Honeywell

Process Guide for Deburring Technologies

Federal Manufacturing & Technologies

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PROCESS GUIDE FOR DEBURRING TECHNOLOGIES

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Abstract

This report is an updated and consolidated view of the current deburring processes at the Kansas City Plant (KCP). It includes specific examples of current burr problems and the methods used for their detection. Also included is a pictorial review of the large variety of available deburr tools, along with a complete numerical listing of existing tools and their descriptions. The process for deburring all the major part feature categories is discussed.

Summary

Burrs on miniature-mechanism precision parts cause many problems. A partial list of these problems includes gaging inaccuracies, damaged surfaces, electrical shorts, interference fits, and plating build-up. This document was written to be an aid in detecting and removing burrs. It includes several useful methods for discovering and verifying their presence and it discusses the required use of at least two different types of verification methods to ensure or deny the presence of burrs. Also discussed are the equipment and tools required for identifying burrs.

Two of the latest case studies on hard-to-identify burrs are presented, along with the methods used to detect and verify the existence of burrs. This document includes a pictorial review of a variety of deburr tools, along with a complete numerical listing of tools currently available for use at KCP. It also includes specific instructions for burr removal on various part features, e.g., shafts, holes, internal as well as external threads, and part edges; and the deburr tools required. Currently used on-machine deburring methods and all mass burr-removal processes used in this plant are described for reference purposes. Finally, the document discusses burrs and deburring from the point of view of the deburring personnel, the assemblers, the engineers, the inspectors, and the machinists who work with miniature precision parts.

Discussion

Scope and Purpose

The purpose of this project was to provide a reference manual, for plant-wide use at KCP, addressing the current deburring problems, deburring processes, and burr identification procedures. Although the reference manual is primarily intended for use by deburr personnel, it is also a resource for associates in production, quality, and engineering. In fact, it is useful to anyone who works with precision miniature mechanism parts and their burrs.

Activity

What Is a "Burr"?

Although the *Merriam-Webster Dictionary* defines a burr as "a thin ridge or area of roughness produced in cutting or shaping metal,"[1] burrs can occur not only on metal but also on plastics and most other materials. Another definition is this: "a rough edge or area remaining on material after it has been cast, cut, or drilled."[2]

Burrs can be caused by a variety of processes, including any type of machining, casting, molding, or grinding. Burrs also occur when parts are damaged, so the burr definition includes any raised material caused by dents, scratches, and other damage.

In this document, we will talk mainly about metallic burrs produced during the machining process, because this tends to be where the most confusion on the subject occurs.

History of Burrs

Burrs have been around since humans first started making tools and products out of stone. They needed some way to finish the parts— to get rid of the rough edges—after they had either chipped, ground, or filed them into the final shape. It is assumed that stones and other types of abrasives were used for this purpose.

This continued for centuries, during which man continued to make slight improvements to the process. With the Dark Ages and the Crusades came a need for large quantities of swords. Someone decided that it was taking way too long to finish the edges on all those swords. Instead of hand-stoning the edges of each sword individually, they threw several into a barrel with lots of small stones, and rolled the barrel around for a while. The finished results were about the same as stoning the edges by hand. This is how men discovered mass finishing of metal parts by barrel tumbling.

Again, the centuries saw only small process improvements, and progress in burr-removal was fairly slow until about 50 years ago. Since then, the development of new mechanized processes and hand deburring tools has expanded and continues to expand at an even faster rate.

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[1] http://www.merriam-webster.com/
[2] http://www.thefreedictionary.com

Why Burr-Free Parts Are Required

Burr free-parts are required at Honeywell for many reasons, depending mainly on the part's use in the next assembly. Some of the problems caused by burrs are listed below.

- Inaccurate gaging: Parts cannot be measured accurately when there are burrs on the surfaces to be measured. See Figure 1.
- Damaged gages: Burrs on parts will scratch and dent gages.
- Damaged fixtures: Burrs on parts will also scratch and dent fixtures.
- Parts improperly located in fixtures: As with gaging, burrs on parts prevent mating parts to locate properly. See Figure 2.
- Scratched surfaces: Burrs not only damage gages and fixtures, but also scratch the surfaces they touch.
- Increased friction in assemblies: Burrs on parts rub against the surfaces of mating parts, which causes friction.
- Increased wear in moving parts: Burrs on parts erode the mating part surface much more quickly.
- Damage to sealing surfaces: Burrs can easily cause damage to any surface they touch, particularly affecting high surface-finish requirements on sealing surfaces.
- Shorts in electrical circuits: Burrs on parts may get knocked off and dropped into circuits/circuit boards, causing shorts.
- Plating inconsistencies: Plating builds up at a faster rate on burrs. See Figure 3.
- Interference with fits. If mating parts have very similar size diameters, burrs can be large enough to interfere with their assembly.

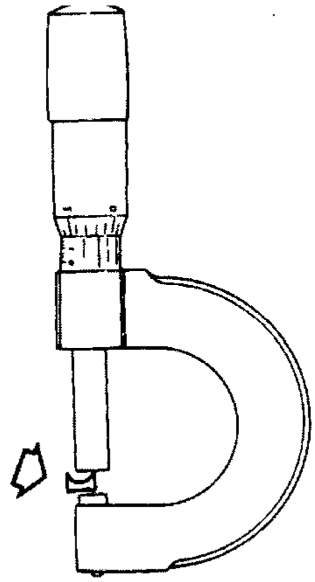

Figure 1: Burrs Prevent Accurate Size Measurement

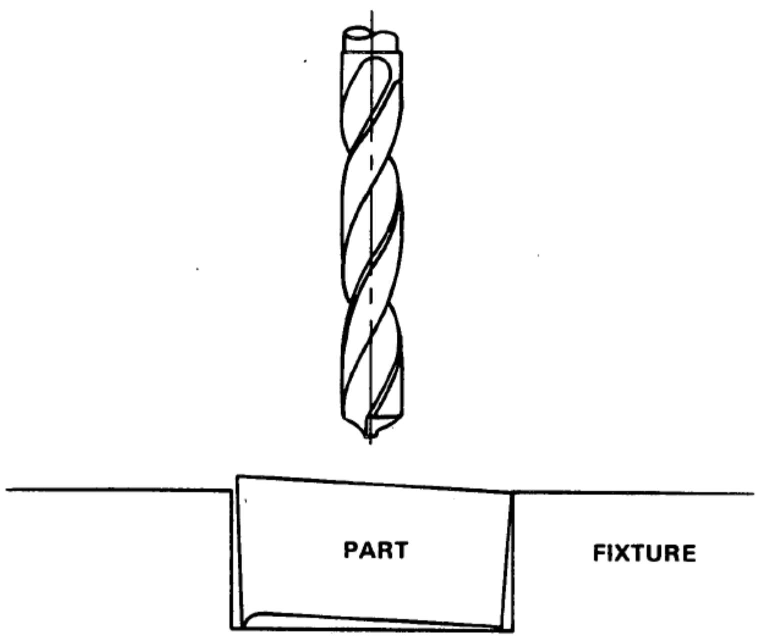

Figure 2: Burrs Cause Mislocation in Fixtures

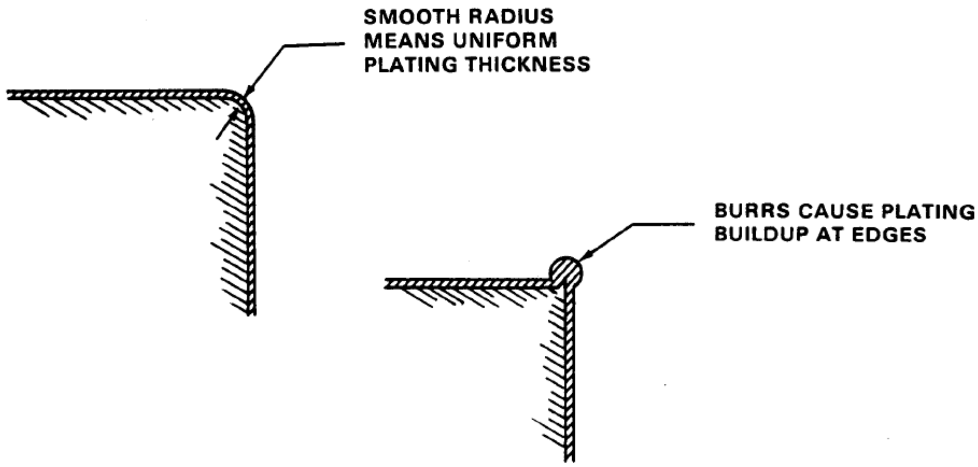

Figure 3: Burrs Cause Plating Build-up on Edges

Safety Concerns When Deburring Parts

Although the parts and the tools used to deburr edges are generally small, safety is a major concern. Burr balls, burr knives, and similar tools have sharp edges and can sometimes cause injury simply by being touched.

Hand motor rotary-type tools have gained popularity with deburr operators. The rotating brushes and other chucked sharp tools can easily cause injury with just a slip of the hand. Even small abrasive points can cause injury from a slip while they are rotating at high speeds. This danger also exists when using bench motors with the larger diameter abrasive bristle brushes. The bench motor brush can pull sharp-edged parts out of an operator's hand, which can cause cuts and produce hazards associated with flying objects.

Burr Knives

Burr knives need to be very sharp to remove burrs properly, efficiently, and with the least amount of effort. Like any other tool, a dull burr knife is more dangerous than a sharp one. Always use good, ***sharp*** burr tools.

This being said, great care must be taken for your personal safety when using knives, which can cut and penetrate your skin with the same efficiency that they cut metal and plastic. Despite the dangers, cut-proof gloves are **not** required during use of burr knives. This is because operators wearing the gloves tend to lose their "feel" and ability to properly manipulate both the knives and the parts. In fact, in this particular situation, cut-proof gloves might cause more injuries than they deter.

Always keep burr knives—and all sharps for that matter—in protective covers to ensure that no one gets accidently cut or poked. One safe and appropriate way to store sharps is to stick them into a piece of Styrofoam or other similar material placed on top of the workbench, as shown in Figure 4. This doubles as a convenient way to have the tools right on the workbench ready for use instead of packaged individually and stuck away in a drawer somewhere out of reach.

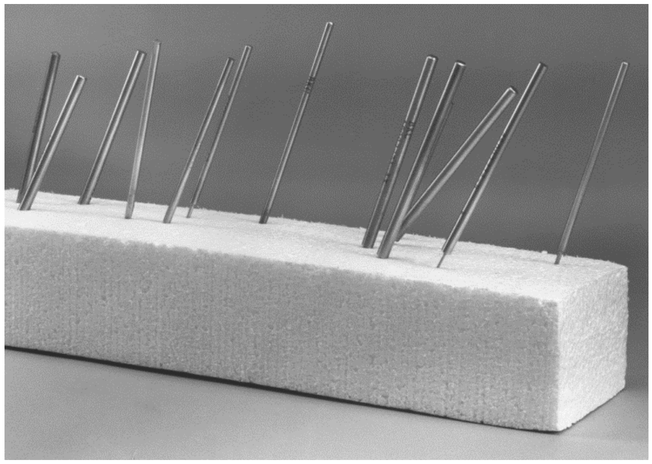

Figure 4: Burr Knife and Sharps Workbench Protective Holder

Bench Motors with Rotating Brushes

Bench motors are typically used with larger-diameter abrasive bristle brushes mounted in the chuck. They have a variable speed control that allows a fairly high rotational speed. Although this combination of the speed and brush size makes quick work of burrs on the outside edges of parts, it also creates a high potential for pulling the part out of the operator's hand and creates a hazard for entanglement of clothing in the motor chuck and brush. Operators should be extremely careful when deburring parts with a bench motor and should use a slower rotational speed when possible. This will reduce the potential for flying parts. As always, safety glasses are a requirement. Although cut-proof gloves are **not** a requirement for this process, they may be worn as long as operators are confident that they can hold the part adequately.

Hand Motors

Even the small hand motors used in deburring can rotate up to 1,000 revolutions per minute. This presents a hazard in that an abrasive tip of any type mounted in the motor, be it rubber-based or stone, can cause injury if it slips off the part onto a finger or hand. As with the bench motor, run these hand motors at a reduced speed that optimizes both safety *and* burr removal. Again, cut-proof gloves are **not** required, for the reasons discussed previously.

Debris from the Deburring Process

When parts are deburred using rubber-based products, sand paper, abrasive wheels, stones, or even knives, particles are generated (from the parts as well as the deburring media) and settle on everything in the area. This debris settles on the parts, the work bench, the floor, and—yes—even on the operators.

Although for years the best practice was to use compressed air to blow this debris off the parts and everything else, **this is no longer considered a best practice.** The current best practice is to use vacuum systems to pull these generated particles away from the operator during the deburring process. Vacuuming keeps to a minimum the amount of debris that is dispersed into the air and then settles out. Vacuum adapters are available that will pull the debris from the back of the workbench, from the front of the workbench, and from directly behind the bench motor. This does not keep all the particulate matter out of the air, but it does significantly reduce it. Again, never use compressed air to blow off the parts or the work surfaces. Instead, use the vacuum system to remove the particles.

Burr Detection

The most important aspect of deburring is the ability to find and identify burrs. On large parts, the burrs are generally big enough to see with the naked eye or a magnifying glass. The smaller the part, the more difficult it becomes to identify burrs. A microscope with appropriate lighting will be necessary to find and remove burrs. (Microscopes and lighting will be discussed in more detail later in this document.)

The Importance of Cleaning

The most important requirement for locating burrs is that the parts must be clean. Otherwise it is difficult to distinguish between actual burrs and any dirt and debris left behind from the deburring or machining process. For this reason, all parts must be cleaned prior to deburring (so burrs can be recognized and removed), and then cleaned again immediately afterward (so parts can be scrutinized to confirm or deny a burr-free condition).

Observation Angle or Best Direction

Because of their sizes and locations, burrs are often difficult to see. The direction at which part edges are viewed can make a big difference in the ability to see the burrs. Through-holes generally have burrs at one end or the other. When the edge of the hole is viewed from the end that the burr is actually on, the burr might not be visible. In contrast, when the edge is viewed through the hole from the opposite end, the burr appears clearly because it is rolled over the edge into the hole. This is illustrated in Figure 5.

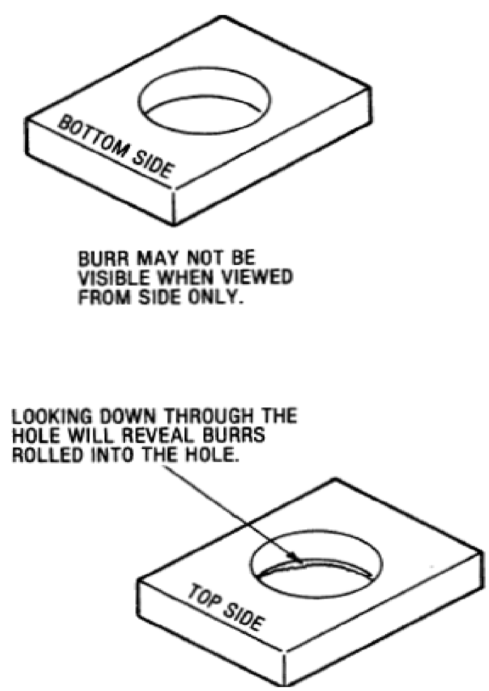

Figure 5: Best Direction for Viewing Rolled-Over-Edge Burr

In addition, the best direction for finding burrs is not simply looking at edges from different sides, but also rotating and manipulating the part so that edges are angled to your line of sight. A general rule of thumb is to view the part at a 30° to 60° angle to any of the edges. This concept is illustrated in Figure 6.

Figure 6: View Edge at Angle to Line of Sight

This also applies to the light source used for illuminating the parts to aid in identifying burrs. The burrs can be hard to see if the light is directed at a parallel angle to the edge of the part. It is better to hold the edge of the part being investigated at a 30° to 60° angle to the direction of the light's focus, as shown in Figure 7.

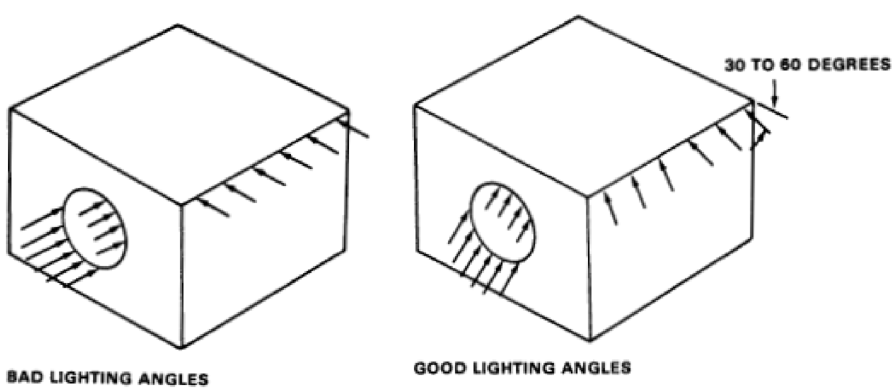

Figure 7: Use of Lighting Angle for Viewing Edges

In short, use angles to your advantage. Look at the part's edges at an angle to your line of sight. Also situate the light source so that it directs the light beam at an angle to the part edge being viewed. Small changes in these two variables will dramatically enhance your ability to see burrs on the part features.

Use and Quality of Microscope

The microscope is the most important tool used in finding and removing burrs. Although a variety of good microscopes exist on the market today, certain qualities are necessary to optimize an operator's ability to find the burrs and remove them efficiently. The microscope's working area, for example, must be large enough to allow the part to be manipulated under the lens while still keeping the part in focus.

The quality of the microscope required to perform deburring should be at least as good as the microscope used by those inspecting the parts. There is just no way to compensate for a poor microscope, i.e., one that prevents an operator from doing an adequate job.

Lighting Sources

Also important is the type of lighting source used—with or without a microscope.

Light sources can be used in two ways to aid in finding burrs. Both of these techniques are effective and may be used separately or in combination. They are as follows:

1. The light is used to illuminate the part so that the burrs can be seen.
2. The light is directed across the part to produce a shadow that identifies the location of the burr.

