Scratches from the Master Lap

by Dave Woolley, Geologist Senior, VDOT
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Dedicated to Bill and Joan Baltzley

This column will be devoted to ideas submitted by members who are stone cutters - from tumblers to faceters. If you have a problem or have solved a cutting problem and care to share your solution, this is your column - please submit your ideas to the editor or myself. The title for the column was suggested by a problem that had me stumped to the point of giving up faceting: it is the topic of the first article.

Observation:

I was just about at my wits' end: I had to re-cut a pavilion of a large pink Afghanistan topaz a third time to eliminate scratches which seemed to show up for no reason. I replaced my Master Lap with other laps and polish compounds which worked for a while, then the "scratches from hell" returned, ruining my attempts at perfection. (Hence, the name of this series of articles Scratches from the Master Lap!)

Problem:

City water has sediments in it: sand filters are used to purify our drinking water! Occasionally, sediments are released and transported through the system, or foreign material is released in the pipes after a repair is completed. (This same type of contamination problem may occur with a home well system.) When you least expect it, fine particles of grit may show up on your lap or in your polish slurry - ruining your perfect polish, (unless you have a filter on your water system to remove particles smaller than the size of your polish compound particles).

Solution:

Polish facets with diamond abrasives and a clean "diamond extender" oil - or polish by using store-bought filtered water for your polishing slurries, disks, drums or barrels. If your polishing lap becomes badly contaminated it can be "cleaned" by resurfacing - a machinist can cut a new face on a lath. A hand held piece of corundum - prepared for polishing with a flat or gentle curve - may wear out a single particle of contaminate if the corundum is polished over the spot. Replacement may be a better choice for inexpensive contaminated cabochon polishing disk or wheels. Your contaminated tumbler barrel may need to be replaced: use the contaminated polishing barrel as an additional grinding barrel.

II. Scratches from the Master Lap
"Groovy Facets"
by Dave Woolley

Observation:

An examination of several of my faceted stones revealed slight groves in otherwise acceptably polished facets.

Problem:

With use, polishing laps develop irregularities in the machined flat cutting surface. A negative image of these irregular groves may show up on your facets.

Solution:

The standard operating procedure calls for the stone to be moved back and forth across the polish lap while polishing to eliminate groves in a facet: this technique also tends to keep the groves from forming in the lap. If groves continue to appear on the polished facets, increase the rate of movement across the lap and/or decrease the rotational speed of the lap if you have a speed control on your faceting equipment. If groves still appear on the facets, especially on softer stones, change the lap and use a finer particle size polish; the finer the polish - the slower the polishing speed; the slower the polishing speed - the less likely you will have "groovy facets".

By first finding the grove making combination for a particular gem material, your equipment, and your faceting technique, and then polishing at a slightly slower lap speed, you will know you are polishing as fast as possible while achieving the perfect polish.

III. Scratches from the Master Lap
"Slipping Girdles"
by Dave Woolley

Observation:

The examination of several of my faceted stones revealed girdles that were not of uniform thickness. In one extreme case, it was obvious that the crown was not centered over the pavilion. Even with proper transfer techniques, somewhere in the cutting operations the stone had shifted.

Problem:

I use the highest melting temperature dop wax or stick shellac I can find to attach a piece of rough to a dop. A high temperature fastener helps to prevent unwanted stone shifting. Using dop wax instead of epoxy allows me to relocate the stone during initial cutting, if needed, to get the maximum yield out of a piece of rough, or to relocate the stone to eliminate a flaw. I cut the pavilion first and I use diamond abrasives. The problem with polishing with diamond is that there is no water drip to cool the stone.

Since diamonds and water don't mix well, I use an oil "diamond extender" as a lubricant on my polishing lap.

Solution:

Especially during the summer months I periodically hold an ice cube against the dop for a few seconds to draw out the heat that accumulates from the polishing operation. Marcus Beale recommends using Leech's "5 minute" epoxy instead of dop wax or stick shellac to prevent the problems of an unwanted stone shift and "slipping girdles". I find his suggestion appealing for cutting the crown. However, I prefer to cut the pavilion first using dop wax so that I can make initial adjustments to the position of the stone if needed.

Marcus also suggests that a "5 minute" epoxy will soften with heat allowing intended stone shifts. Marcus says you will never go back to dop wax, once you have tried "5 minute" epoxy. Heat will remove the dop stick and "Attack" brand solvent or acetone will dissolve any remaining epoxy.

A new approach is to use a zinc polishing lap with diamond polish. Zinc is reported to polish with less heat build up.

[Try the BATT lap for cool cutting and very sharp facets.]
Also see: "Beale's Bee's Wax"
Scratches from the Master Lap XV.

IV. Scratches from the Master Lap
"Prancing Pavilions"
by Dave Woolley

Observations:

Try as I might, many of my early faceting attempts did not demonstrate a correct alignment between crown and pavilion facets: my Graves transfer block has no radial alignment lock.

Problem:

When faceting a stone the crown facets should precisely align with the corresponding facets in the pavilion. If your faceting machine and transfer block has a built in radial alignment locking device you probably haven't experienced this aggravation.

Solution:

With a standard brilliant, I make it a habit to cut and polish facets on the girdle at 90? while I am cutting the pavilion. These facets are indexed the same as the corresponding pavilion girdle facets. (Many fancy cuts call for similar 90? girdle facets.) Before transfer, I make marks with an aluminum pencil on the edges between the 90? girdle facets that correspond to the index of the "main" facets. After transfer I insert the dop in the faceting machine and rotate it until an aluminum mark lines up with a "main" facet number on the

index gear - then I lock the dop in the faceting head. Shallow trial cuts at adjacent crown girdle-facet index settings reveal if the radial cheater (adjuster) is necessary for fine tuning the alignment. Not only will you eliminate "prancing pavilions" - achieving perfect crown to pavilion alignment - your faceted stones will look finished at the girdle! I make an aluminum pencil from a piece of aluminum wire such as is used to support telephone poles. Aluminum makes a bright mark on a stone and it resist washing or rubbing off. An aluminum pencil also makes a great marker for stenciling cabochon outlines on slices of rough, or for carving marks.

