on the ideal proportions (allowance must be made for shallow or over-deep stones). The weight of other brilliant cut colored gemstones may also be estimated with a hole gauge, but allowance must then be made for the specific gravity (SG) difference of the colored stones versus that of a diamond. As you will see, many colored stones have very obvious departures from the ideal diamond cut.

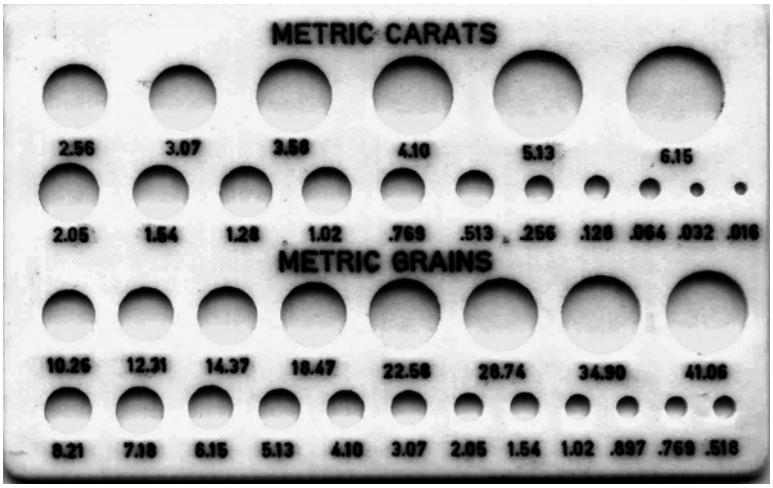


Figure 4. Hole gauge for estimating diamond and pearl weights.

The Leveridge and Moe Gauges

Gemstones are not always cut to their ideal proportions. This is particularly true and significant with diamonds, where in an attempt to increase weight, stones often are cut to retain weight disregarding their ultimate beauty, particularly in regards to brilliance

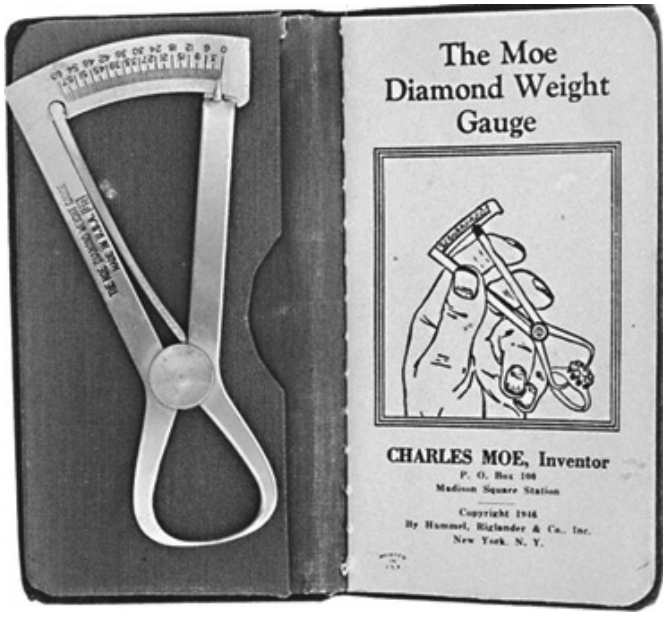


Figure 5. The Moe Gauge. It is used for diamond weight estimation.

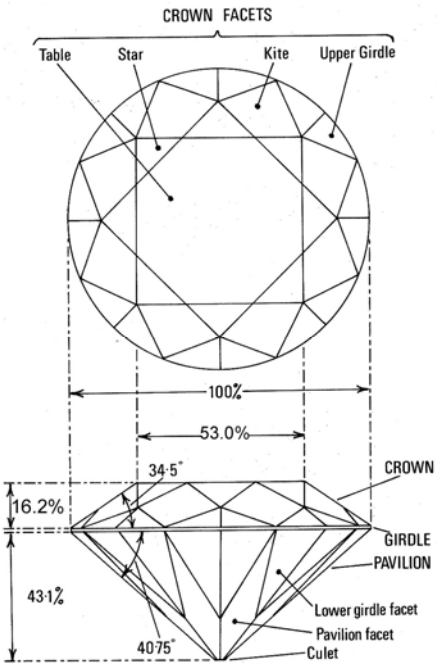


Figure 6. Proportions of the round brilliant cut after Tolkowsky, 1919.