The intensity of the light is crucial. With low light, the part appears too dark to see the burrs. With too much light, the part reflects so much that the reflection masks the burrs. Find a happy medium.

Indirect Lighting

Indirect lighting is the most widely used light source for deburring. It includes most light sources that can be directed at the working area and have enough intensity to illuminate the part. Such light sources include tensor lights, fiber optic lights, ring lights, and fluorescent illuminators. Some are brighter than others, and some have a more concentrated beam of light than others. Each has attributes that can be used in certain situations to aid in finding and removing burrs.

Through-the-Lens Lighting

The best lighting source for finding and removing burrs, particularly in deep holes, is "through-the-lens lighting." The beam of light is directed down through the microscope optics, parallel to its line of sight. This provides more depth of field and is always pointing in the direction that you are looking when using the scope. The best microscopes have this type of lighting.

Backlighting

In backlighting, either the light source is located in the base of the microscope or the base has a reflective surface that illuminates the part from below. Although this type of lighting is rarely used in deburring, it might be helpful in some circumstances.

Methods for Discovering Burrs

Sometimes visual verification is not enough to validate the presence of burrs, because they cannot be seen well enough. A useful technique is the tactile method using your fingernail, toothpicks, steel probes, Q-tips, pipe cleaners, and cotton gloves. (A "go" plug gage can also be used to detect burrs at the edges of through-holes.)

Fingernail

A fingernail dragged over the edge of the part can detect burrs as small as .0005 inch. See Figure 8. This may be the most convenient method, since the tool is readily available. Note: Part of the fingernail itself might be shaved off and left on the part if there is a burr or very sharp edge.

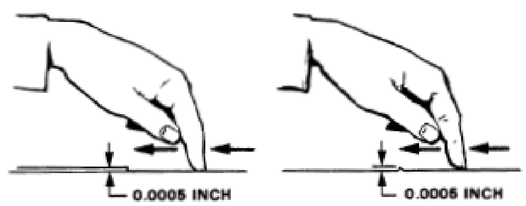

Figure 8: Detection of Burrs with a Fingernail

Toothpick/Wooden Probe

If the part's edge is inaccessible to probing with a fingernail, try a toothpick or other small wooden probe. This "toothpick method" is the tactile method used most often to validate the existence of burrs in hard-to-reach and hard-to-see areas.

The toothpick or similar probe is pulled or pushed across the area in question. Not only will a slight hang-up at the burr be felt, but part of the wooden probe itself will be removed by any burr. A small bit of the probe will remain on the part. In fact, tiny burrs might actually dislodge and embed themselves in the end of the toothpick. For this reason, inspect both the part edge and the end of the toothpick for remaining material. This inspection is a hard and fast rule, because it helps distinguish between (for example) a mere depression in a metal surface and a real burr. Only a real burr will catch/capture a piece of the probe.

When using a toothpick to detect and confirm burrs on edges and surfaces, do so correctly. Push or drag the toothpick across the edge or surface in question at an angle of 15 to 50 degrees to that edge or surface. Avoid dragging or pushing the toothpick along a line almost parallel to the edge or surface.

Although the tip of the toothpick may "hang" when lightly rubbed over the edge, this does not necessarily indicate a burr. Unless the toothpick leaves a little piece of itself on the part edge, or removes part of the burr by embedding it in the tip, then a burr is unlikely. Again, use only the ***tip*** of the toothpick or wooden probe, not its side.

Note: Most toothpicks today are manufactured with a thin coating of wax. This wax will be deposited on any part probed by the toothpick. For parts with critical cleanliness requirements, another burr-detection method might be more appropriate.

Dental Probe

Although a metal dental probe can be used in a manner similar to the toothpick described above, a metal probe has certain disadvantages. It will leave no visible indication that a burr is present, so detection will be by "feel" only. Also, metal probes are generally avoided because they are too likely to damage the part surfaces they probe.

Q-Tips and Pipe Cleaners

Another tactile method used to verify the presence of burrs in hard-to-reach areas is lightly rubbing a clean Q-Tip or pipe cleaner across an edge where burrs are in question. If burrs are present, they will catch on the fibers, cause drag, and trap small pieces of the fibers on the part edge. Again, if the burrs are very fine, they may be dislodged and deposited in the Q-tip or pipe cleaner, so both the part edge and the investigating tool need to be visually inspected. Clean tools make this investigation process much easier and more reliable.

When Q-tips cannot be used, as in the case of small hole edges, use only pipe cleaners. Warning: Be very gentle when using pipe cleaners for this process. Pipe cleaners have fine cloth fibers held together by twisted wires. These twisted wires often have sharp protruding ends that can cut the operator and scratch the part surfaces—particularly the sides and edges of small holes. In fact, even the smooth part of the pipe cleaner wires can damage part edges if rubbed too forcefully.

Cotton Gloves

The use of cotton gloves for identifying burrs is nearly equivalent to the use of Q-tips and pipe cleaners. Instead of being probed with tools, the part is manipulated by white-gloved hands. With hands and fingers, the operator carefully rubs and probes part edges to feel for the drag of burrs on the gloves. If burrs exist, they will tend to pull fibers from the gloves. These fibers will then be visible on burr-laden part edges. This method is generally used on larger parts where the entire part can be manipulated and probed with gloved hands.

Plug Gages

A "go" plug gage can also help determine the presence of rolled-over burrs at either end of a through hole. If a "go" plug gage cannot be inserted into a hole that is supposed to accept it, then the hole is either undersized or has a rolled-over burr on the hole's entrance edge. Similarly, if the plug gage is inserted into the hole but will not go completely though it, then the hole is either tapered or has a rolled-over burr on the hole's bottom edge. Important: This use of "go" plug gages does not—by itself—confirm or rule out the presence of burrs. It is simply an aid to be used in combination with another burr identification procedure before making the final decision.

<u>Specific Examples of Problem Burrs</u>

"Sparkle Burrs" in Holes

Much recent discussion has focused on "sparkle burrs," i.e., actual or apparent very tiny burrs that are pulled and sticking up from a hole's surface or from a bored interior diameter surface.

What causes sparkle burrs? As material is removed during the machining process, the cutting tool sometimes tears out tiny pieces of material, leaving tiny divots in the part rather than smoothly cutting it off. This generally leaves both plus and minus material on the surface, both of which look very shiny when viewed under the microscope. Just as there are "sparkle burrs" as shown in Figure 9, there are also "sparkle divots."

Figure 9: Example of "Sparkle Burrs" in Hole

Again, what seems to be a burr might not really be one. A possible sparkle burr requires a secondary source of justification. A toothpick, wooden probe, or even a Q-tip can be used for the final determination. When the suspected "sparkle" is probed, one or both of two things will happen: A part of the burr will be removed and will stick in the probe, or a piece of the probe will be left on the burr. A probe hanging up on a suspected "sparkle" is not enough evidence to assess it as a burr. When using probes always look for evidence of the burr, either on the probe or on the part surface.

Shiny Edge Burrs

Another recently discussed phenomenon is "shiny edge" burrs—part edges that appear extremely shiny under a microscope. Although a typical assumption is that this shine indicates either an extremely sharp edge or a rolled-over burr, this is not necessarily true. Edges shine for a variety of reasons. A major reason is that deburring with a metal or motorized tool often leaves a very shiny surface on the edge being worked. The more material removed from the part edge, the wider the area of the shiny surface. The less material removed, the narrower the shiny surface. If nothing else is done to that edge, it will remain bright and shiny.

This is why—after an operator's best effort at deburring a part—the usual follow-up practice is to brush the part lightly with a bench motor to ensure that the surface finish is consistent over the entire part. Although surface-finish consistency over the entire part (and even from part to part) is not actually required, it is nevertheless a desired and expected quality. Everyone involved with the parts after the deburring process—including inspectors, next-assembly engineers, and operators—expects to see a consistent finish.

So once again: If a part has a “shiny edge” that might be a rolled-over burr, a secondary source of justification is needed to make the final determination. This is probably the best example of when to use a toothpick or wooden probe (if it is used correctly). Figure 10 and Figure 11 show “shiny edges” that actually are burrs.

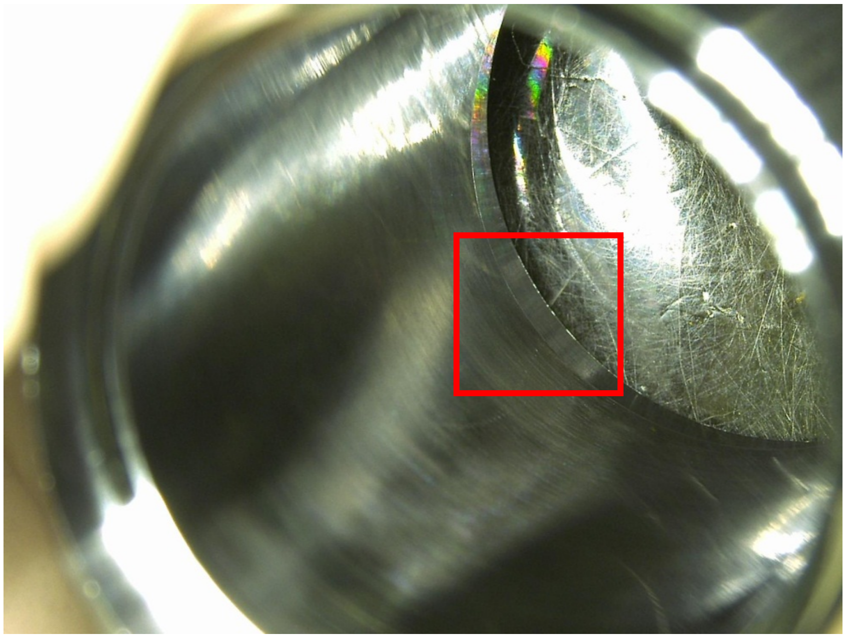

Figure 10: "Shiny Edge" Where Burr is Present

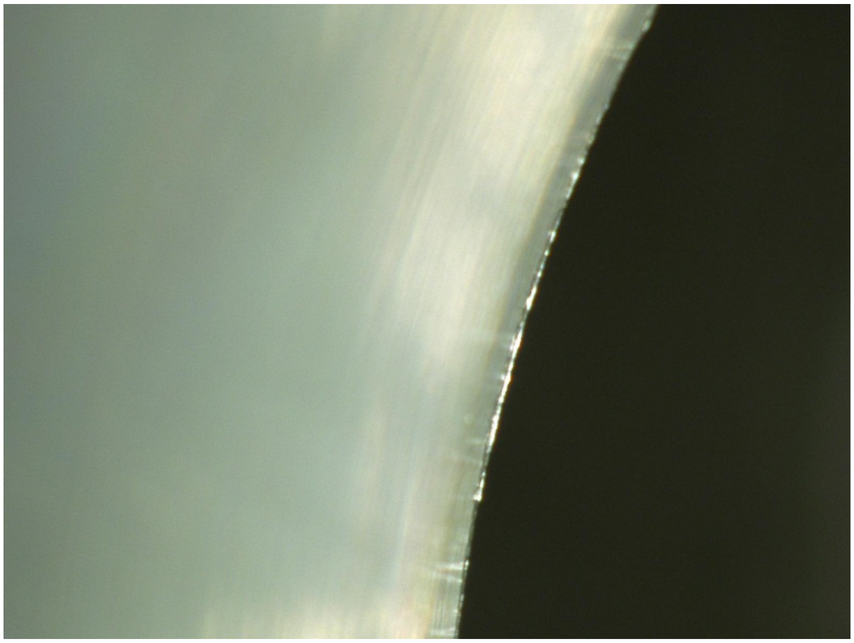

Figure 11: Enlargement of "Shiny Edge" Burr

Edge Breaks

Definition

An “edge break” is the corner radii, chamfer, and/or any other shape in between that is left on the part edge after deburring or removal of material. The size of the edge break is determined by the size of the 45° chamfer that the break fits within. For example, a .010 inch x .010 inch chamfer would be considered to be a .010 inch break.

Suppose that the drawing calls out a .010 inch max break. In that case, any shape or size of break that falls within the triangular area made by the .010 inch chamfer line and the square shoulder lines of the part edge would be considered acceptable, as defined in the Figure 12 drawing.

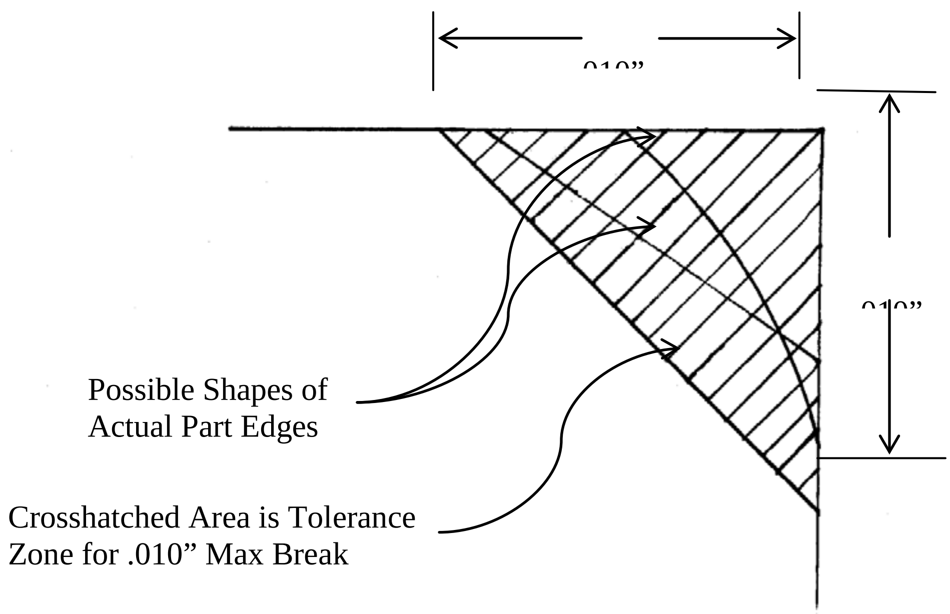

Figure 12: Definition of .010-inch Max Edge Break

As for edge-break size on miniature mechanism parts (at least at Honeywell FM&T), the most frequently cited values are .010 inch, .005 inch, and .003 inch max. If a part is covered by the general workmanship specification 9900000, and no other specifications are referenced, then a .010 max edge break is allowed unless the part drawing specifically calls out a different tolerance. Important: Many parts are controlled by program-specific specifications requiring tighter breaks than .010 max. These generally specify .005 max breaks and (occasionally) even breaks as small as .003 max.

Unless you have actually viewed parts with edge breaks of this size, it is difficult to envision how small these edge breaks really are. In outside industry, such edge breaks would be considered sharp and non-essential, but this is what we have to work to at FM&T.

Edge Break Standards

Edge break standards are available for comparing edge break sizes. These standards serve as useful guides and help to determine the size of part edge breaks. Figure 13 shows an example set that includes five cylinders. Each cylinder has a precisely generated radius on one end, and on the other end has the equivalent size of precisely machined chamfer. These samples are sized so that they can be physically removed from the case and placed directly adjacent to the part edge in question, allowing a visual side-by-side comparison of the two. The reason that each standard includes both a radius and a chamfered edge is that these are the extremes in the shapes that edge breaks contain, as explained earlier.

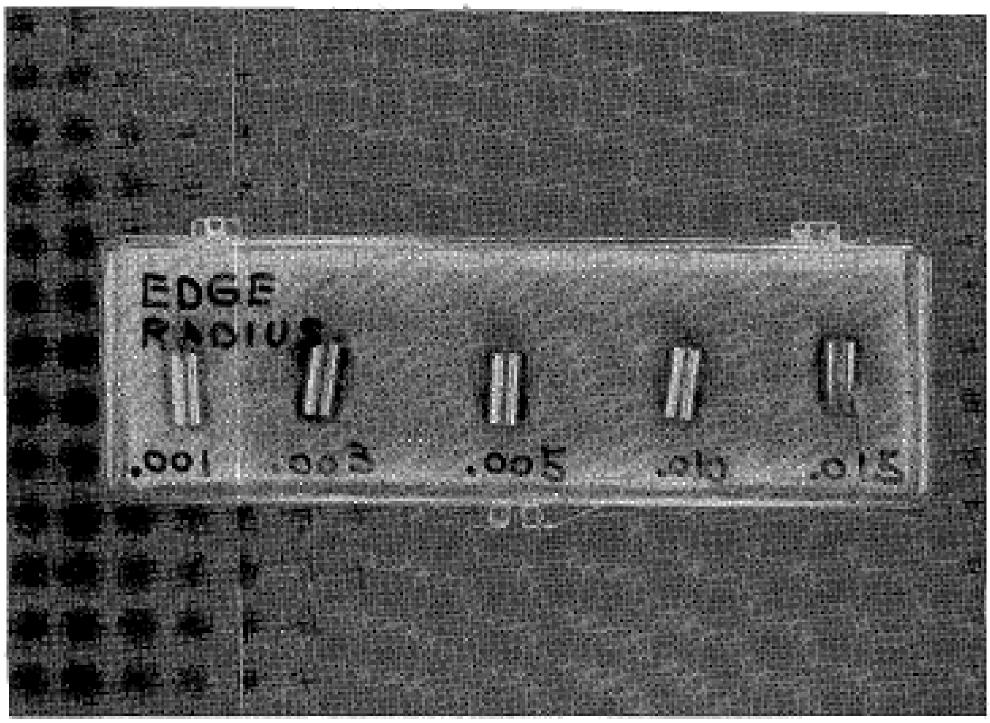

Figure 13: Edge Break Standard Set Used to Compare Edge Break Sizes

Edge Break and Surface Finish Consistency

In edge breaks of the same tolerance, consistency is generally not a drawing requirement. For that reason, a part—or even the same edge—may contain breaks with different sizes and shapes, as long as they are within the specified tolerance. This also applies to surface finishes. Nevertheless, as explained previously, inspectors and assemblers not only prefer but also *expect* consistency in both the shape and the size of edge breaks on a part. (This is discussed in more detail later.)

This expectation applies not only to edges on the same part, but also to all of the parts within the job lot, and also applies to the surface finish appearance on parts. Again, even though consistency of part edge breaks and surface finishes are not a requirement, they are definitely an expectation.