Late breaking news:
Graves has a new transfer device! With Graves Keyed Dops and Graves Deluxe Transfer Fixture - part number 02-060 - you can get perfect transfers every time. The new system uses the original dops except the keyholes in the dops now have short permanent brass pins attached. The brass pins slide in groves on the transfer block and align in a slot in the faceting head.

V. Scratches from the Master Lap
"Kiss the Corundum"
by Dave Woolley

Observation:

Some gem materials do not take the highest polish by conventional methods. Ruby and sapphire - the corundum twins - at times resist the best efforts to obtain a very high polish. If your ruby or sapphire is not taking the best polish, you might want to try this suggestion offered by Marcus Beale.

Problem:

Until science can come up with all the answers, the art of faceting will have to provide solutions to unique polishing problems.

Solution:

Marcus Beale suggests that after polishing corundum by conventional means - using a diamond polishing compound - each facet should be touched against a polish lap charged with an aluminum oxide polish - Linde A - for just a second or two. This lap may be a Mylar backed disk such as an "Ultralap" placed on a Master Lap or another supporting lap, or a conventional metal polishing lap of hardness compatible with an aluminum-oxide slurry. The important thing to remember is to "kiss the corundum" with Linde A polish after polishing with diamond if your corundum lacks the perfect polish. It is typical for the stone to screech as it takes the final polish.

VI. Scratches from the Master Lap
"Burnishing Baloney"
by Dave Woolley

Observation:

All the reading I have done on polishing states that the final bit of polishing is best done just as the polishing wheel dries out. (I have old instruction books.) This technique supposedly cause a great amount of heat just at the surface of the facet causing a microscopic glass layer to form yielding the perfect polish. This burnished layer, was "invented" by the discoverer of the Loch Ness Monster and has been believed ever since.

Problem:

The perfect polish has been the goal of lapidaries since stone cutting was first attempted. As soon as a technique was discovered - some one had to invent an explanation as to why it worked. In the case of polishing on a drying lap, however, the explanation of burnishing is pure "Baloney". In this case science has caught up to art of lapidary. A scanning electron microscope study of "burnished" stones has found no glass layer. (As reported in a recent Lapidary Journal article.)

Solution:

With some polish slurries, it is true that a better polish can be obtained just as the lap dries out. The reason is that the polish particles become immobilized: while the slurry is wet, the polish particles are free to rotate exposing fresh cutting surfaces. When the slurry dries out the sharp edges of the exposed polish particles are worn off. These immobilized particles subsequently become finer grained and expose flat sides rather than sharp edges.

If you find that you like the polish achieved by letting the slurry dry out but you don't want to take the chance of cracking the stone or melting your dop wax, try using a finer grain sized polish or a diamond polish.

[Burnishing may take place under certain circumstances; try cutting sulfur or amber...]

VII. Scratches from the Master Lap
"Graves Grief"
by Dave Woolley

Observation:

First time faceters often buy equipment sold in the "inexpensive" price range or as "used equipment". Often there is at least one problem with the machine caused by poor design or lack of maintenance, that contributes more than a fair share of grief for the new owner. Actually, if the previous owner could figure out a good solution to the problem, he might not have sold the machine in the first place! Such has been my experience with the purchase of a used Graves faceting machine.

Problem:

The pivot bearings that allow the faceting "head" to swing back and forth on the Graves faceting machines are designed to be adjusted. On older Graves machines these bearing can be easily adjusted by loosening an Allen setscrew and advancing the bearing pivot up or down to eliminate any free play in the head. A wobble in this bearing precludes being able to reproduce settings to polish a facet - a problem I call " Graves Grief ". Tighten the pivot bearing gently until the head will not swing easily from its own weight and then loosen it slightly. Re-tighten the Allen setscrew. Check for any wobble in the bearing; there should be none. This is a good time to clean and re-grease the bearings - while you are adjusting the pivot bearings.

Solution:

" Graves Grief " can be eliminated in the modern Graves faceting head in much the same way it was done with the old design although it is a little more complicated:

1.) The four setscrews holding the two pivot bearings of the modern Graves faceting head provide too much complication in the alignment process and they do not hold the pivot bearings as well! Remove the four small Allen setscrews. Grind and polish a flat dome on the load carrying surface of two setscrews and insert them - with out tightening them - in the two front holes; one each at the top pivot and bottom pivot bearing. Put the other two setscrews in the spare parts department! (A domed setscrew will allow adjustments to be made to the height of the pivot bearings latter on; the factory original "cup" setscrews without a domed surface will cut a grove in the pivot bearing metal. They resist movement as well as re-adjustment.)

2.) Remove the faceting head by loosening the top pivot - Allen head attachment bolt and removing the top pivot bearing.

3.) Loosen the lower pivot bearing - Allen head attachment bolt and raise the pivot bearing; tighten the lower setscrew which moves the pivot bearing to the flat back support, (eliminating the need for the back setscrew); and re-tighten the lower pivot - Allen head locking bolt.

4.) Clean and re-grease both pivot bearings. I use a good wheel bearing grease. (Always be consistent with any grease job - mixing different brands of greases will cause liquefaction of the grease and therefore cause lubricant failure.) Replace the faceting head and the upper pivot bearing and its Allen head attachment bolt.

5.) Use a model maker's "C" clamp and a tiny block of wood to push the upper pivot bearing downward; apply a gentle pinching pressure to the two pivot bearings. Tighten the "C" clamp until the faceting head just begins to resist turning under its own weight. Tighten the top Allen setscrew and then the upper pivot - Allen head attachment bolt. Remove the "C" clamp; the faceting head should now turn with a slight drag and with no play in the bearing.