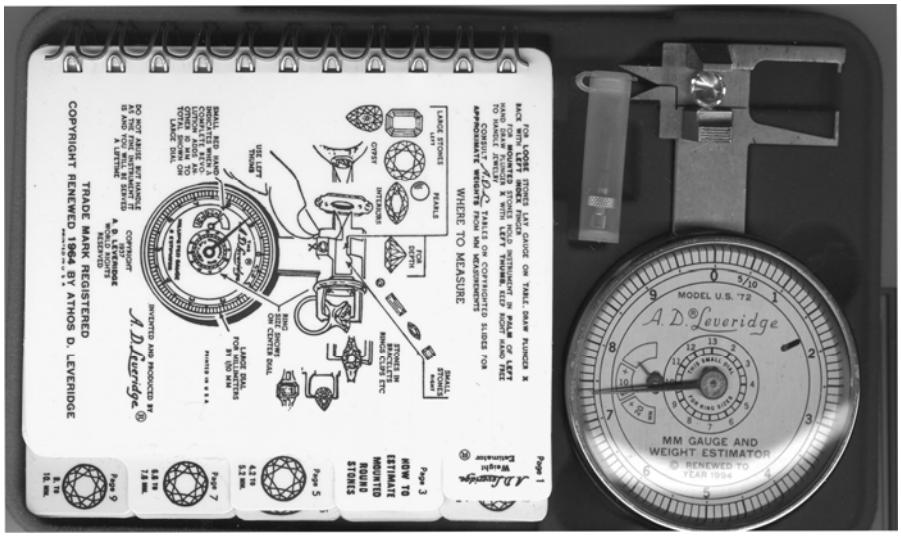


Figure 7. The Leveridge gauge. Used to estimate diamond weight very accurately, including in mounted jewelry. Stone diameter in this picture is 7.39 mm! The small cylinder case contains a probe for finding the height/depth in mounted stones.

and fire. As described above, Marcel Tolkowsky's 1919 brilliant cut is rarely achieved, and you pay significantly more for this superior cut. As with horseshoes and

handgrenades, close may be good enough, and a very beautiful result may be achieved, but you must judge that while looking at the stone!

Now if a loose stone, such as diamond or a cubic zirconia is cut at close to the ideal proportions a hole gauge will work to estimate the its weight, but the Moe and Leveridge gauge and accompanying booklets are needed to get a good estimate of the weight of a mounted stone in jewelry.

A Moe Gauge is less expensive than a Leveridge Gauge, but is harder to use (ie. The reading of the gauge dial is easier) and the Moe Gauge does not measure ring size and inner diameter, but does allow proportions to be measured (see Figures 5, 6, and 7.).

Try to describe the size of a cubic zirconia and estimate its weight using a Leveridge Gauge.

Diamond Lite and Color Grading of Gemstones

This unit provides a diffuse illumination similar to that of northern daylight, and encloses the adjacent area to the test stones with a neutral white background. Diamonds are **placed in the grader with the pavilion up**, the table facet down.

The diamonds or colored stones to be graded can either be placed on the large pad, or they can be placed in the translucent adjustable tray and inserted in the recessed compartment at the top of the unit. This allows the light to be filtered through the translucent tray before entering the gemstones.

The unit is fitted with a separately-controlled LW ultra-violet light source to test diamonds for fluorescence. Controls for the lamps are on the back of the unit.

The main purpose of the unit is for color grading diamonds, but it also can be used to compare colored stones under controlled and repeatable lighting conditions that can be important. Our unit is not a true Gemological Institute of America (**GIA**) Diamond Lite but is identical in design (Figure 8). GIA no longer makes these units. Some questions about whether they are off a little as to Northern exposure daylight exist and this lead to their disuse by GIA, EGL is shown using one in the film “Modern Marvel’s Diamond Mining.”

The unit is usually used with “**master stones**.” These are perfectly calibrated diamonds whose colors are known precisely. According to GIA the following should be considered in grading gem color.

The Diamond Lite grader should be used with a set of diamonds of known color that have been chosen for comparison grading; this set is called a Master Set. Although GIA

does not supply a Master Set, if you wish, they will grade your diamonds into such a set, using GIA's master diamonds.

According to GIA. “The Color Grader/Diamondlite will show that there is very little difference in color between the finest and the average stone.” This may console the customer who cannot buy the most expensive stone.

There are several points to consider in a master set. The set may vary, depending on the quality of the stones you handle and the grading approach you plan to use. Comparison stones should bracket the diamonds being compared. One on either side of the graded stone should be used to come up with the diamond color.

The stones should he approximately the same size and proportions and weight, and at least 0.25 carats. Slightly imperfect stones are satisfactory, providing the imperfections do not affect the color or transparency. Fluorescent stones should not be used.