Surface Finish Requirements

The general workmanship specification, 9900000, states that—unless otherwise specified on the part drawings—a minimum surface finish of 125 microinches is required on all surfaces. However, as we discussed earlier, most parts are covered by their program-specific specifications that might contain tighter surface finish requirements. In general, most miniature precision parts require a minimum surface finish of 63 microinches. Some part surfaces require even better finishes. In fact, most of the small parts deburred at KCP today meet a minimum surface finish of 32 microinches.

Although it is beyond the scope of this document to describe exactly how the surface finish number is determined, the number is basically the average value of the peaks and valleys of the microscopic ridges on the surface of the part. Therefore, the higher the surface finish number, the rougher the finish; the lower the number, the smoother the finish.

If a part's surface is large enough, a surface finish analyzer can be used to determine the actual surface finish. The analyzer will sweep the surface and calculate an actual value of the finish. It is not feasible, however, for everyone involved with deburring and machining to have one of these analyzers, and not all surfaces are large enough to accommodate an analyzer. An available alternative is a surface finish comparator (Figure 14) that can be used as both a visual and a tactile comparison. Each comparator has a range of different surface finishes that are produced by different machine types and are marked accordingly for comparison purposes.

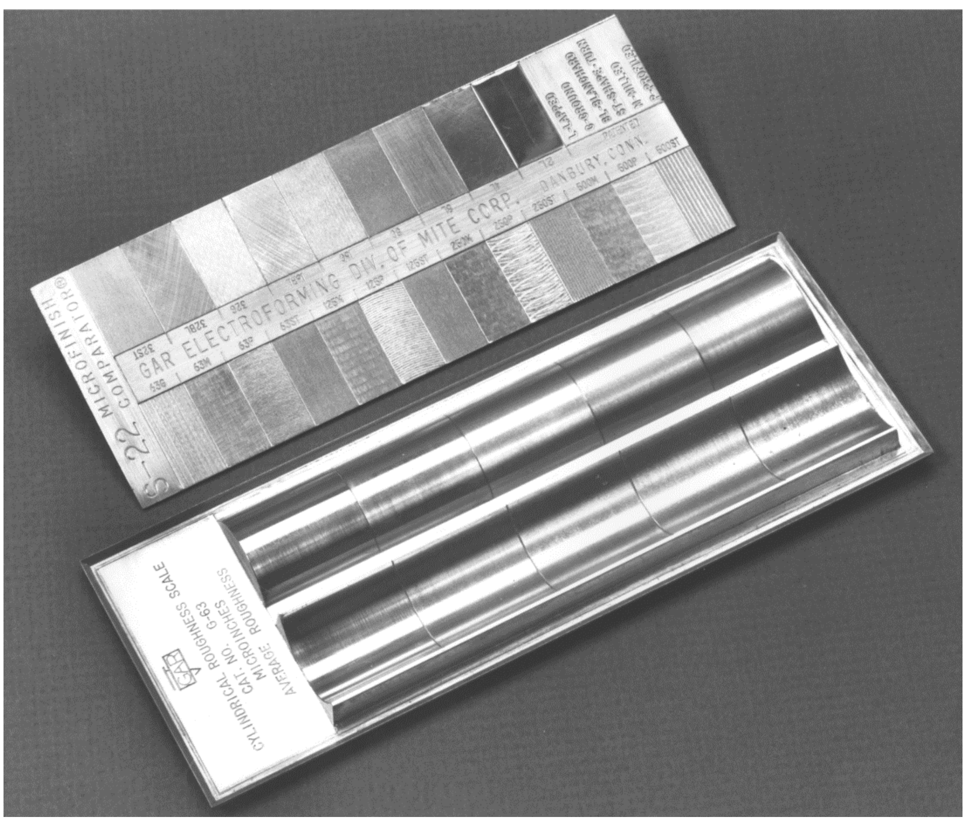

Figure 14: Surface Finish Comparators

Tools Available for Use in Hand-Deburring

A broad variety of tools exist for deburring machined parts. (As will be discussed later, deburring larger parts requires different tools than deburring smaller parts. Also, in some situations only certain tools can be used.)

The next few pages of this document illustrate the wide variety of deburr tools available at Honeywell. Each tool image is accompanied by a label with the corresponding support stores number. This is by no means a complete pictorial listing, and several of the tools are no longer available, as indicated by their accompanying “Obsolete” labels.

Immediately following the pictorial listing of the hand deburring tools is a more complete numerical and descriptive listing of tools available for use. Although the list is in support-stores numerical order and is as complete as possible, there are always some tools that will be missed. Although in some instances the support-stores numbers are no longer active, they are still tied to the description so they can easily be reactivated if the tools are required.