Note: The hole in the pivot bearings may not be big enough to allow the bearings to be re-adjusted for height. If the lower bearing is in its highest adjustment, it may be

necessary to file or grind the hole - to elongate it - in one or both pivot bearings to allow for further adjustment.

You may notice that the axis of swing of the faceting head is no longer parallel to the lap spindle axis; the proper place to make that adjustment is the three adjustment mounting screws holding the lap bearing under the wood frame.

We will check, (and adjust if necessary), the alignment of the lap spindle axis to the faceting head pivot axis in a following Scratches from the Master Lap: "Graves Run Amok".

Note:
"Graves Grief" and similar repairs described in Scratches from the Master Lap can be accomplished by sending the machine back to the factory. It is advised that you first call to describe your problem, to ask for the repair work to be done, and to get shipping instructions.

Graves Attention: Peter Erdo
800 327-9103
1800 Andrews Ave. Ext. North
Pompano Beach
FL 33069
http://www.rockhounds.com/graves

IIX. Scratches from the Master Lap
"Timely Tips"
by Dave Woolley

Observation:

In learning to facet time is a great teacher - if you have a lot of time. If you are short on time, like I am, then each suggestion from some one else's experience - that works - is worth its weight in pure gold.

Problem:

I don't have the time to reinvent all the practical solutions and tricks so please help me with your ideas and I will pass them on.

Solution:

A member of the Eastern Federation gave me several tips in using the Graves faceting machine, information that may also apply to your machine. Last months column, " Graves Grief ", was a result of working with some of his ideas. Here are several more " timely tips ":

1.) If your faceting head is mounted on a mast that has a slide base, use a paste floor wax or bowling alley wax to lubricate the slide base. First, clean the build up of dirt with very fine steel wool, if needed.

2.) Graves markets a wonderful Quickie Lap Nut, part number 02-064, which fits any 1/2" - 20 right hand threaded - standard arbor. Half a turn releases the nut from the lap shaft!

3.) Any setscrew will adjust better and not scar the piece being held if the bearing surface is slightly domed and polished. The circular grove that some factory original "cup" setscrew makes will prevent fine adjustment moves to be made; the setscrew will slide back into the grove it previously made. "Cup" setscrews are designed not to slip at the cost of being unadjustable. Don MacIntire reports that a setscrew with a nylon insert is being manufactured, which will be an improved design - check with Valley Fasteners of Lynchburg, 3401 Campbell Ave., Lynchburg VA.

4.) Most small facets will polish in less than four seconds. Can your machine reproduce its cutting positions for polishing? If not, why not: let's fix it! Have you properly fine ground your facets?

5.) A single high-intensity halogen bulb mounted in a "goose neck" lamp higher over head than the standard lamp will help you see the facets, (and the scratches). Be sure the halogen lamp uses an ordinary glass filter between your eyes and the lamp to block any short wave ultraviolet rays. Be careful not to touch the bulb while installing it, or afterwards, because they operate at a high temperature and finger print grease will cause bulb failure. (Clean with a good grease solvent like alcohol or acetone.) You may find that a 60 or 75 watt halogen lap is sufficient. Angle the lamp on the machine - with a standard light bulb - to help you see the stone while cutting on the lap.

6.) On faceting machines that have a head that moves free on the mast - no crank to move the head up or down, like a Graves - always stand and look down the mast. Be sure the head bracket is in the same orientation every time you move the head up or down. Align it with the slide base slot. If the mast is not parallel to the arbor you will not be able to reproduce the setting used to cut a facet - when you try to polish it - unless you use this technique.

7.) Always listen to the cutting sound especially on a course lap with machines that do not have an electronic or dial read out gauge. Your only hope of accurate cutting depths and angles on similar facets is to go around the stone an extra time to be sure that you get the exact same sound from each facet. If you don't add this step on the main facets, at least one facet will always be bigger or smaller than the rest of them and the minor facets, subsequently, will have to be different in size. Minerals have grain or variable hardness that causes adjacent facets to alternately cut fast and deeper or slow and shallow unless you use some technique to balance out the depth of cutting.

IX. Scratches from the Master Lap
"Going Against the Grain"
By Dave Woolley

Observation:

Occasionally, I have observed an interesting phenomenon while cutting or prepolishing facets of various gem materials. Instead of a uniform textured surface, I will see a facet that has an island of "polished" gem floating above a textured surface. In extreme cases

the opposite situation occurs - areas of the facet's surface are" pulled out" leaving a very rough surface.

Problem:

Even in cubic crystal system minerals, there are unique cutting directions that have different hardness. This variation in hardness is well known in the other crystal system minerals. In the mineral kyanite, for example, a knife blade will scratch a kyanite crystal the long direction but not the short direction across the crystal! In faceting, this phenomenon is called "grain" and is one of the topics a diamond cutter must learn. Diamond facets can not be easily cut and polished against the "grain" because of an extreme difference in hardness within a diamond crystal.

Solution:

When "grain" shows up while you are cutting or prepolishing a facet, regardless of the gem variety, reverse the direction of rotation of the lap and cut on the other side of the lap shaft. In most cases, a smooth textured facet will appear indicating that you are no longer cutting against the grain. In an extreme case you may have to re-dop the stone and re-cut it. Here is where a class in crystallography will help a lapidary orient the stone the correct way the first time!

If your faceting machine has only one direction of rotation, check and see if it has a direct current electric motor. My Graves Mark II has a direct current, variable speed motor. I added a "double pole - double throw" electrical switch to reverse the current going to the motor. I now have a reversible lap and a partial cure for "going against the grain". If you make this modification, always turn the motor off and allow the lap to stop turning before reversing the control switch. Stopping will prevent stretching of the drive belt.

X. Scratches From the Master Lap
"The Weighted Graves"
by Dave Woolley

Observation:

Many faceting machines, especially those without an electronic stain gauge or position meter, seem to encourage one to push the stone being cut into the lap. This is especially true when cutting a larger stone or cutting on a fine grit lap and you are pressed for time.