Figure 8. GIA Diamond lite

The Diamond Microscope

The diamond microscope we use is basically what is known as a stereo microscope. It is like a pair of binoculars in many ways. You must get used to using both eyes and looking at 3-D objects. Gems and minerals are very interesting under the microscope and you should know the parts of the diamond or gem microscope (Figure 9).

The diamond microscope uses a darkfield base. The figures on the next page show such a microscope, but it is more modern than ours. A hollow cone of light illuminates the gem, but allows you to particularly see internal features. These features divert the light from the included (Inclusion means “flaw.”) object in the stone into the microscope’s view and brightly illuminate the inclusion against a dark back ground (darkfield) (see Figures 8 & 9.)

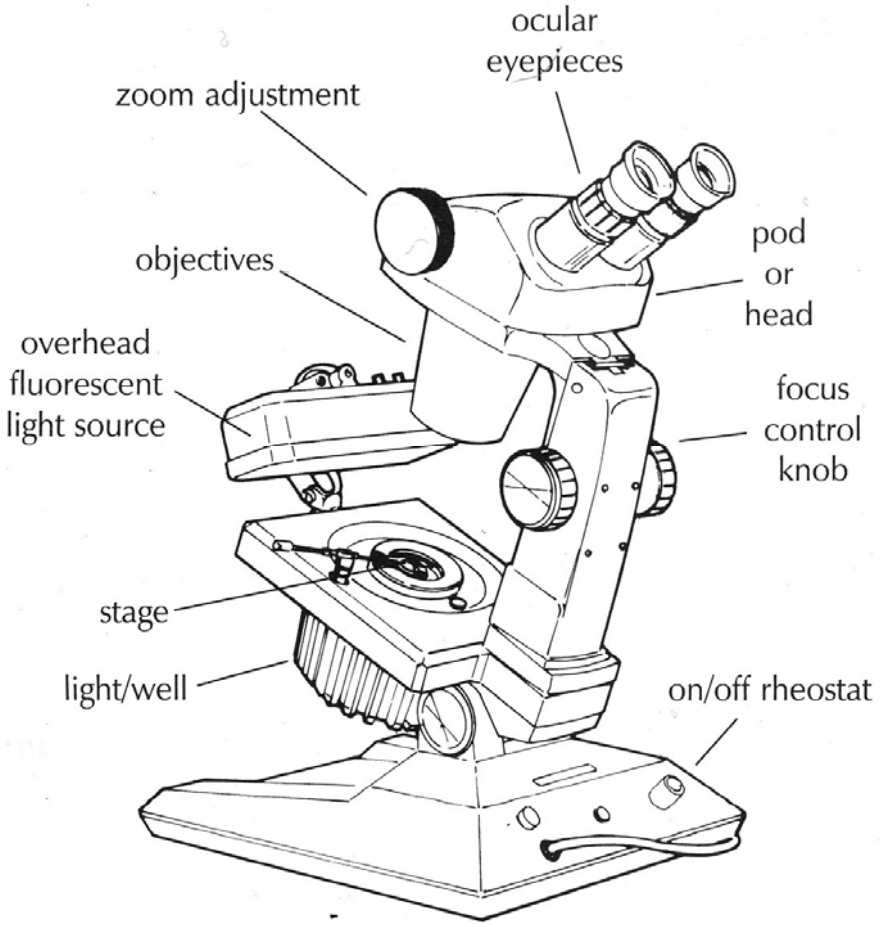


Figure 9. Diamond microscope.

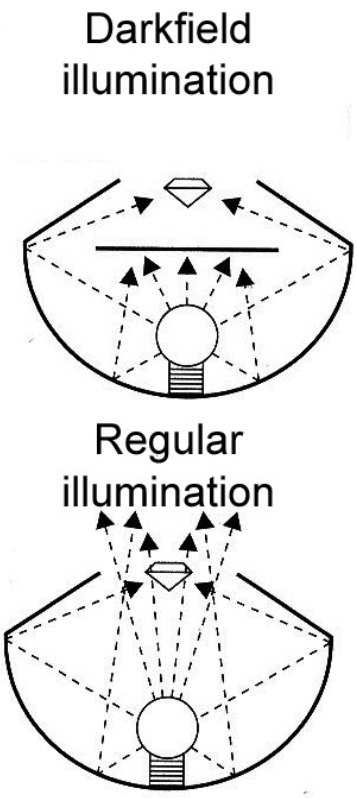


Figure 10. Darkfield and transmitted illumination.

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