Pictorial Review of Support Stores Deburring Tools

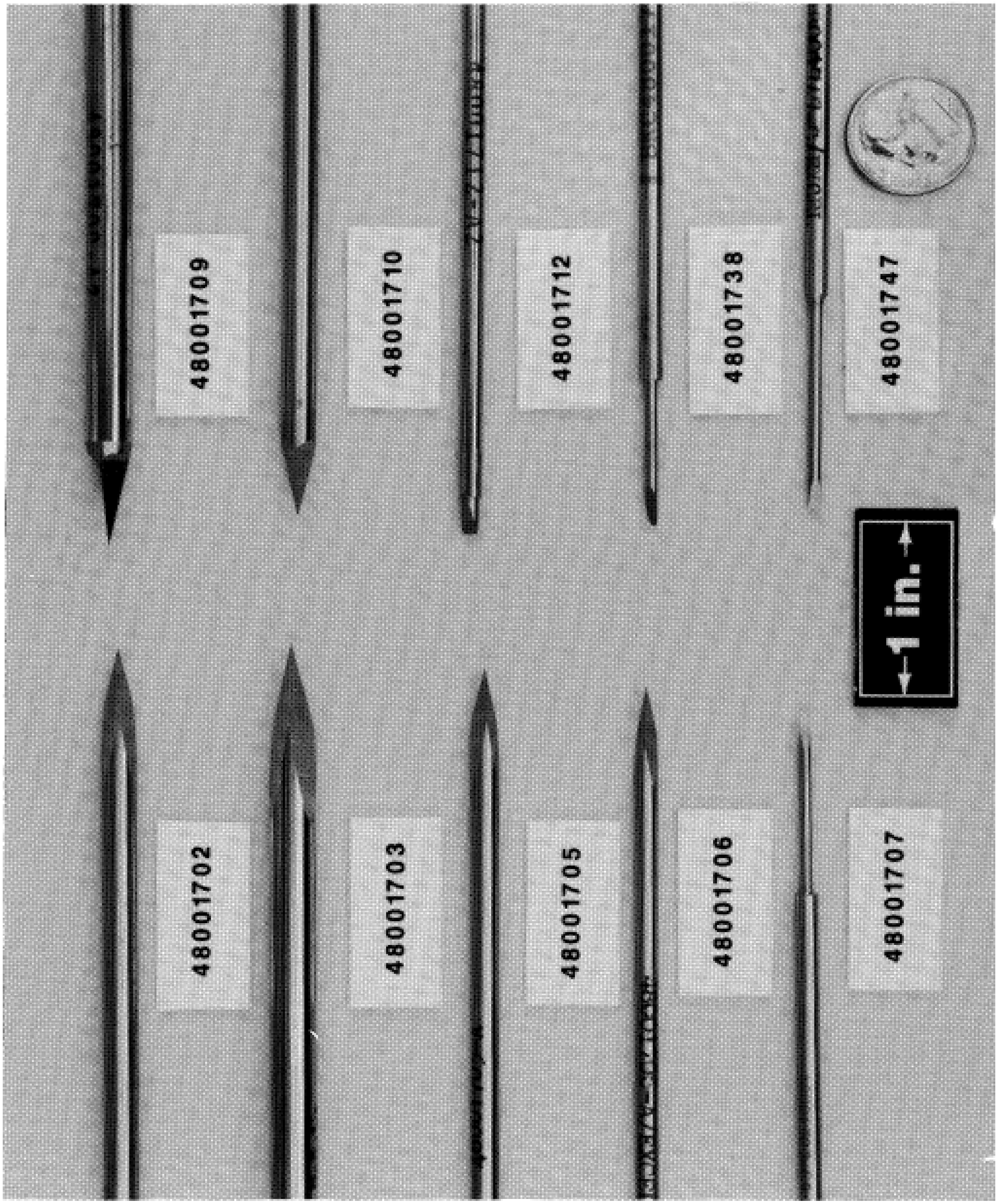

Figure 15: Deburr Tools Picture 1

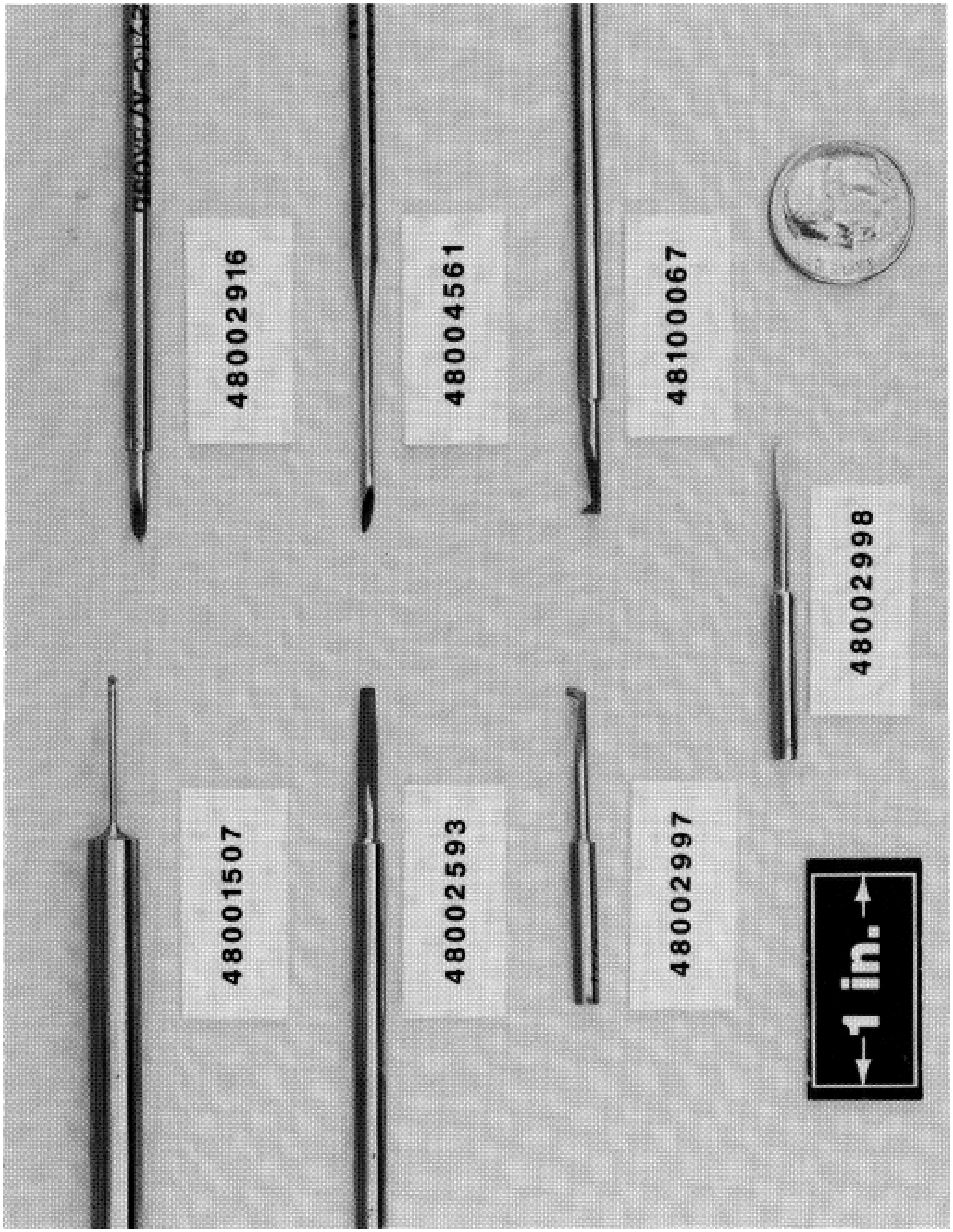

Figure 16: Deburr Tools Picture 2

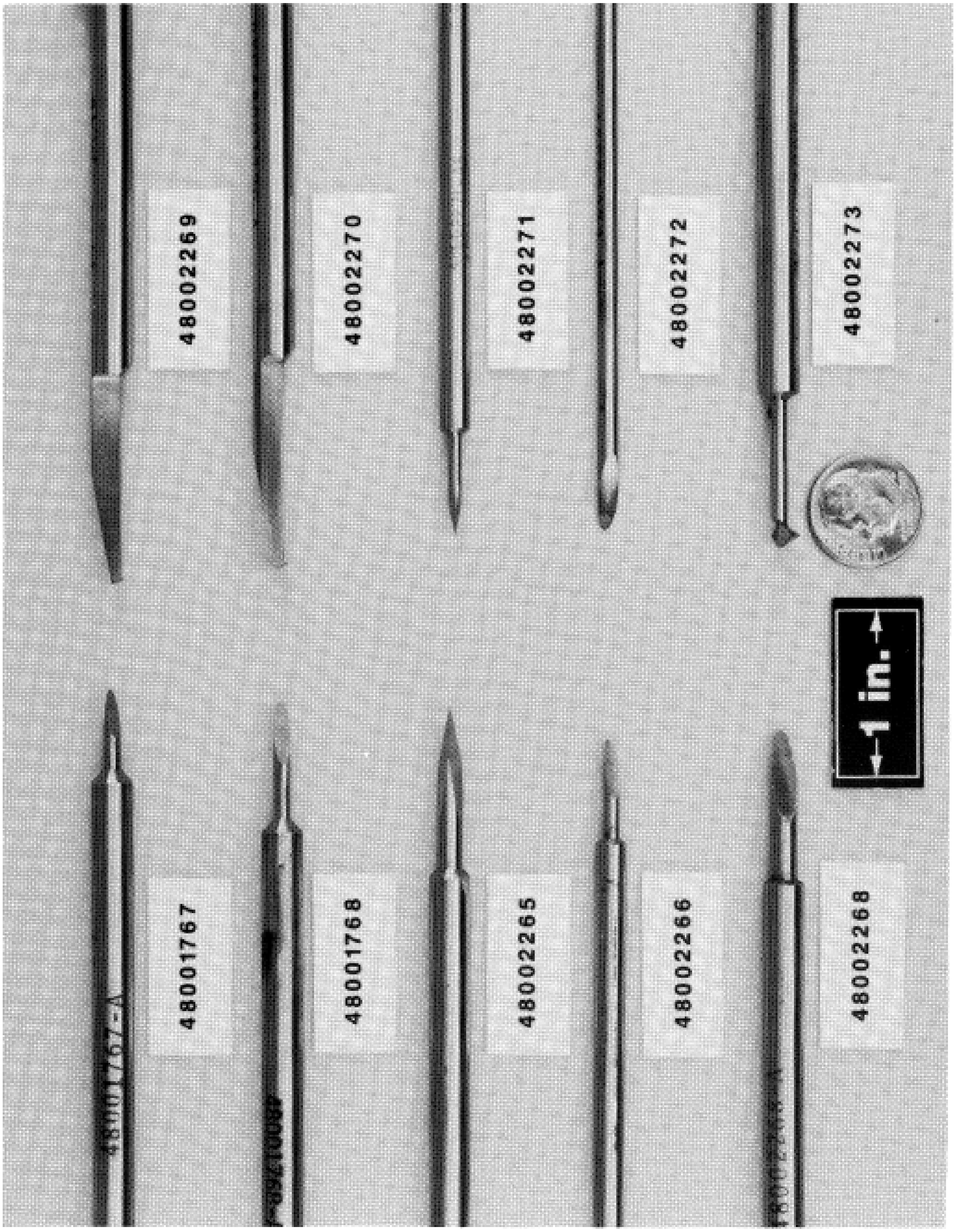

Figure 17: Deburr Tools Picture 3

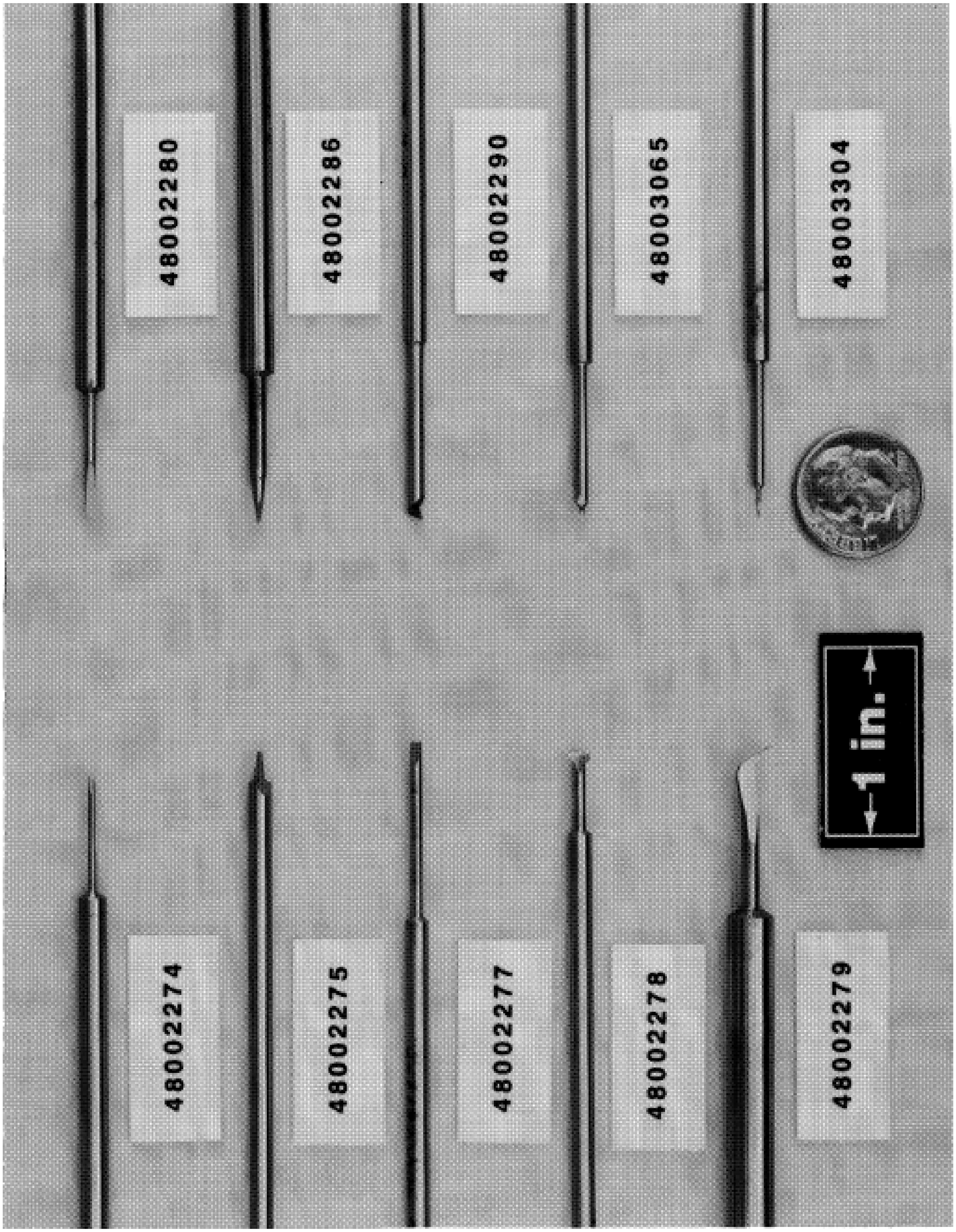

Figure 18: Deburr Tools Picture 4

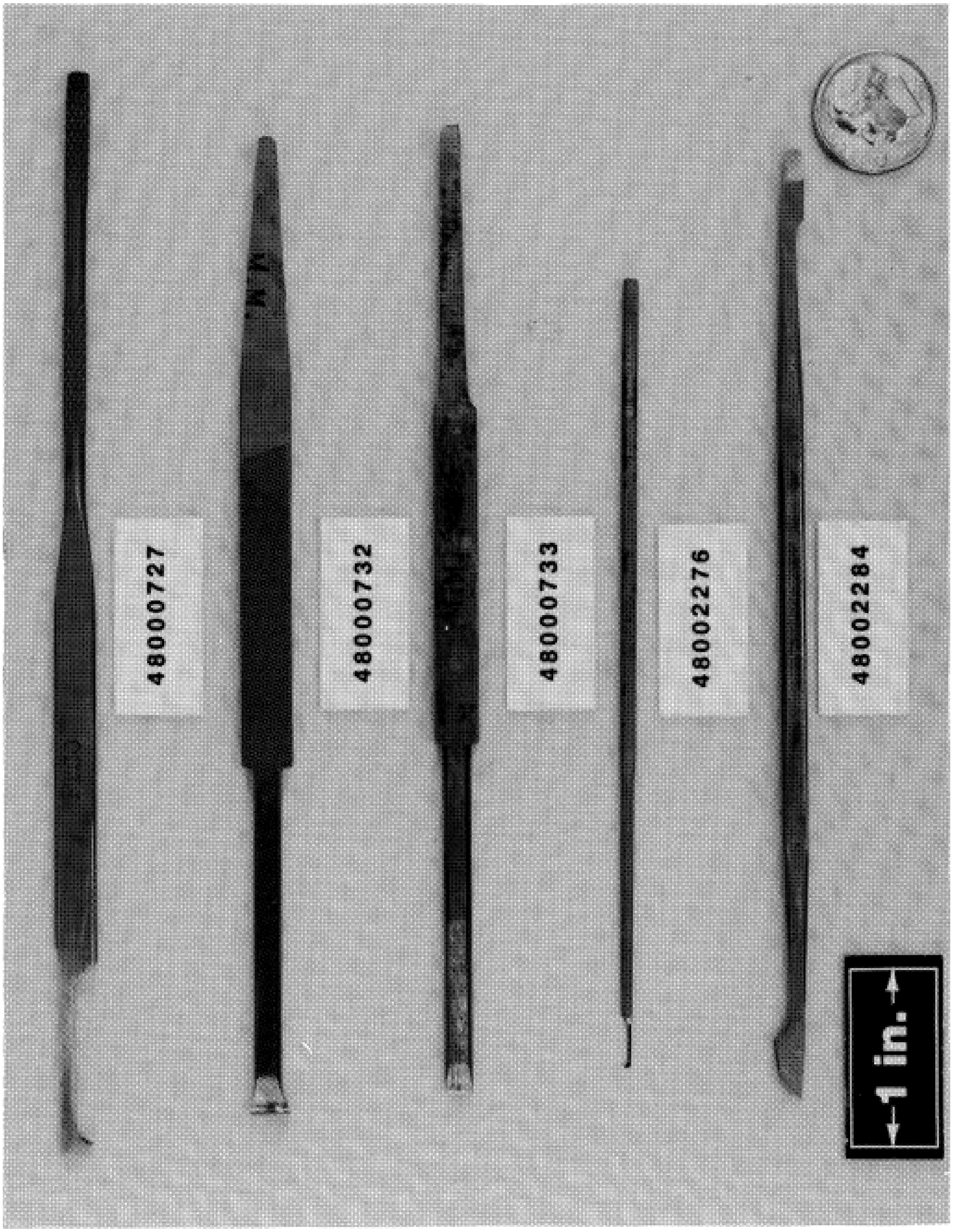

Figure 19: Deburr Tools Picture 5

Figure 20: Deburr Tools Picture 6

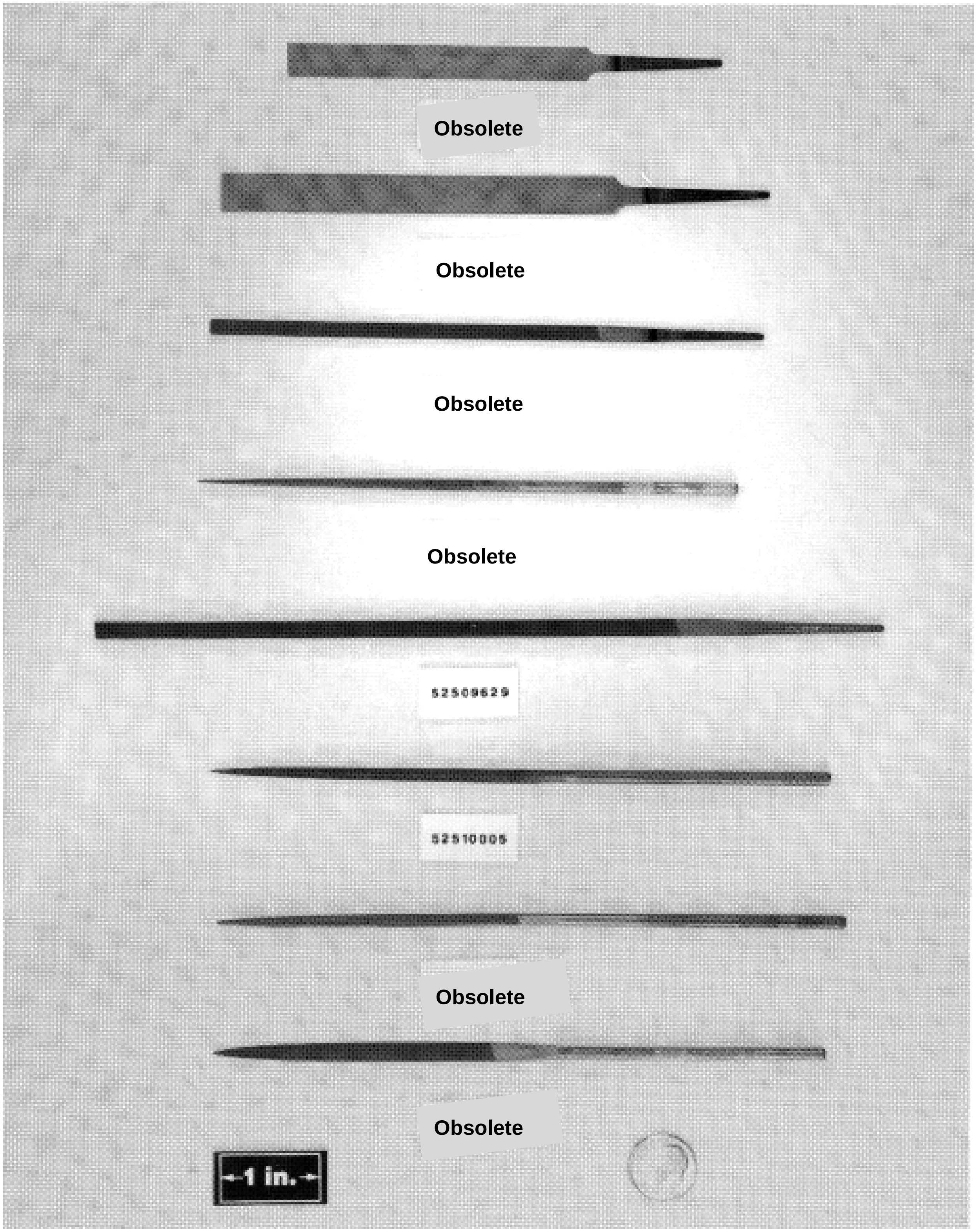

Figure 21: Deburr Tools Picture 7

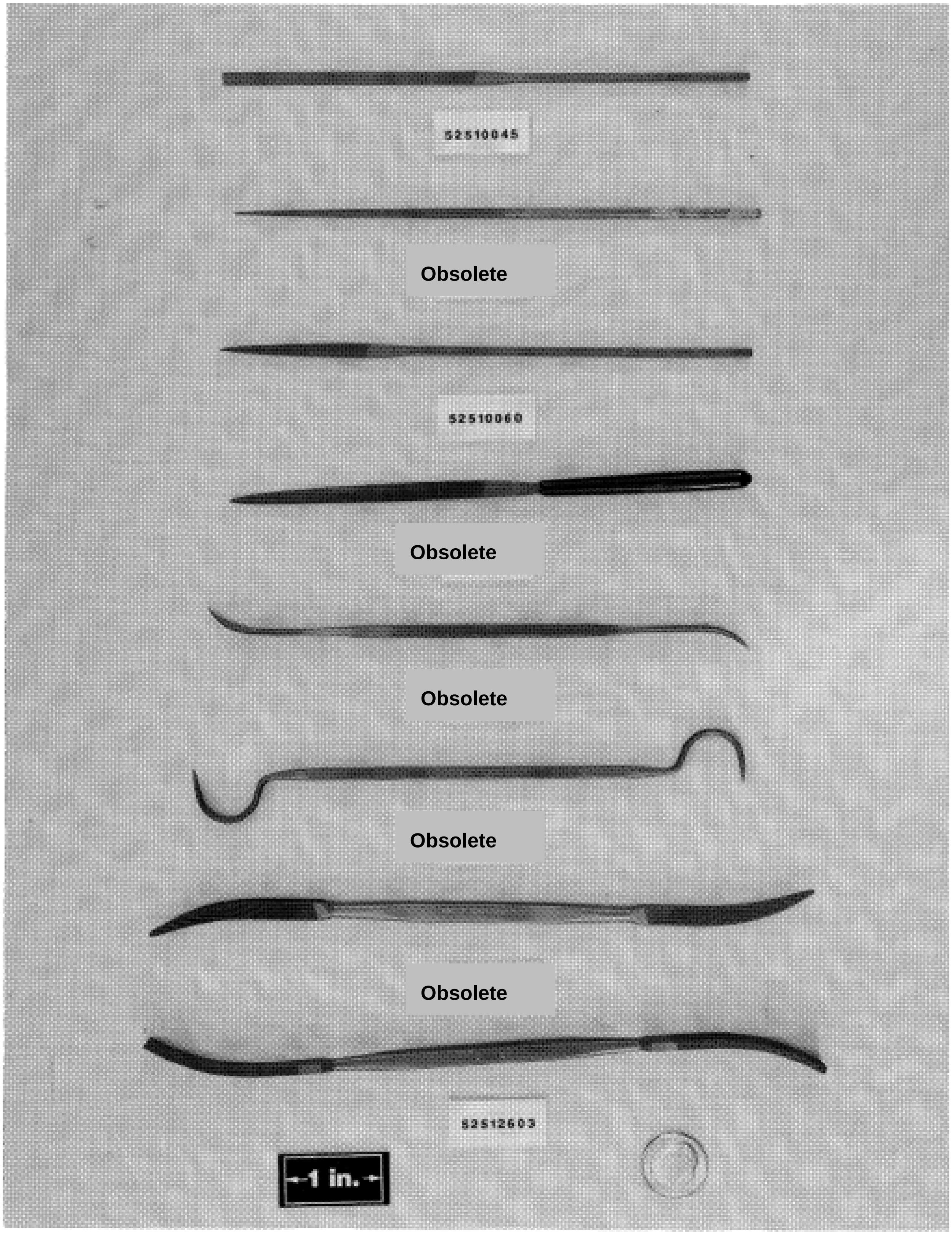

Figure 22: Deburr Tools Picture 8

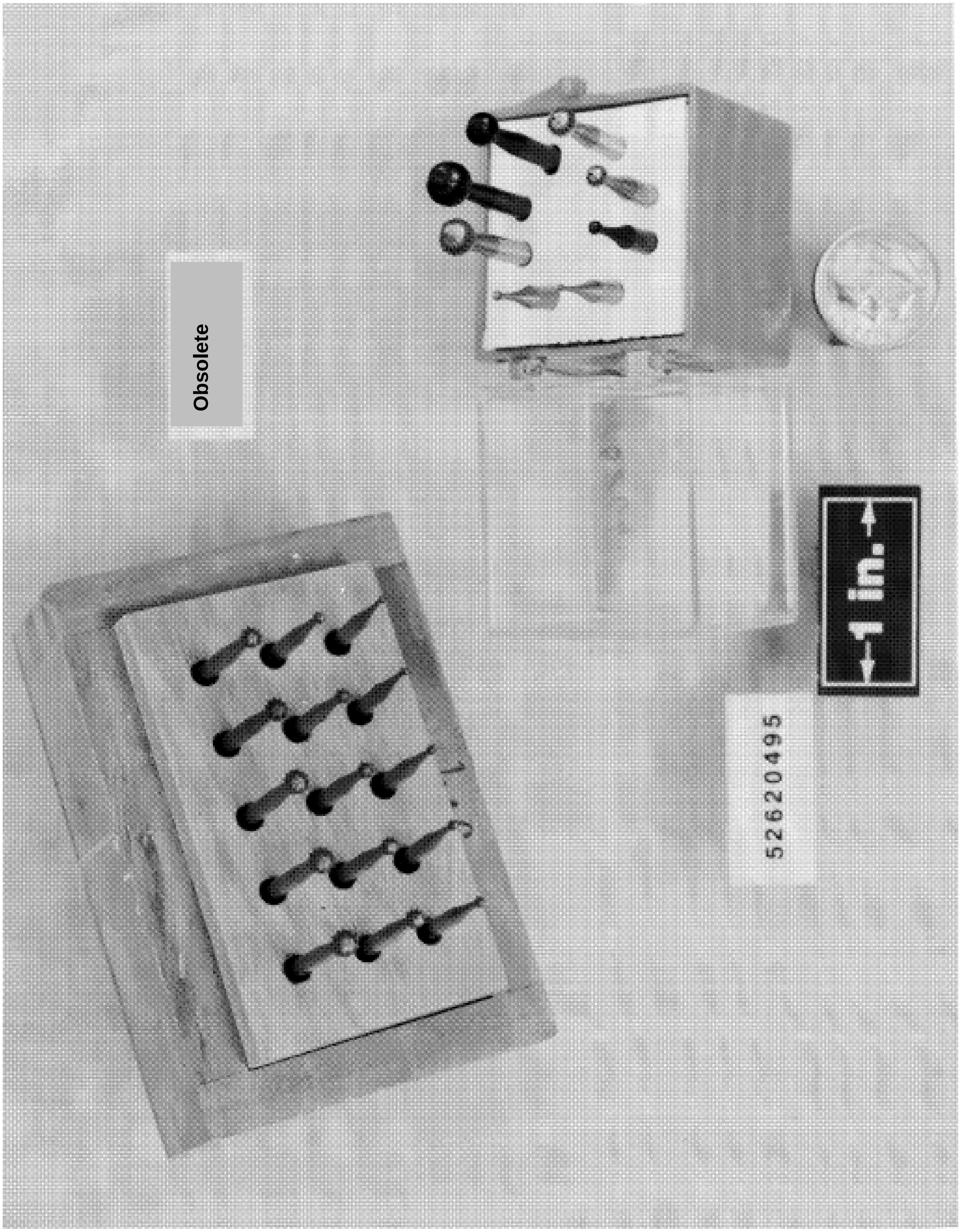

Figure 23: Deburr Tools Picture 9

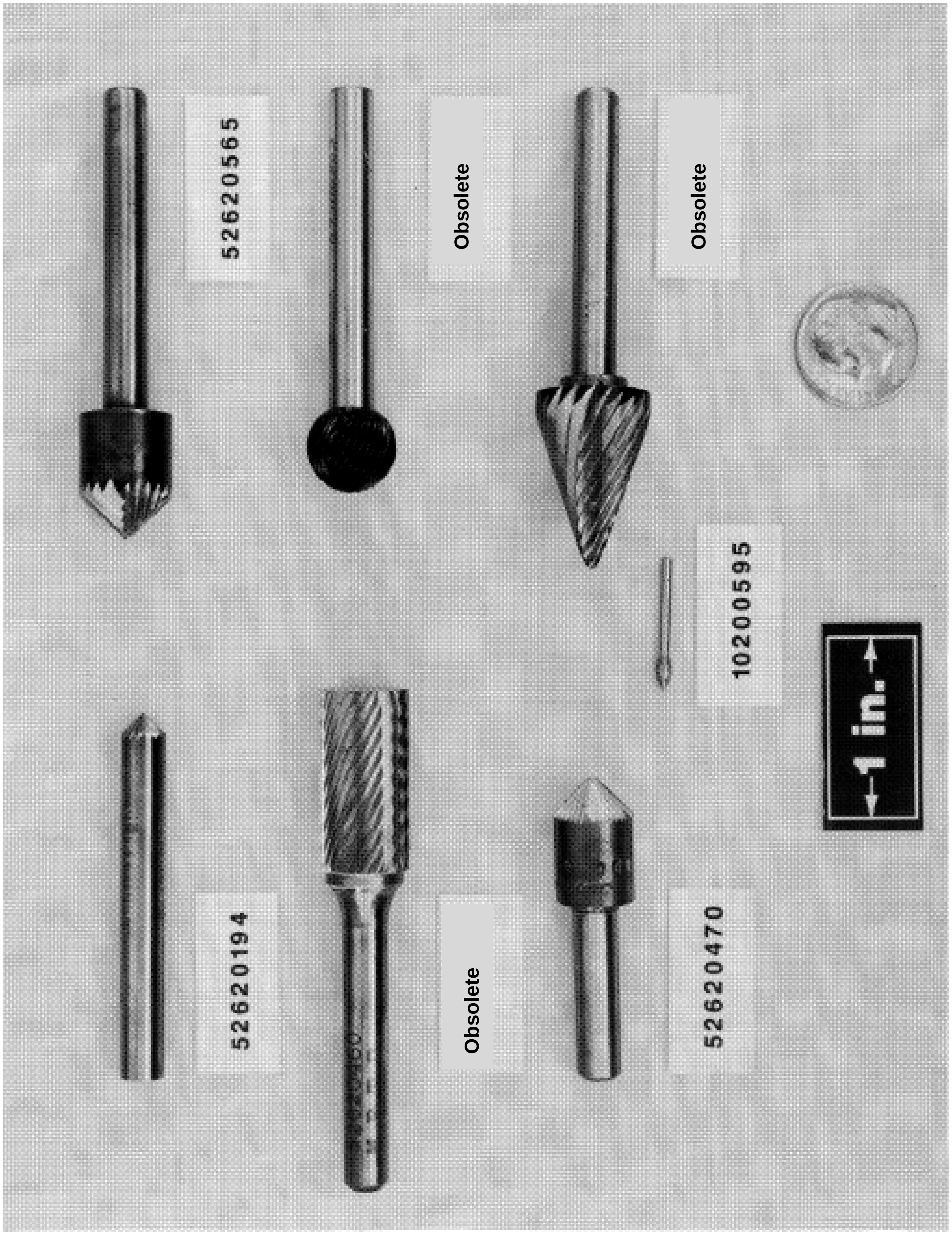

Figure 24: Deburr Tools Picture 10

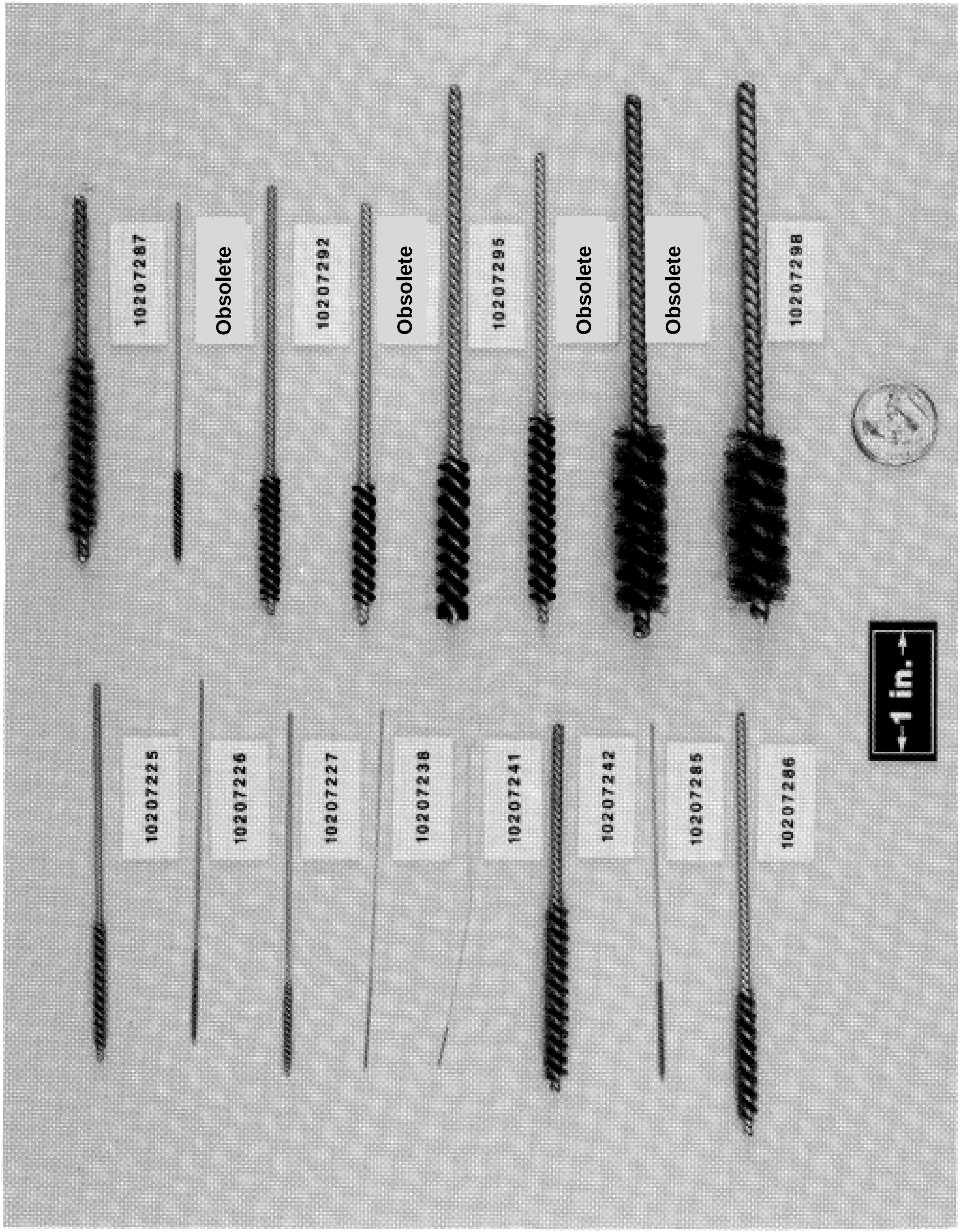

Figure 25: Deburr Tools Picture 11

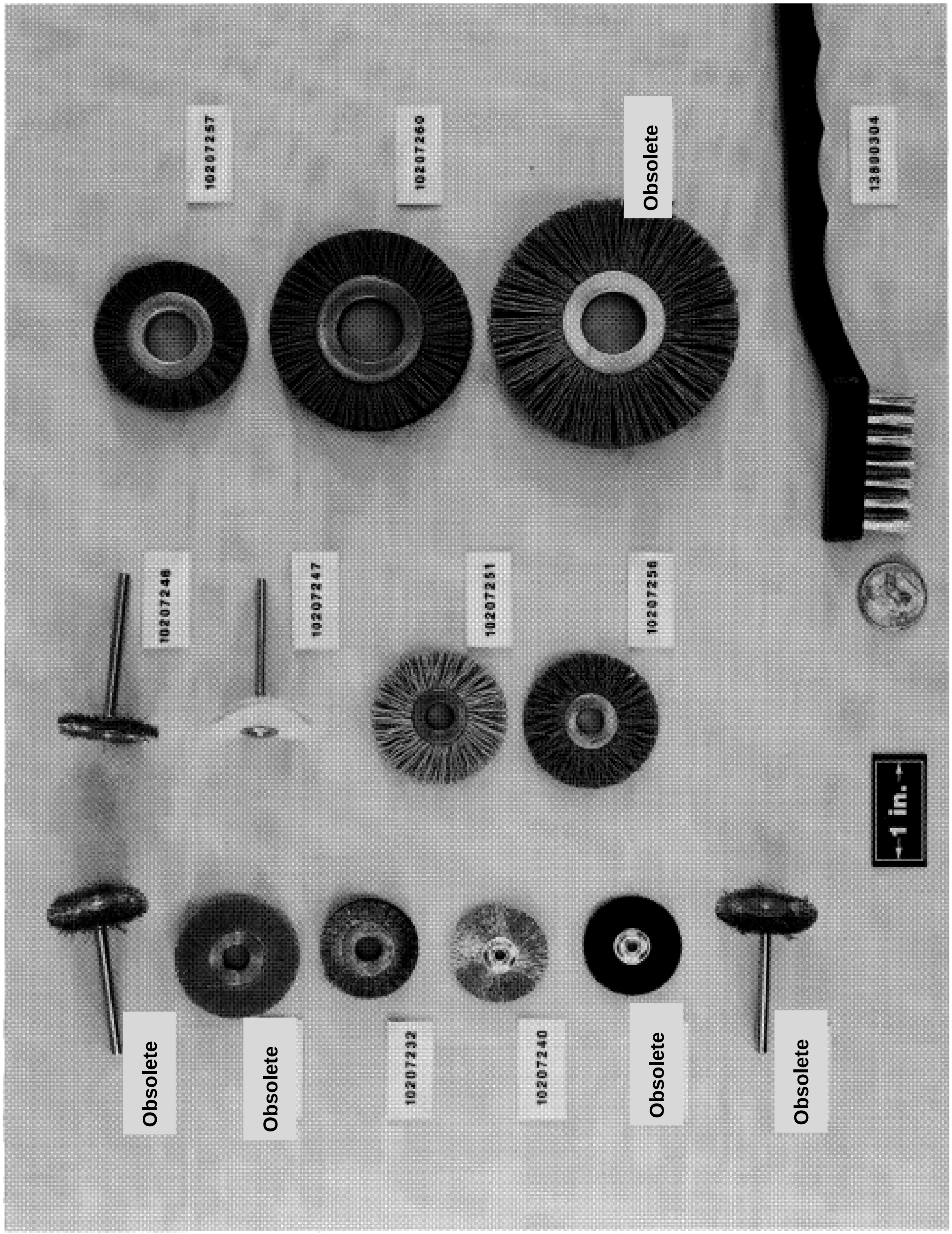

Figure 26: Deburr Tools Picture 12

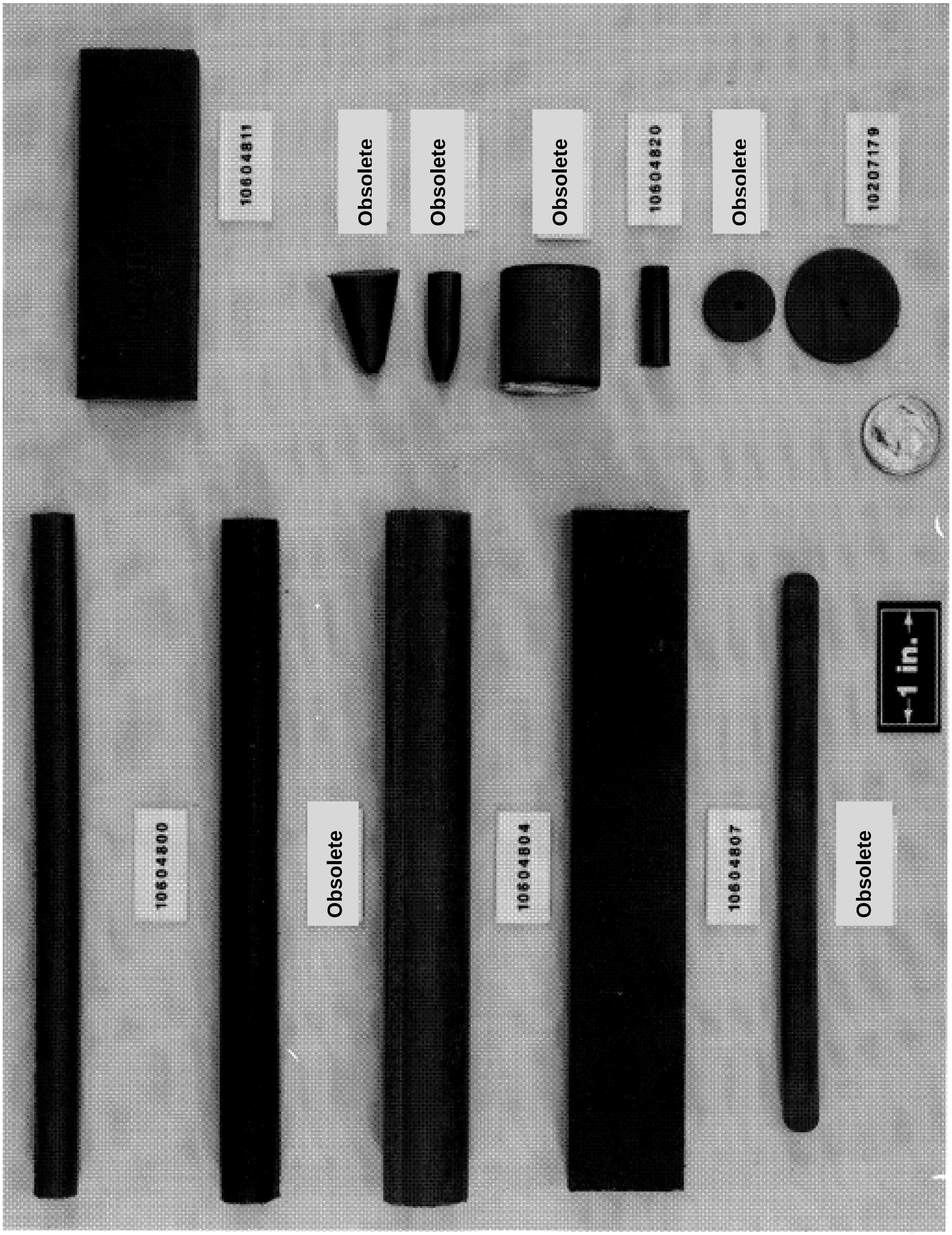

Figure 27: Deburr Tools Picture 13

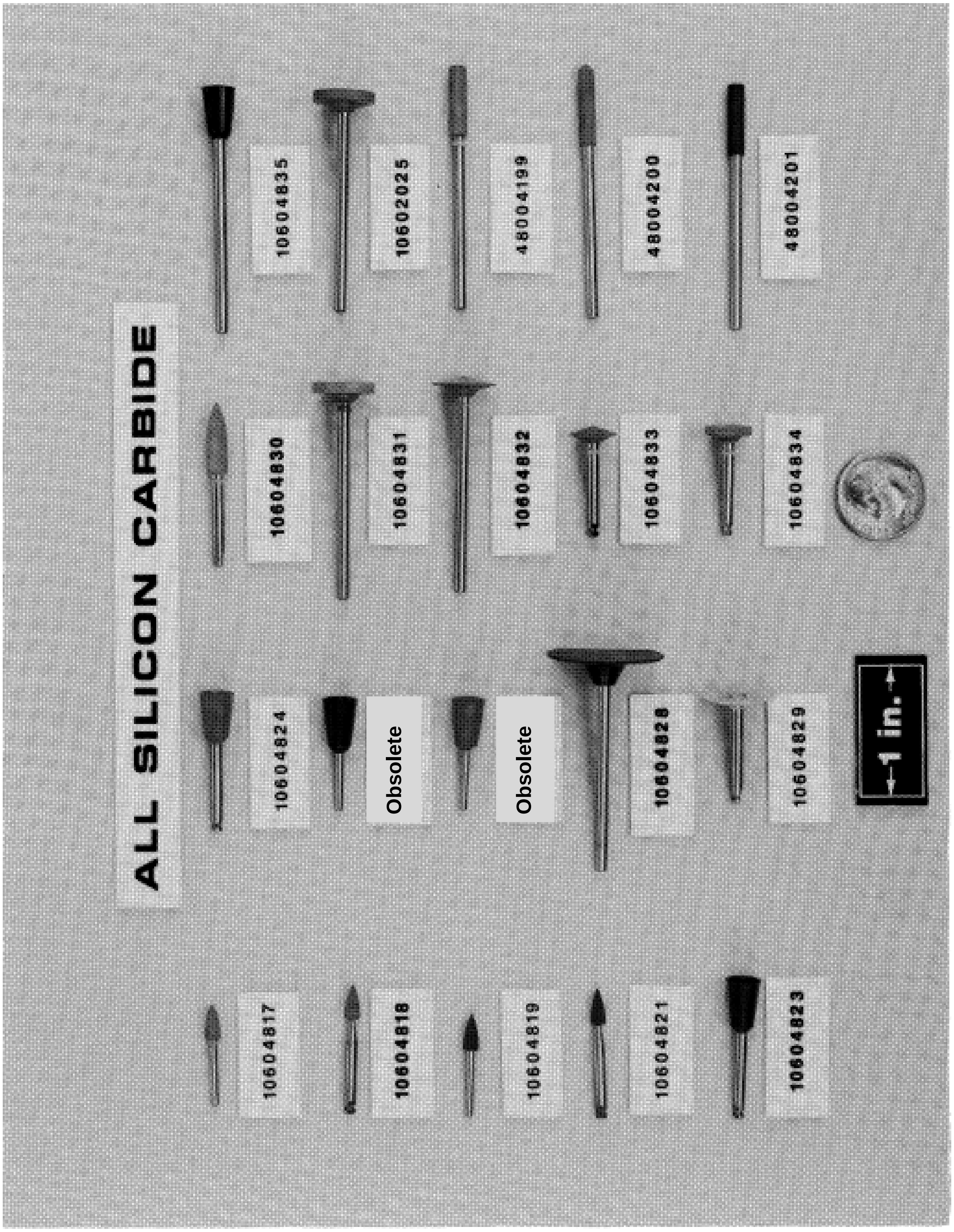

Figure 28: Deburr Tools Picture 14

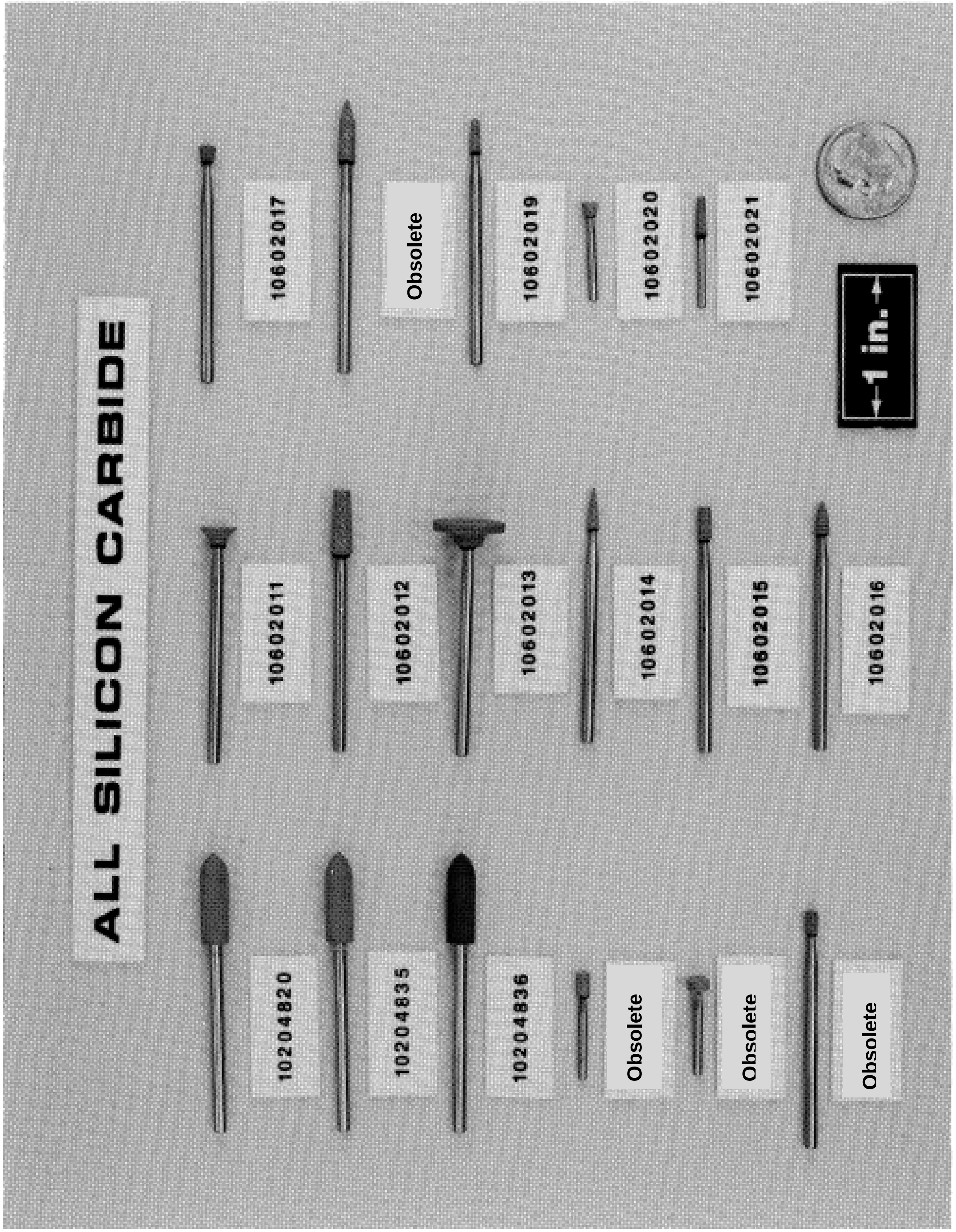

Figure 29: Deburr Tools Picture 15

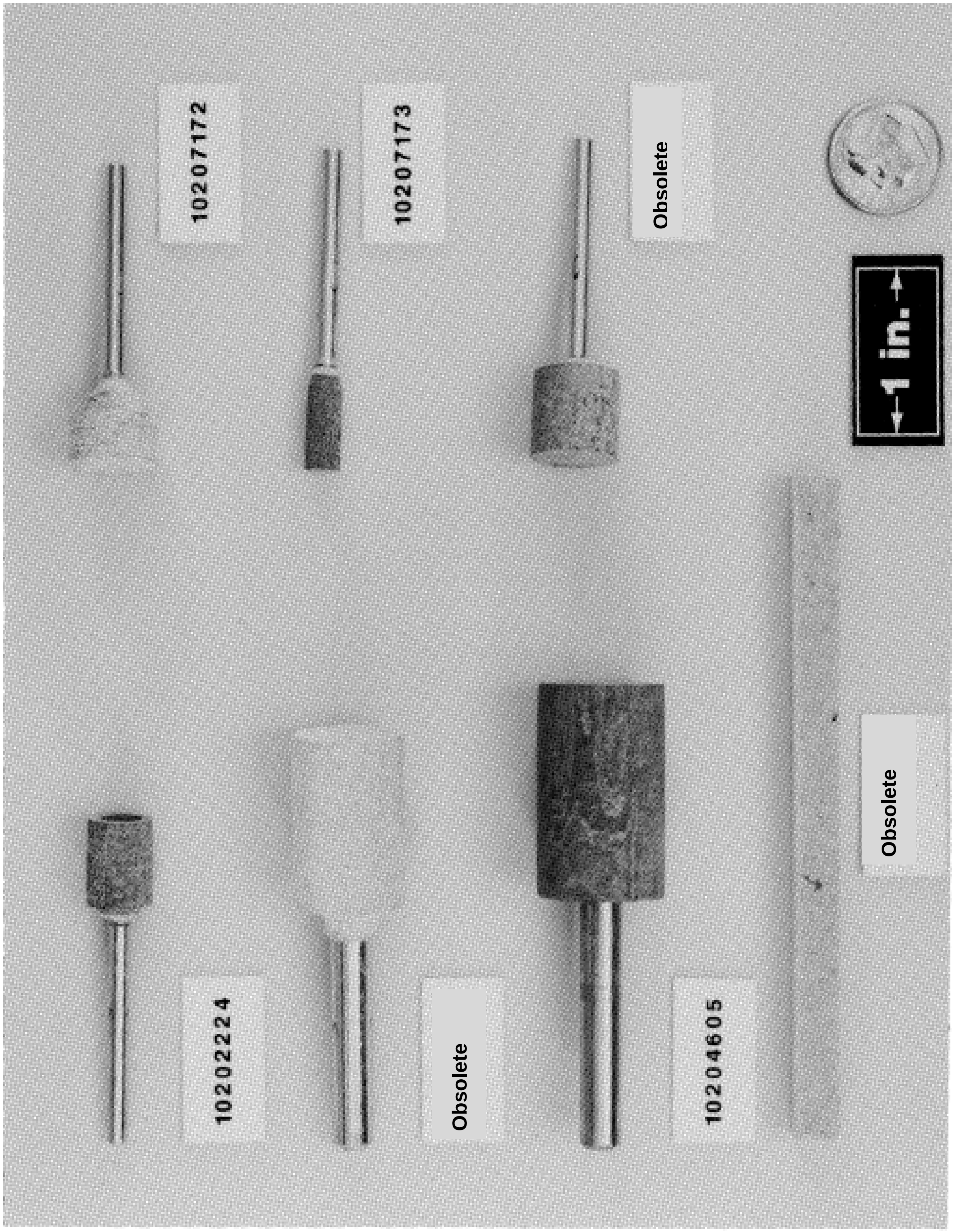

Figure 30: Deburr Tools Picture 16

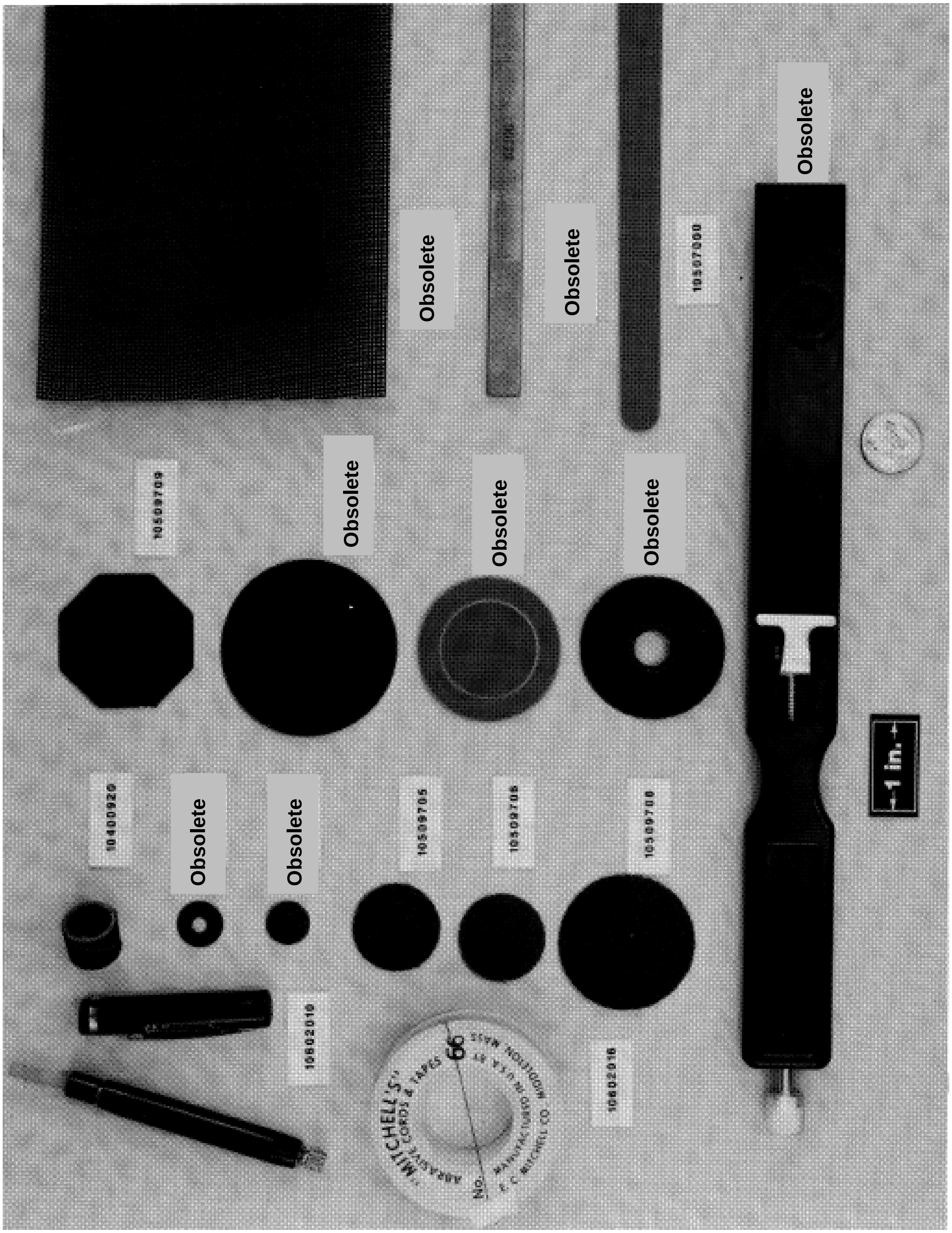

Figure 31: Deburr Tools Picture 17

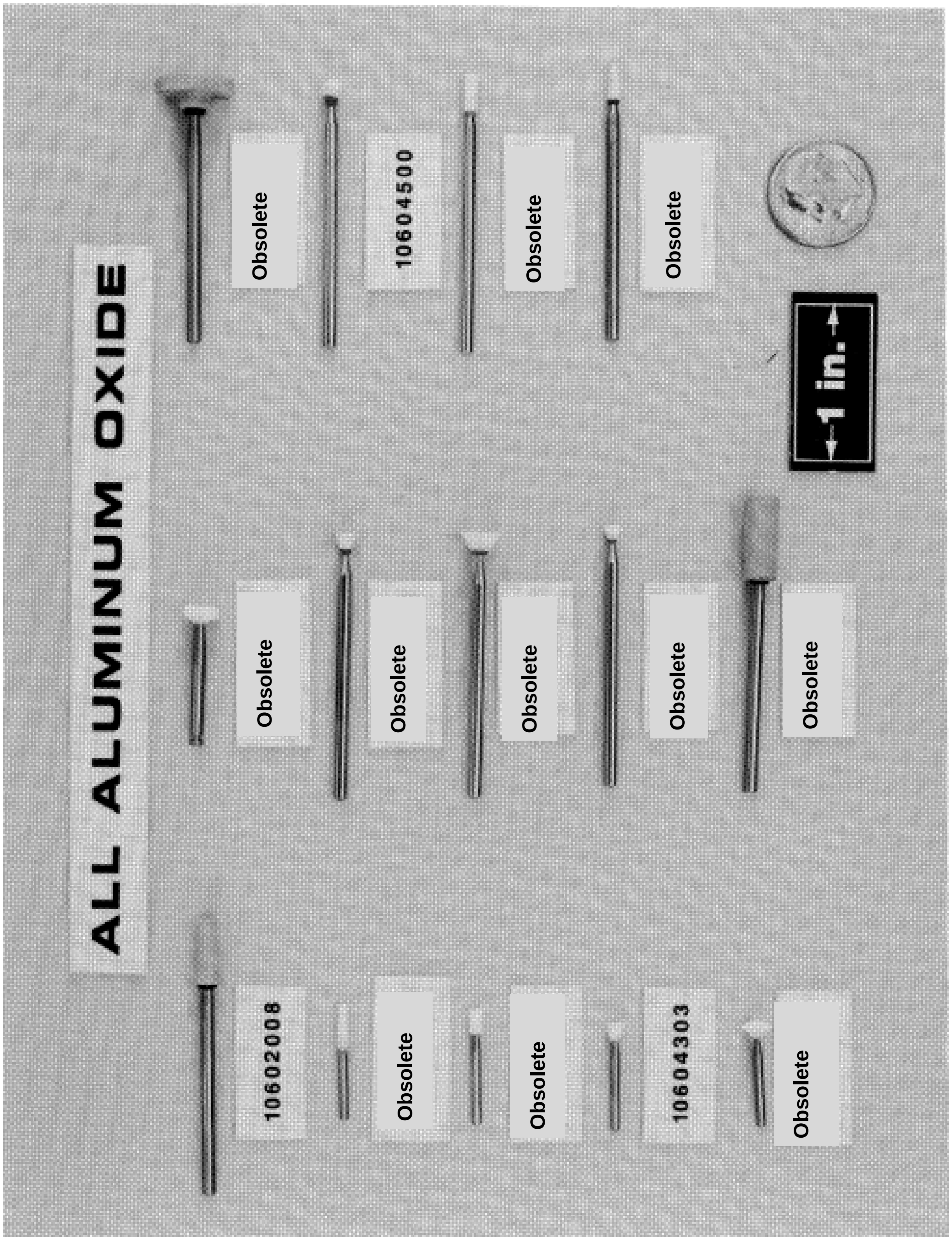

Figure 32: Deburr Tools Picture 18

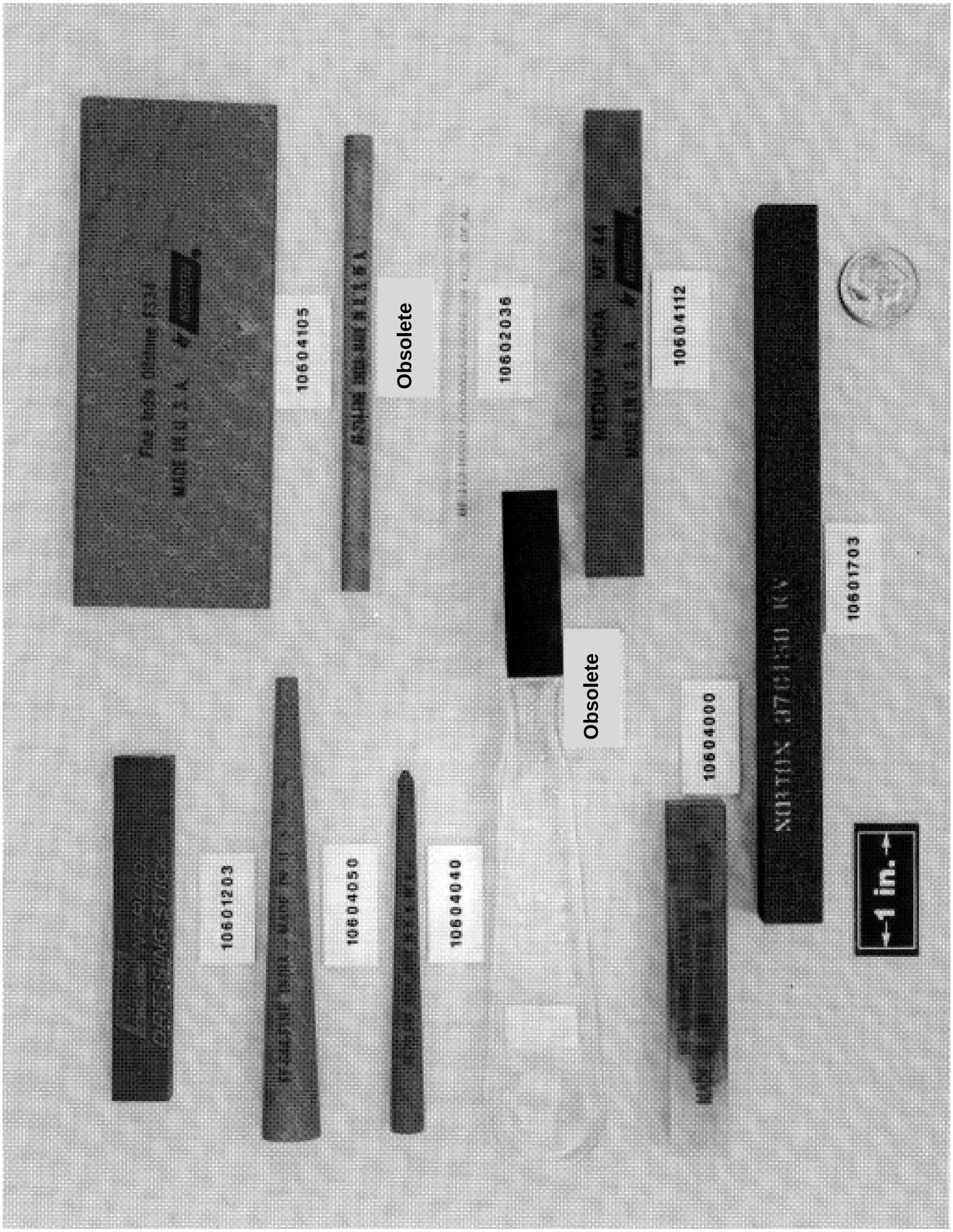

Figure 33: Deburr Tools Picture 19

Figure 34: Deburr Tools Picture 20

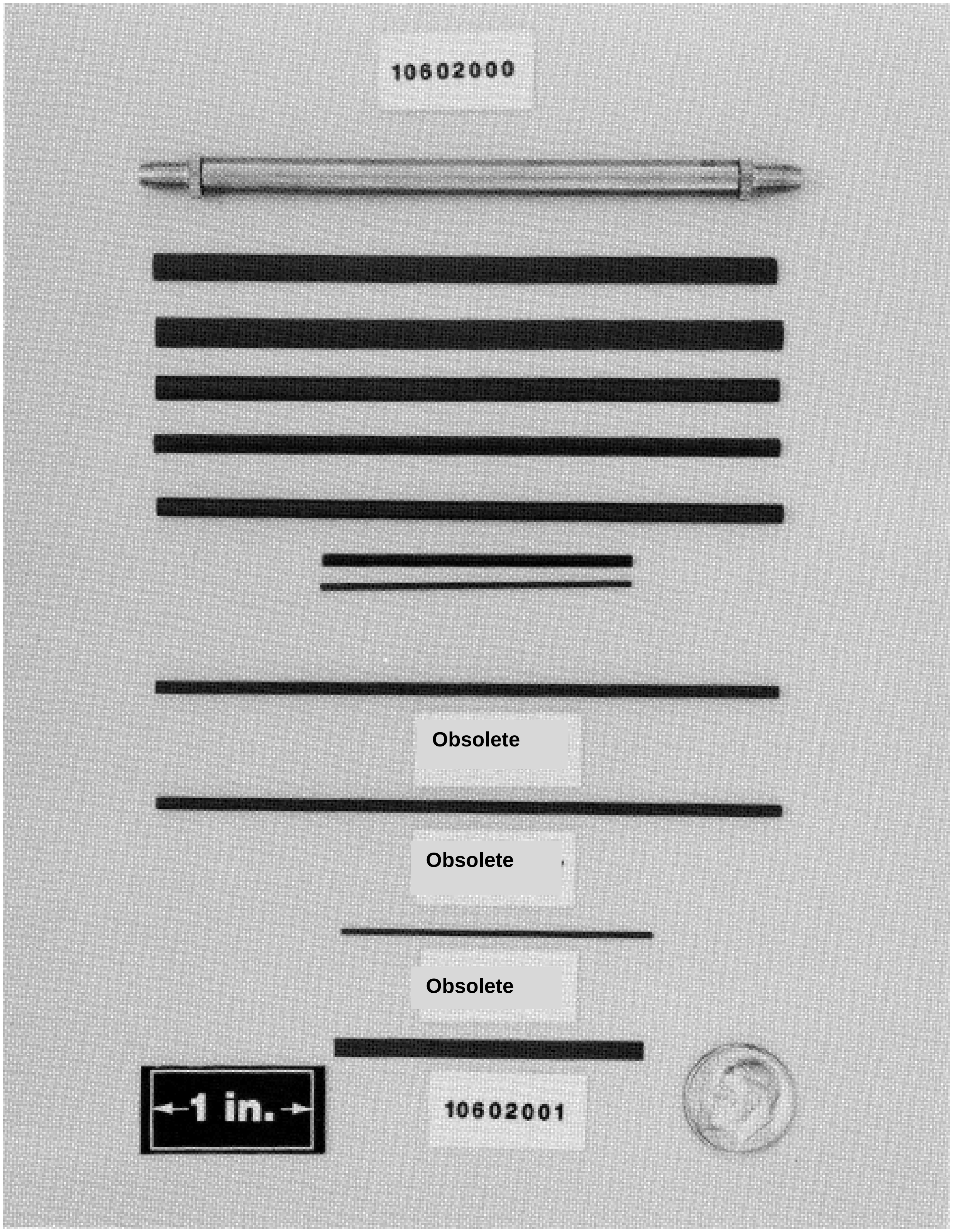

Figure 35: Deburr Tools Picture 21

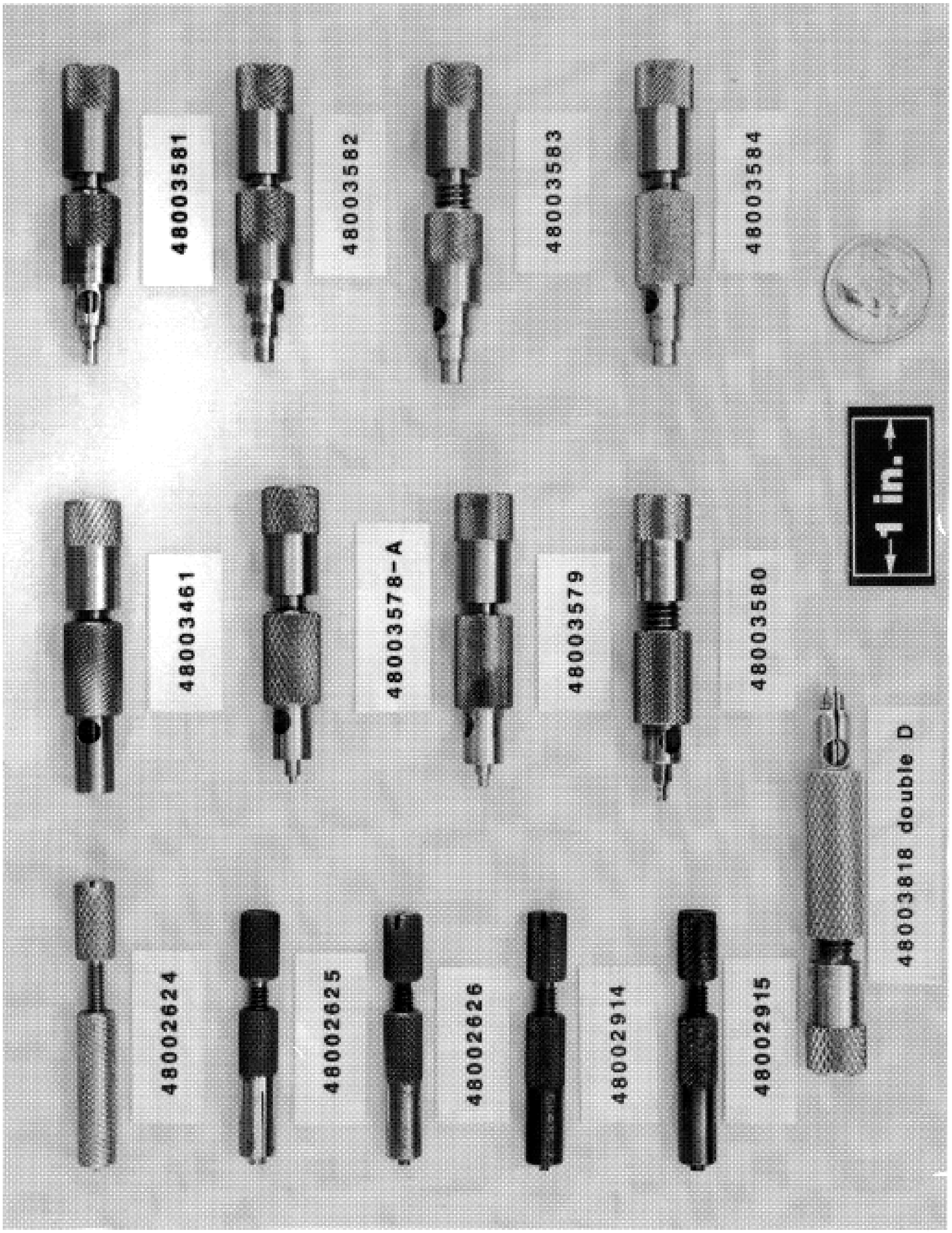

Figure 36: Deburr Tools Picture 22

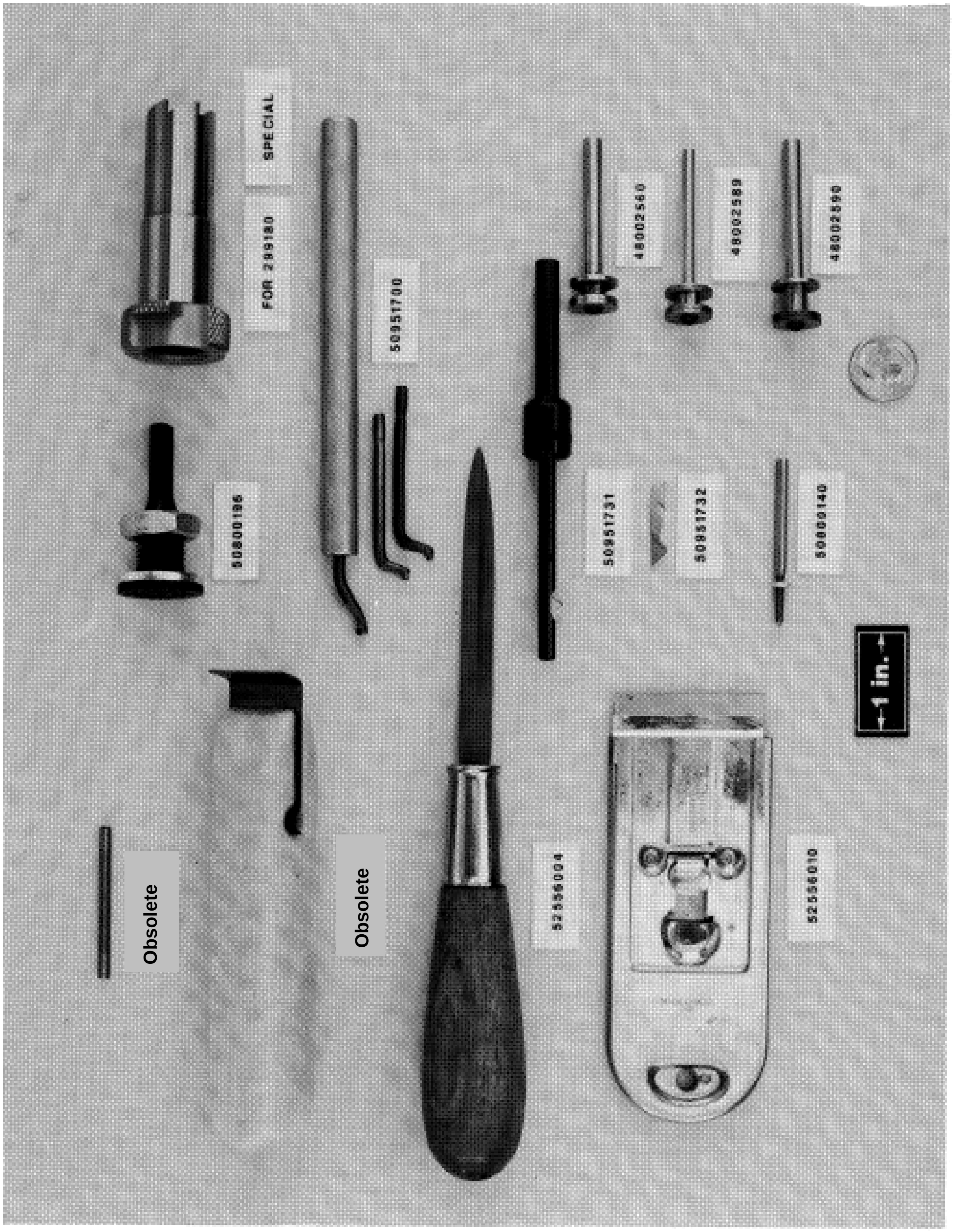

Figure 37: Deburr Tools Picture 23

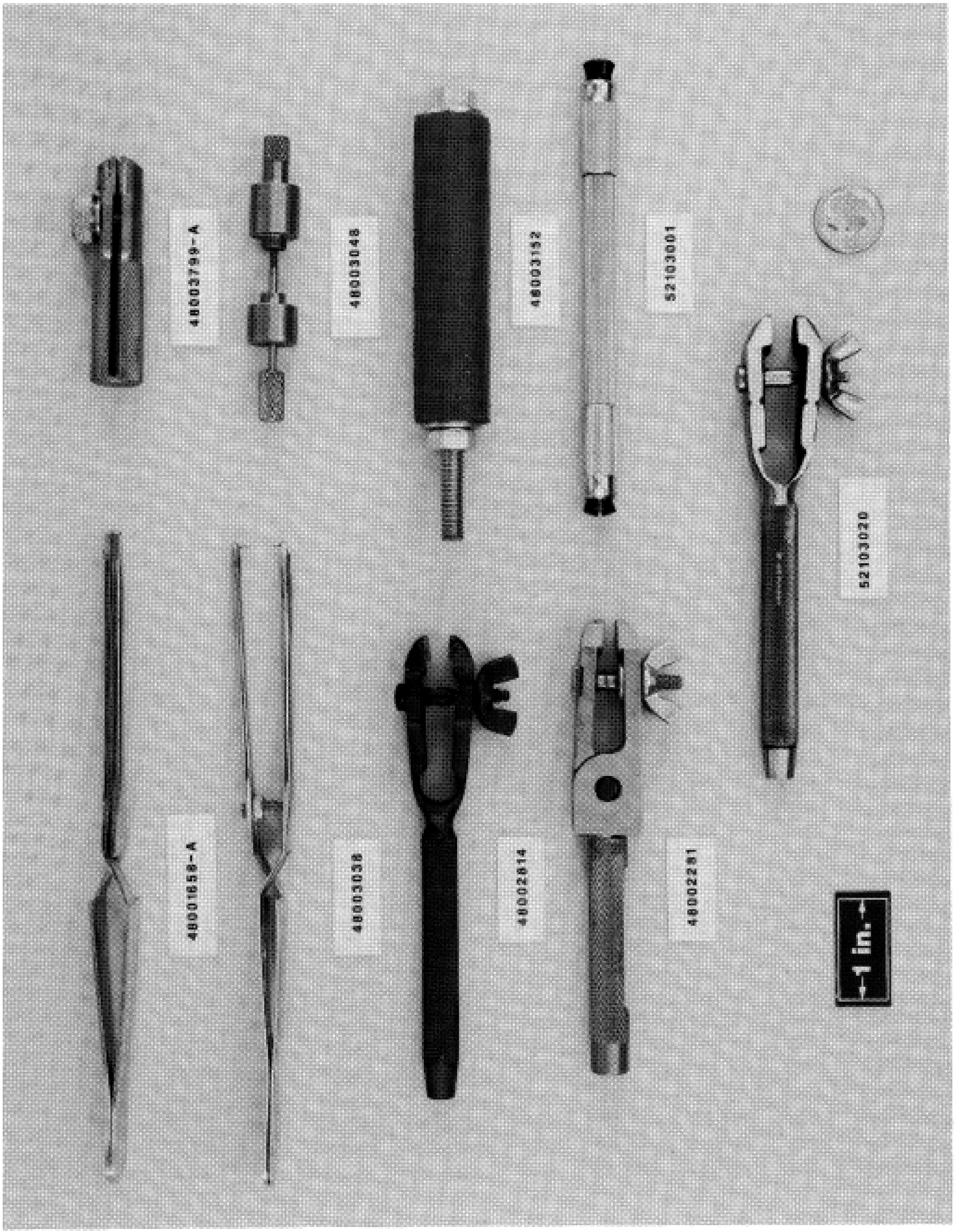

Figure 38: Deburr Tools Picture 24