Problem:

Unless you have a strain gauge or position meter you probably don't realize that you are bending the mast when you reach the protractor stop lock! This unfortunate event is noticed when you start to polish the stone and a height cheater has to be used to "find" the angle where the facet was actually cut. The mast springs back but the accuracy of the cut angle is lost.

Solution:

Mr. Graves taught his students to cut by the sound the stone made as it was cutting. By gravity feeding the stone into the lap, a characteristic sound is made as the protractor stop lock begins to hold the stone from further cutting; thus angles can be reproduced if the same sound is generated at the end of each gravity fed cut. Since we want to force feed some stones to decrease cutting time, the logical solution to the problem is to increase the gravity feed not the variable muscle feed. "The Weighted Graves" can be easily constructed by using tire weights!

- Go down to your friendly tire store and ask for a couple of 16 inch wheel tire weights - long heavy ones.

- Take them home and tap them flat with a hammer on a piece of wood to remove the 16 inch diameter rim curvature.

- Cut two or three pieces - with out the iron mounting strap - to the length of the radial cheater housing.

- Go to your friendly grocery store and buy a bunch or two of broccoli. Cook the broccoli and serve it with butter and lemon juice. Take the broad rubber bands left over from the broccoli and attach one, two, or three lead pieces to the cheater assembly - as needed - to force-gravity feed the cutting.

- If your faceting machine has no strain gauge or position meter, follow Mr. Graves advice and cut by sound. You can approach the same reproducible angles as the more expensive machines, use less time than usual completing a stone, and enjoy a good meal!

XI. Scratches from the Master Lap
"Off Centered Alignment"
by Dave Woolley

Observation:

A subtle problem can occur with faceting machines that use a setscrew to hold a dop on the faceting spindle. A very slight off - centering can occur after a gem has been transferred using a standard transfer block. The crown will not match the pavilion and the girdle will be uneven.

Problem:

If your faceting machine uses a setscrew to hold a dop in the spindle, the pressure applied to the dop from a setscrew on the spindle can slightly off center the dop. This will not affect the symmetry of the first side - either the pavilion or the crown. The problem will show up if the two dops are not oriented the same during transfer. The push-to-the-side caused by the setscrew will be in a different direction causing the second side of the stone - either the crown or the pavilion - to be cut slightly off center in a different direction from the first side.

Solution:

The off center alignment problem will vanish if the two dops are rotated to the same position on the transfer block. If your transfer block has an alignment key so that the transferred stone's pavilion main facets and crown main facets are "stacked" - are perfectly aligned - one on top of the other, then the problem is automatically eliminated. If your transfer block has no alignment key, then simply "eye ball" the orientation of the two dops so that the two pin holes, (or the two bevels), are facing approximately the same direction. This will cause both sides of the stone to be slightly off center the same direction and the same amount - canceling the "off centered alignment" between the crown and the pavilion.

XII. Scratches from the Master Lap
" Its That Darn Graves - Again "
by Dave Woolley

Symptom:

Just when I thought I had everything under control with my used Graves Mark II faceting machine, I discovered I could not reproduce the angles, or polish the facets, that I had just cut with out using the "cheaters". I checked the feel of the main bearing under the lap - no wobble there. I checked the compression on the pivot bearings, (see "Graves Grief") - no wobble there. I checked the dop shaft and the main bearing in the head - still no wobble. Then, I checked the micrometer height adjustment shaft - its bearing surfaces were worn out!

Problem:

Talk about being upset, this bearing - complicated by having a threaded lower portion and a straight upper portion - does not seem to have enough metal in its housing of aluminum alloy to allow drilling, the insertion of bushings, and re-taping. A new expensive head replacement seems to be the only cure.

Solution:

The design of the Graves faceting head uses a spring loaded steel ball to lock the grooved micrometer knob at a position - controlling the height setting. This spring loaded ball pushes the shaft to the opposite side of the bored and partially tapped hole. It also causes the aluminum alloy of the head to be subject to wear in the bore on the side opposite the spring.

- Remove a pivot bearing and separate the head from the head bracket, (see "Graves Grief" for disassembly and re-assembly).

- Loosen the Allen setscrew holding the grooved micrometer knob on the shaft.

- Unscrew and remove the micrometer shaft from the head while removing the knob. (Don't loose the spring-loaded ball!)

- Clean the shaft and the bore with acetone.

- Re-grease only the threads of the shaft with a good wheel bearing grease, and partially re-install the shaft.

- Slide the knob back on the shaft while holding the spring loaded ball in position.

- Take a piece of mechanic's shim metal or cheap mechanic's "feeler" gauge and cut a thin strip of the 0.002 mm brass gauge metal to a length a little longer than the length of the top hole where the non-threaded shaft is located. The width of the strip should be about 1/8 inch or less depending on the amount of play. This width measurement and the thickness of the gauge metal may need to be changed during re-assembly if there is still some play, or if the movement of the micrometer adjustment becomes to tight or stiff.

- Bend a "tab" on the shim and lay the strip with the "tab" facing out - in the machined flat surface on the micrometer shaft where the knob set screw touched the shaft. Place one drop of "Liquid Lock Nut" on the outside of the shim. Keep the shim opposite the spring and ball. With the Knob loose on the shaft and the spring and retention ball in place, slide the shaft and the shim up into the bearing

- Let the tab overhang the aluminum alloy so that you can see the shim and keep it positioned opposite the spring and ball.

- Turn the shaft to engage the threads and carefully return the shaft to its normal position. You may have to temporarily tighten the knob set screw and turn the shaft with the knob: do not tighten the setscrew on any surface other than the machined flat on the shaft.

- Carefully grease the upper bore making sure that the shim stays in position. The "Liquid Lock Nut" will set in a few minutes - gluing the shim in position. If the shaft binds during re- assembly, use a thinner gauge shim and/or use a thinner width of shim metal. Be sure that the spring and ball are in their proper positions.

- Relocate the knob in the middle of the range of movement of the micrometer shaft and re-tighten the setscrew on the flat surface on the shaft.

- Reinstall the pivot bearings and reassemble the faceting head.

- Check to see that there is no play in the micrometer shaft bearing or the pivot bearings: both sets of bearings should feel a little tight.

- The alignment of the lap spindle shaft to the faceting head pivot should be checked and will probably need adjusting. (See the following "Graves Run Amok")

This repair took less than fifteen minutes to complete - the first attempt! I am indebted to Glenn Hawes of Lynchburg - Master Mechanic and Inventor - for his response to my cry of dismay; "It's That Darned Graves - Again." {The first repair attempt failed: the shim rotated with the shaft - glue the shim with Liquid Lock Nut.)

XIII. Scratches from the Master Lap
"Graves Run Amok"
by Dave Woolley

Observation:

Faceting machines have to be designed to allow for compensation in the alignment of their components in case the machine becomes worn or damaged. The Graves Mark II allows for these adjustments by making the lap spindle bearing a separate unite from the base. (The lap spindle bearing and its housing are replaceable!)

Problem:

At any time in the life of a faceting machine, the vertical axis of the swing movement of the faceting head may become non- - parallel with the lap axis. This results in the stone climbing upwards or downwards when the stone is swept back and forth across the lap. You can correct for this problem - poorly - with "cheaters" facet by facet. A badly worn lap will mimic this problem. Any repairs of any of the bearings in a faceting machine will create the necessity of checking this alignment. (See "Graves Grief" and "Its That Darn Graves - Again".)

Solution:

Ideally, every component of the faceting machine has been machined to perfect alignment. Each component should be rechecked individually and re-machined if necessary to achieve perfect alignment.

Since I can't afford that luxury, I settle for adjusting the spindle bearing to regain parallelism between the pivot axis of the faceting head and the lap spindle bearing.

You will need a set of small Allen wrenches, an 11mm wrench, and a Dial Indicator for this job [or the Beale/Woolley Depth of Cut Indicator].

As you know, a plane can be defined or located by three points. Our task is to move the plane of the lap, (if need be), to become at a right angle to the pivot axis in the faceting head. Unfortunately there are several pieces of metal between the lap and the pivot bearing - any of with may not be cut and mounted perfectly, or become worn or damaged. The slide base may not be cut parallel to the three spindle bearing mounts, the mast may not be at a right angle to the slide base, the boring in the head may not be parallel to the mast, the pivot bearings may not be parallel to the boring, the micrometer shaft boring may not be parallel to the pivot bearings, and the angle bearing in the head may not be at right angles to the mast. And yet, the Graves can be made to cut nearly perfect gems!
Here's how to check the alignment:

- Place the faceting head on the mast and put the 45? dop in the chuck. Place a straight dop in the 45? dop. Mount a dial indicator on the straight dop.

- Adjust the 45? dop, the protractor stop block, the height of the faceting head, and the dial indicator until you can touch the surface of the spindle that supports a lap - with the

dial indicator "finger". You will have to "fiddle" with the parts and pieces until you can clear the top of the spindle shaft when the mast is moved left and right on the slide base.

- Turn the spindle with the dial indicator "finger" just touching the spindle - lap supporting surface. (Always turn the spindle in the direction that tends to lift the indicator finger.) If you have an uncharged lap such as a "Master Lap" use it instead: check near its perimeter. Using an uncharged lap is faster and far more accurate than using the spindle-lap bearing surface. Find a spot that does not vary much in height when the spindle is turned and mark it with a magic marker - black dot. This black dot will move to become the "three" points that will define the location of the plane of the lap - as you rotate the spindle. Do not make three black dots for the three points because as you have just proved - neither your lap bearing surface on the spindle, nor your lap, is not perfectly true.

Take a break and read the following:

The difficulty in taking a reading from the "three" points that will define the plane of the lap is that you will be able to read only two points at a time without moving the slide base. Choose your three reference areas to be as close to the three adjustments underneath as possible: the two points closest to where you actually facets are the most important two to adjust to the same elevation. You will read the height of those two points first with the mast moved some what to the left - on the slide base. The third point can now be read by moving the mast somewhat to the right - on the slide base. Rotate the spindle to bring the black dot nearest to the three adjustments. If all three readings give the same value on the dial indicator, no correction is necessary! If they are not within about plus or minus one thousandth of an inch, you may wish to make corrections as follows:

- Retest as above being certain that the height lock knob is always facing the same direction[align it parallel to the slot]: an error may be induced from the bore that slides up and down the mast - if the faceting head is turned on the mast.[Always push the slide base away from you so that the nylon guide and the threaded shaft in the slot touch the far wall of the slot.]

- Unplug the machine. Carefully disassemble the major components of the machine: remove the water jar, and the faceting head. Clear your workspace.

- Tilt the machine backward to expose the underneath components. Block the machine so that it will not roll over.

- Remove the drive belt. Use a magic marker to make a reference as to the location of the large pulley on the spindle shaft. Remove the pulley from the shaft: the Allen setscrew may be located on the top side of the pulley Be careful: a spring is used to hold the spindle down into its bearing - the spring will push the pulley off the shaft. Do not raise the spindle shaft up out of its bearing.

- The three adjustment points are now accessible. Loosen the three lock nuts on the longer lock bolts. (If you should take these bolts out remove the lock nuts - they are not needed and should not be used.)

- Turn the machine right side up and mark the housing with three pencil marks so that you can visualize the location of the three adjustment points underneath.

Take a break and read the following:
At this point it is important to record the elevation of the three points each time you take a reading: I draw a circle on a piece of paper representing the bowl of the faceting machine with a mark in the center representing the spindle shaft. I draw three radial lines to the circle representing the location of the three adjustments. As I take a reading I write down the value in the approximate location of the where the reading was taken. At the first reading, I "zero" the gauge: subsequent readings will be positive or negative if the subsequent heights are above or below the first reading. This will help in visualizing which adjustment needs to be corrected when I turn the machine over. (Always remove the faceting head each time you turn the machine over.)