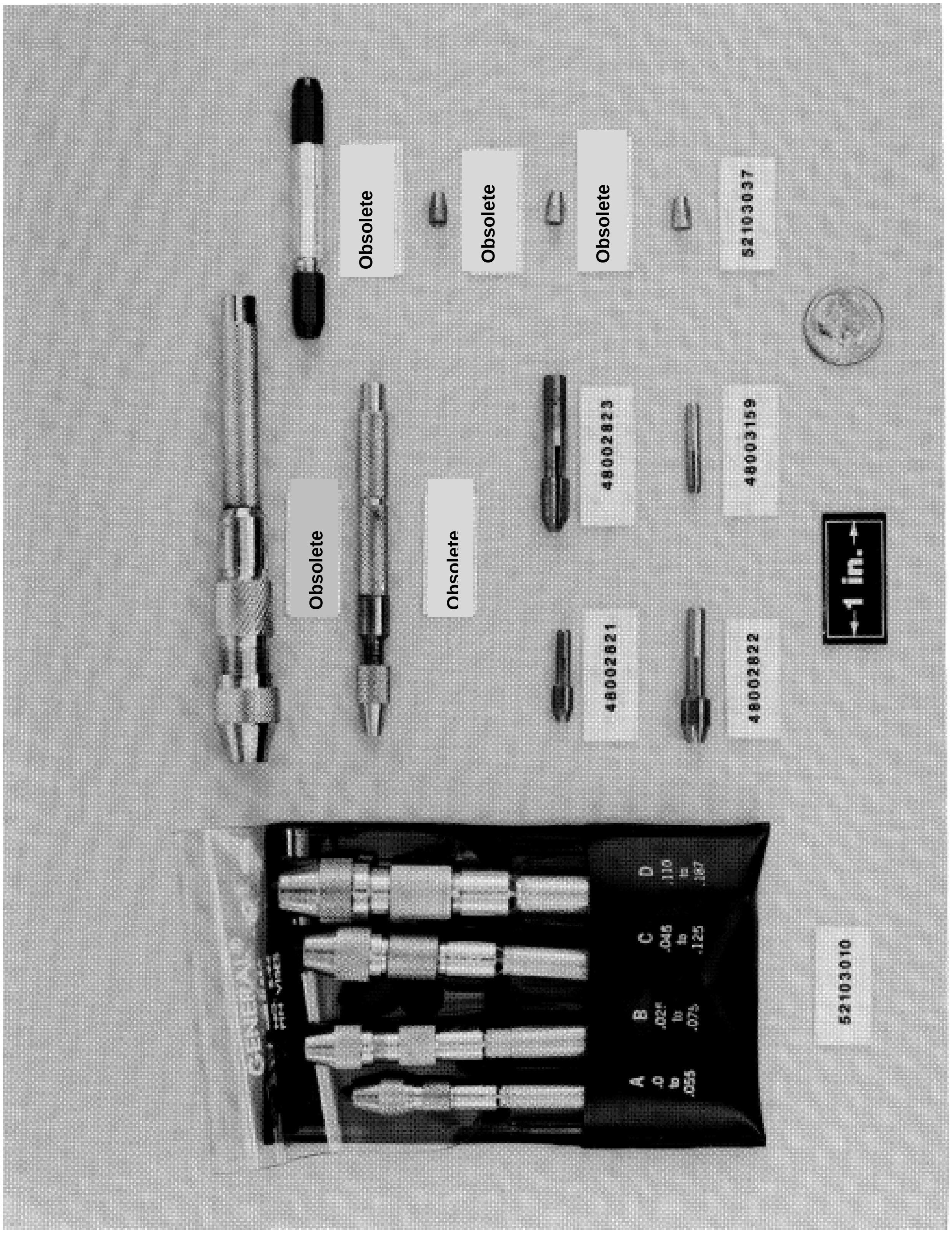

Figure 39: Deburr Tools Picture 25

Figure 40: Deburr Tools Picture 26

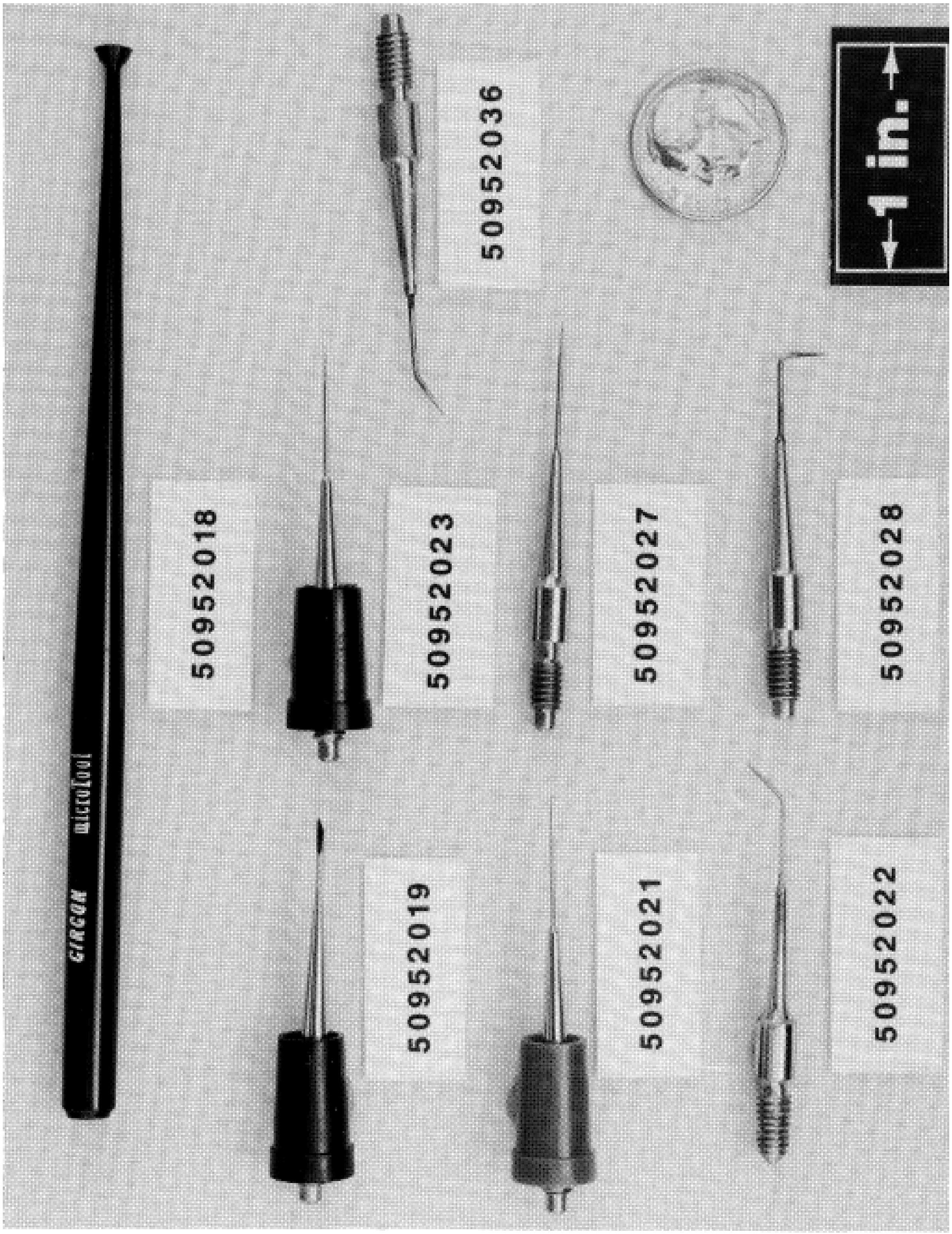

Figure 41: Deburr Tools Picture 27

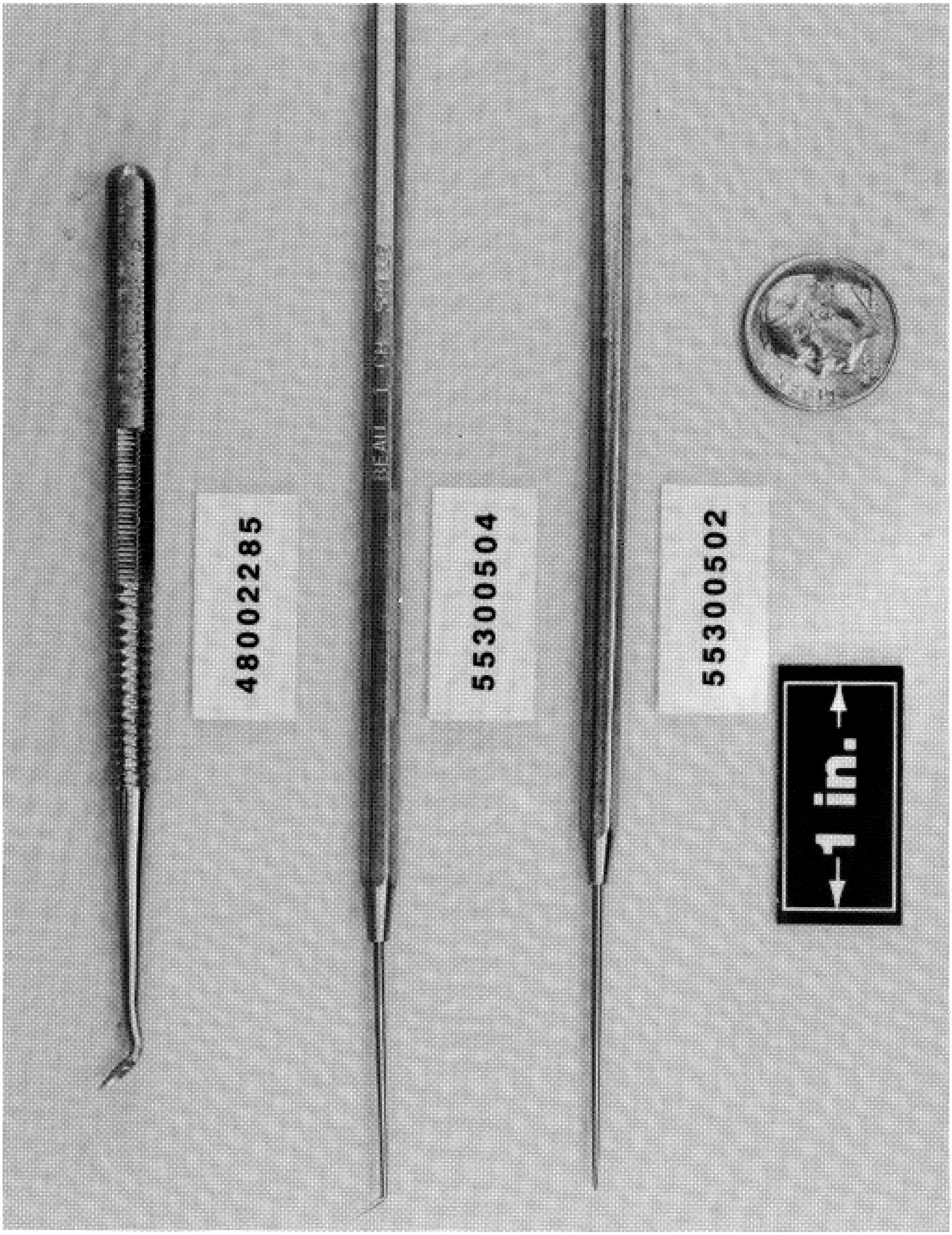

Figure 42: Deburr Tools Picture 28

Listing of Current Deburr Tools Located in Stores, in Numerical Order

10200607	1/8" x 5/16" Shape B-48, Bay State Vitrified Mounted Point 32A9CVV8EM 1/8" Ø shank.
10200608	1/8" x 1/8" Shape B-124, Bay State Vitrified Mounted Point #38A60-PVM or equivalent.
10201004	3/16" x 3/16" Shape B-123 Vitrified Mounted Point Norton #38A90 QVM or equivalent.
10201006	3/16" x ¼" x 1/8" shank x 1½" 38A60 PVM Norton W152 Mounted Point.
10201100	7/32" x 3/8" Shape B-44, Bay State Vitrified Mounted Points #38A60-TVM or equivalent.
10201410	Al20-0A-A24, Atlantic Mounted Points. ¼" x ¾" x 1/8" shank.
10201415	¼" x 5/8" with 1/8" Ø, SS., Shape B-53, Norton Vitrified Mounted Point 38A90-0V.
10201418	¼" x ½" Shape W-163, Bay State or equivalent Vitrified Mounted Point 38A6C-PVM.
10202223	Mounted Point, Vitrified, 3/8" x ½" x 1/8" shank, Shape B-132, Norton 38A90TVM or equivalent.
10202224	3/8" x ½" with 1/8" shank Shape B-132, Grit MX Mounted Point Carborundum or equivalent.
10202225	3/8" x 1¼" x ¼" - W-179-38A90-MV, QVM Norton Vitrified Mounted Point.
10202245	¼" x 3/8" x 1/8" med plain mandrel-mounted felt bob or equivalent.
10202246	3/8" x ½" x 1/8" med plain mandrel-mounted felt bob or equivalent.
10202247	½" x ½" x 1/8" med plain mandrel-mounted felt bob or equivalent.
10202248	½" x ½" x 1/8" med shape mandrel-mounted felt bob, #MS-6 or equivalent.
10202249	½" x 1" x 1/8" med plain mandrel-mounted felt bob, #MP-1 or equivalent.
10202250	¾" x 1" x 1/8" med plain mandrel-mounted felt bob.
10203015	½" x ½" x .250 shank 32A60 PVBEM Norton Mounted Point or equivalent.