Start the correction by choosing one adjustment that needs to be lower - back off its lock bolt, the longer one, by turning it to the left. Turn the adjustment bolt to the right, (about three lines on the head of the bolt for reference mark). This will drop the elevation of this adjustment perhaps 5 thousands of an inch, (depending on where your black dot was made - on the spindle lap-bearing surface or on the perimeter of an uncharged lap). Re-tighten the locking bolt.

Check the new alignment of the spindle bearing as before. If necessary, repeat the procedure until the "three" points are at the same elevation.

Note:

If the machine is badly out of adjustment, it may be easier to start over by loosening the three lock bolts, (and removing their lock nuts), and raising all three adjustments until the spindle bearing housing touches the bottom of the machine. Then turn each adjustment bolt about half a turn to the right - this will cause each bolt to engage as an adjuster and allow you to start from a position that has a lot of adjustment travel. Tighten the three lock bolts. Each adjustment attempt should be to lower a high reading. Always be careful not to over tighten bolts - you can break the bearing housing!

When you are satisfied that you have tightened all three lock bolts and the spindle bearing adjustments are at the right heights, reinstall the spindle pulley and drive belt. Use the reference mark you made when you took the pulley off the shaft to locate the pulley at its proper place. Your Graves should be properly aligned and be ready to facet again!

Note:

The spindle bearing alignment procedure described in "Graves Run Amok", can be checked at any time with the dial indicator used in the following "Graves Reprieve".

XIV. Scratches from the Master Lap
"Graves Reprieve"
by Dave Woolley

Observation:

After studying as many faceting machines as possible, (and being dismayed at the going prices), I was determined to improve the performance of my second hand Graves Mark IV. The advertisement for the GemMaster with an electronic strain gauge claimed a gem could be cut in 20 minutes, "with the accuracy of microsurgery." Ultra Tec, with a dial indicator claimed, "absolutely reproducible angles." Facetron, with an original "floating needle" gauge claimed to be "simply the best."

Problem:

All of these modern American faceting machines - with their good and less than good points - have one thing my Graves does not have. They have a mechanical or an electronic device that lets you see - by dial indicator gauge pointer, floating pointer, or digital electronic strain gauge - the progress of cutting a facet to a preset angle. Once you have set the angle with the protractor stop-block and cut the first facet, you can duplicate cutting similar facets by cutting to the same number or position on the gauge. Likewise, when polishing there is no hunting and adjusting the cutting depth or angle; you set the protractor stop-lock from the previous cutting, zero the dial or match the floating needle, and polish without double checking and adjusting all the facets of a group.

Without such a device I have to judge the depth of each cut by the sound the cutting makes. Over cutting and incorrect angles are constant threats as the mast bends slightly when the faceting head is pushed against the protractor stop-block or the hardness of the rough changes with different facets. This requires constant readjustment of the settings or the use of the "cheaters" for polishing the facets. I would rather listen to classical music and enjoy faceting!

Solution:

I have epoxied a small diameter, dial indicator, manufactured by Starrett - "Last Word", part number 711-F, 1/1000 - to the side of the faceting head, which holds the gem. A small brass plate is epoxied to the side of the protractor stop-block. A bent brass rod, soldered to the plate, goes through the slot under the protractor, and a second soldered plate at the other end of the brass rod is in position to touch the dial indicator "finger" as the faceting head rotates downward - approaching the stop-block.

I have ground off a little of the protractor stop-block so the faceting head goes past the locked setting by about 0.1 degree.

The "finger" of the dial indicator makes contact with the brass plate about 1 full degree before the faceting head moves down to the protractor stop-block. Thus, I can watch the indicator pointer move around the dial as I approach the locked angle setting. I choose a stopping point about 0.1 degree short of touching the protractor stop-block so that the dial pointer is free moving and the protractor stop-block is never touched!

[The actual angle to which facets are cut is never "critical" except for the pavilion main facets. If the pavilion mains are cut too shallow or too steep, the gem will be a "fish eye": light will leak out the back of the stone rather than bounce around and back through the top of the gem. Somewhat "critical" is the angular difference between facets. If the facet angles are incorrect - all the same amount - the relationship between the facets will remain the same and meet point faceting will be successful. Therefor, the induced error of less than 0.1 degree described above will probably never affect the cutting of any gem and probably is much less error than the accidental - built-in - manufactured error of the Graves faceting head.

Note: The Critical Angle listed with the refractive index for each gem variety is an angle measured inside the stone at which light neither passes through a facet nor is internally reflected, but passes through the stone - parallel to the facet! The "critical" angle referred to above with the pavilion is related to the Critical Angle, but it is not measured the same way as the pavilion main facets, nor is it the same value.

Alternately, by locking the protractor stop-block at 45 degrees and turning the dial indicator face while I have a 45-degree dop resting flat on a Master Lap, I can "zero in" or adjust the dial indicator to read zero when the faceting head is actually at 45 degrees. There after, when any desired angle has been set or locked on the protractor, I know I can cut that angle when the dial indicator pointer comes to just touch zero.

Since there is no hand pressure applied against the stop-block - thus no springing of the mast - I can now cut accurate and reproducible facets.

Note: A modest pressure is applied against the mast by the return spring in the dial indicator and the flex of the soldered brass rod. However, this pressure is just about a constant over the full movement of the dial indicator and therefor, is not a variable while cutting a facet, nor from facet to facet.

The first advantage of this type system is that I can watch the dial and know how close I am to the desired depth of cut. Once I have "located" the first of a group of facets, I can push the stone into the lap as hard as I wish with no fear of cutting past the depth or desired angle. Since I never hit the protractor stop-block, there is "no" springing of the mast! I now have the speed and cutting accuracy that approaches the better machines with just a modest improvement that I call " Graves Reprieve ".

With the "Graves Reprieve", preform cutting is to a constant depth - the preform cylinder or cone is not lopsided even if the cylinder or cone has an irregular height. An additional benefit in cutting a variable hardness gem is that all facets in a set of facets will be cut to the same depth regardless of the orientation of the crystallographic axes and variable hardness!

Note: All minerals have variable hardness - even cubic crystal minerals - the "grain" of a diamond is an extreme example.

Previously, there was a persistent slight out of roundness in the finished gem. In cutting by sound, "harder grained" facets were not cut as deeply as "softer grained" facets. Using "Graves Reprieve" results in the following additional improvements:
1.) A uniform girdle height.

2.) The crown correctly aligns with the pavilion.
3.) Round cut stones are round and fancy cuts are easier to complete symmetrically.

Additional Construction Notes:

The dial indicator was from my dad's tool and die making supplies, circa 1945. I had to remove one set screw - grease port from the back side of the indicator to make a flat side for gluing. Many other brands are available: choose a small diameter dial indicator that will rest flat on the faceting head for good epoxy contact.

The epoxy was a Leech's "five minute" epoxy purchased from Marcus Beale. Trial locations of the components were glued with a minimum of epoxy so that I could relocate things if needed. Once I was satisfied with the location of components, I took "Graves Reprieve" apart, cleaned everything with acetone, and re-glued everything with a small surplus of glue: the tiny radius fillets of epoxy around the joints make the glued joints "shock proof" and much less likely to break loose.

The brass rod and plates were cut from model maker's supplies I purchased from a local Hardware Store. Any hobby shop should be able to supply the same material. I used electronic tin-lead solder with a rosin flux. (Never use acid-core solder for this type modification because the acid will encourage corrosion.) If I had the soldering to do over, I would use silver solder because it is stronger and more rigid than tin-lead solder. I also made a swing limiter of a springy, smaller diameter brass rod and soldered brass plate epoxied to the top of the height adjustment part of the faceting head to prevent the faceting head from accidentally swinging the dial indicator "finger" into the mast.

"Graves Reprieve" revisited
The Beale/Woolley OHM Meter Modification

The concept of the "Graves Reprieve" and the lumpy gear problem in a dial indicator caused Markus Beale to consider another way of modifying his Ultra Tech faceting machine. Instead of using a dial indicator, he tried a light bulb circuit and then used a Volt OHM meter as followed:

The bolt in the stop block that makes the fine adjustment to the angle stopping position was attached by a wire to the OHM meter, (solder the wire to a washer). The fine adjustment can still be made by rotating the bolt. Note that the friction band of the lock is made of an insulating material so that the stop block and fine adjustment bolt is electronically isolated from the body of the faceting machine. The other wire from the OHM meter is attached to the moving side of the stop block by soldering to make another excellent electrical connection. Note that the electrical circuit does not pass through a bearing. The OHM meter selector switch is set for the meter to have a lesser sensitivity while grinding and for its greatest sensitivity for prepolishing and polishing.

As a facet is cut and the stop block is approached, the end of the adjustment bolt begins to makes a poor electrical contact that improves as the cutting is finished. The meter needle moves as the facet is completed. By stopping the cutting at the same meter value, subsequent facets will be cut to the same reproducible angle and depth.

In a similar fashion a Graves head can be modified as follows. Drill a hole through the lock block at right angle to its stopping face. (Also grind a small flat - at right angles to the boring - on the opposite side where the hole exits the stop block. This becomes the bearing surface for the washer and nuts on the back end of the bolt.) Shave about 0.1 of a degree's worth of metal off the stopping face. Counter sink the drilled hole to allow clearance for the head of a slotted head stainless steel model airplane engine mounting bolt. The depth of the counter sunken hole must also accommodate a little more than an adjustment nut, a metal washer, and a plastic washer. Grind one nut to the diameter of the head of the bolt and place the modified nut on the bolt - advance it to almost touch the head - this allows the adjustment to the height of the head of the bolt. Next, place a metal and a plastic washer on the bolt. Insert a section of model airplane fuel line in the bored hole and insert the bolt with its head to be the protractor-lock stopping surface. Install a second plastic, a second metal washer, a lock washer, and two more nuts on the bolt. Attach a wire between the last two nuts. Run the wire to an OHM meter. Scratch the white paint off the stopping finger of the head to make electrical contact with the head of the bolt. Attach the second wire to the OHM meter and run it to the end of the dop spindle under the end nut - secure it under the nut between the washer and the aluminum alloy metal of the faceting head by making a single loop of wire. The washer must not tilt on the shaft due to this wire - center the loop.

Note: I found it necessary to make my own plastic washers from a thin sheet of plastic used as a collar stiffener from a new shirt and I also found it necessary to reduce the diameter of first metal washer and nut.

If the plastic parts insulate the bolt correctly, the OHM meter will read zero with the faceting head pushed into its storage position. Set the OHM meter to its greatest OHM sensitivity. The OHM meter will register a full movement of its needle after the faceting head touches the installed bolt. Adjust the height of the stopping bolt head with a 45 Degree dop sitting flat on a utility lap with the protractor reading 45 degrees by turning the head in or out with a screw driver. Tighten the nut against the lock washer.

I left the two probe wires plugged into the ohmmeter - using the inserted ends of the probe wires to lock in the two wires from the faceting head - so that I could trouble shoot using the meter. If the plastic insulator washers and the plastic tube do not isolate the bolt from the stop block, the meter will register before the head reaches the stop lock.

XV. Scratches from the Master Lap
"Beale's Bee's Wax"
by Dave Woolley

Observation:

In re-cutting a damaged gem it is desirable to remove the least amount of material possible to restore the stone: the size of the stone rapidly diminishes if the gem is not precisely located and centered on the dop stick. Often, only the crown will need to be re-cutting. Even in totally re-cutting a broken gem or cutting a piece of rough, a correct orientation of the stone will maximize the size and weight of the finished gem.