10203016	½" x ½" x 1¼" shank, W-185 38A60-J8VBE Norton Mounted Point, Carborundum AA-60KV40. White premium wheels only.
10203019	Mounted Point, ½" x ½", Shape B-121, Norton #38A90-TVM or equivalent.

10203105 5/8" x 5/8", Shape B-41, Bay State Vitrified Mounted Point.

10203107 Mounted Point, 5/8” x 11/16” with 1/8“ Ø shank, silicon carbide, Shape B101, #37C60PVM.

10203108 5/8" X 3/16", Shape B-103, Bay State Vitrified Mounted Point 38A60-0V 1/8" Ø shank.

10204605 ¾" x 1¼" x ¼", Carborundum, Al20G-FX5 Mx Mounted Point, #W206, Norton Bay State or equivalent.

10124607 ¾" x ¾" x .250" shank A-39 38A60-JVBE Norton Mounted Point. White premium wheels only.

10124609 ¾" x 5/16" Shape B-81, Bay State Vitrified Mounted Point. #38A120-QVM or equivalent.

10124810 7/8" x 2" A36SVM Norton Alundum Mounted Point Shape A-11, mounted on ¼" spindle.

10204820 Shofu Greenie silicone points for finishing gold and cast alloys, HP shank, PC2 shape, Shofu P/N 0275.

10204835 Shofu Ceramiste silicone gray point for porcelain, HP shank, ultra PC2 shape, Shofu P/N 0265.

10204836 Shofu Brownie silicone points, shank HP, shape PC2, P/N 0272.

10205810 Mounted point, ball end, 1/16" Ø. CBN coated with 100 grit size. Shaft is 1/8" Ø x 2" OAL. Norton Catalog #BE-2-CBN or equivalent.

10205811 Mounted point, ball end, 3/64" Ø. CBN coated with 100 grit size. Shaft is 1/8" Ø x 2" OAL. Norton Catalog #BE-1-CBN or equivalent.

10205820 Cylinder-mounted point, round end, 1/16" Ø x ¼" long. CBN coated with #100 grit size. Shaft is 1/8" Ø x 2" OAL. Norton Catalog #RE-1-CBN or equivalent.

10205821 Cylinder-mounted point, round end, 5/64" Ø x ¼" long. CBN coated with #100 grit size. Shaft is 1/8" Ø x 2" OAL. Norton Catalog #RE-2-CBN or equivalent.