Problem:

Using dop wax, stick shellac, or epoxy to mount the damaged gem to a dop somewhat limits your ability to make minor corrections to precisely center the stone. With these dop cements, a fair degree of heat is required to soften the cement and shift the stone; stone shifts are often difficult to control when the wax is hot.

Solution:

Marcus Beale suggest that if the crown only needs to be re-cut, first glue the crown to a dop stick using bee's wax. Thoroughly clean the stone and the dop, and gently heat the stone, dop, and the wax to just above hand temperature and dop as usual. The secret of success is to use what ever centering technique you like, such as centering and leveling the stone with a three arm transfer block, or making test checks, (not test cuts), with the dop mounted in the faceting head. Sometimes pushing the pavilion into an empty cone dop stick mounted in a transfer block will center and level the stone. The soft bee's wax will easily allow readjustments of the stone until you are satisfied; then allow the stone, dop, and bee's wax to cool to room temperature. Now, transfer the stone to cut the crown: use "Leech's" five-minute epoxy for the transfer dop cement. With the epoxy on the pavilion side of the gem you are now ready to cut a new - perfectly aligned and leveled - crown. Of course, if both the pavilion and the crown of a broken gem must be re-cut, start with re-cutting the pavilion, but use the Beale's Bee's Wax technique to align the stone on the dop to minimize over cutting and rapid loss of gem material.

Addendum
"Beale's Bee's Wax for Cabochons"
by Dave Woolley

Marcus Beale points out that this "Beale's Bee's Wax" technique is especially useful for doping expensive rough for cutting cabochons. For example, an irregular chunk of precious opal can be oriented for a standard size cab or a maximum yield cab with the least loss of material if the cab is mounted on a faceting dop in bee's wax - bottoms up - first. Careful orienting with the soft wax will allow you to determine the best center; the best side to side; and best end to end position for the finished gem. Use a template and draw cab outlines. Draw centerlines for the short and the long axes of rectangles and ovals, etc. This will help you visualize what shape and size will give the best yield. Confirm the orientation by checking with a three-armed transfer block; this will allow you to see if each axis is symmetrical and if the outline is centered. Shift the stone as necessary and when you are satisfied, transfer the stone to a second faceting dop with a transfer block using epoxy cement. You can now cut a high yield cabochon: the initial outline shaping - length of axes - can be performed with a faceting machine set at 90?. Try this "Beale's Bee's Wax" technique for cabochons with a piece of inexpensive rough first for practice.

XVI. Scratches from the Master Lap
"Spodumene Splinters"
by Dave Woolley

Observation:

Three of the more difficult gems to facet, due to their perfect prismatic cleavage at 87? and 93? and good parting parallel to their front pinacoid, are the spodumene triplets: kunzite, green spodumene, and hiddenite. Successful cutting requires time, patience, a light touch, smooth running equipment, and the use of finer grained grinding wheels. An understanding of crystallography helps in the orientation of the rough to predict the cleavage and parting directions as well as in predicting the best orientation for color. "Spodumene splinters" are the result of a rushed job. Note: The most intense color is often looking down the length of prism but remember to tilt the table a little to avoid placing the table parallel to the parting - and the girdle parallel to the perfect cleavage.

Problem:

Frances Villemagne, proprietor of Frances's Stones, 13101 Spring Run Road, Richmond, offers the following tip. One of her acquaintances knew a professional spodumene faceter in another country who made an interesting discovery. Kunzite and green spodumene preforms, left overnight from one cutting operation, sometimes would be fractured on cleavage planes when examined a day or two latter. Apparently, some stones would crack after a period of time, as stress was relieved due to the removal of the rough.

Solution:

Frances's friend reported that the cutter had no more spontaneous fracturing if he stored his spodumene preforms in kerosene. No explanation was offered - perhaps the preforms had a smoother adjustment period in the kerosene bath. Be sure to wash the stone in acetone before doping.

XVII. Scratches from the Master Lap
"Graves' Cheating Cheater Lever"
by Dave Woolley

Observation:

While attempting to polish a Barion brilliant, I sadly discovered that the indexing of every facet had to be compensated for with the radial cheater (or adjuster). Having fixed just about everything else on a second hand Graves Mark IV faceting machine, I could not believe something else had gone wrong.

Problem:

The pivot bearing for the lever that holds the radial cheater and which unlocks the index gear, is a simple hole drilled in the faceting head casting with a steel pin pressed in through the hole and through a similar hole drilled through the lever. Eventually, the slight rocking movement caused by unlocking the index gear will wear the primitive

bearing surface so that the pin will slip back and forth - sideways. This movement is undetectable except that, all of a sudden, the radial cheater will have to be massively adjusted for each facet, a condition caused by what I call the "Graves' cheating cheater lever".

Solution:

The first attempt at a repair should be to press the pivot pin back in with a small "C" clamp - if it has worked loose. This may be attempted if the pin is sticking out of the body of the faceting head.

The second attempt at a repair:
A trip to the spare parts department, i.e. the junk bin, provided a small spring that could be slipped between the lever arm and the body casting of the faceting head. This spring provides a strong lateral force on the arm keeping the arm pressed to one side of it's unfortunate wear movement. Due to the fact that the lever has such a short swing to unlock the index gear, the added spring has no tendency to work its way loose or fall out. The spring that I found is slightly larger in diameter than spring used inside a retractable ball point pen; is much shorter in length; and has considerably more resistance to a squeeze pressure. If you find your Graves having a "cheating cheater lever", this may be the least expensive cure you can find.

The final attempt at a repair - if needed - will be to re-drill the holes and use a larger diameter pin. A bushing should be considered. This re-drilling type of repair should be done in an instrument repair shop so that the new holes and pin do not start off with the same problem.

UPDATE: GRAVES CHEATING CHEATER LEAVER

Graves repairs this loose pin by wrapping it with thin shim metal and reinstalling the shim and the pin in the original boring. ..