10205830 Taper deburr point with round end, .044 small Ø and .066 large Ø x 5/16". CBN coated with #100 grit size. Shaft is 1/8" Ø x 2" OAL. Norton Catalog #RT-44-CBN or equivalent.

10205831 Taper deburr point with round end, .060 small Ø and .082 large Ø x 5/16" long. CBN coated with a #100 grit size. Shaft is a 1/8" Ø x 2" OAL. Norton Catalog #RT-60-CBN or equivalent.

10207100 1-5/8" X 3/8" Shape A-36, Bay State Vitrified Mounted Point #9A6005V72 Norton 38A60-TVM or equivalent.

10207110	Mounted point, Shape A-38, #60 grit 1" Ø long X ¼" spindle, Norton #9A60MV22 or equivalent.
10207172	.5" Ø x .25" long mounted point on .125" shank, Carborundum No. W183-D-1, A120-G-BMX5 composition.
10207173	Mounted wheel 3/16" Ø x ½" x 1/8" Ø shank Bayflex (laminated muslin), #120 grit aluminum oxide, Gesswein #154 or equivalent.
10207179	Cratex #83F rubberized abrasive wheel, 1" Ø x 3/32" wide, 1/16" arbor hole, fine abrasive.
10207200	Bright-Boy Handy Kit #8OA, assorted sizes, ½" to 1" Ø - 44 pcs per kit with mandrel and chuck.
10207225	Cross hole deburring brush, 0.109" Ø, 304 SST bristles having .002" Ø, Brush Research Mfg. Co. series 81 or equivalent for deburring small tapped holes.
10207226	Cross hole deburring brush, 0.047" Ø, 304 SST bristles having .002" Ø, Brush Research Mfg. Co. series 81A or equivalent for deburring small tapped holes.
10207227	Cross hole deburring brush, 0.079" Ø 304 SST bristles having 0.002" Ø, Brush Research Mfg. Co. series 81A or equivalent, for deburring small tapped holes.
10207229	Cross hole deburring brush, 1/8" Ø, 304 SST bristles having Brush Research Mfg. Co. series 81 or equivalent.
10207232	Brush, 1" Ø x ¼" wide x .003" wire size, Osborn Ringlock No. 2660 SV Code 8072-11070 with ¼" arbor hole, stainless steel bristles.
10207234	Wire brush, .014 Ø stainless steel wire, 4" brush Ø, 3/8" arbor hole, ½" face width, Faeth Co. Catalog #1304-SV-1.
10207235	Cross hole brush, .156" Ø, cross hole deburring series 81 stainless steel “A” drill size.
10207236	Cross hole brush, .142" Ø, cross hole deburring series 81 stainless steel "A" drill size.
10207237	Cross hole brush, .097", cross hole deburring series 81, stainless steel "A" drill size.
10207238	Cross hole brush, .032", cross hole deburring series 81, stainless steel "A" drill size.
10207240	1" Ø x .005" wire size, Dixon #441 single section, unmounted crimped brass wire brush, Weiler UM-18 or equivalent.
10207241	Cross hole brush, 0.020" cross hole deburring, stainless steel, Mill-Rose industrial wire brush, P/N 320101.

10207242 Cross hole brush, 0.219 cross hole deburring series 81, stainless steel, 7/32 drill size.

10207245 Brush, deburr, .640 Ø, 5" OAL, 1" brush length. Bristles are .017 Ø nylon filled with 500 mesh silicon carbide, Osborn #56442.

10207247 1" Ø Dixon #422, style 0, double section, mandrel-mounted soft bristle brush with 3/32" shank Ø, Weiler 160 bristle.

10207249 2" Ø x 0.0025" wire size, Anderson Brush No. 09363 or equivalent, stain- less steel wire, ¼" face width, 9/16 trim length arbor hole with knockout insert. Will accommodate 3/8" or ½" arbor.

10207251 Abrasive brush, 1-3/8" dia. ¼" arbor hole ½" flange Ø, .018" Ø nylon bristle impregnated with #500 grit aluminum oxide, Weiler No. 16310 or equivalent.

10207256 Abrasive brush, 1-3/8" plus or minus 1/16" O.D. with ¼" arbor hole .014" Ø nylon bristle impregnated with #600 grit silicon carbide. Approximately 690 bristles per brush. DuPont Tynex or equivalent.

10207257 Abrasive brush, 1½" Ø x ¼" thick with ½" arbor hole, nylon bristles impregnated with 320 grit silicon carbide, Osborn brush No. 3807 code No. 11148 or equivalent (use mandrel 50800196).

10207260 Abrasive brush, 2" Ø x ¼" thick with 5/8" arbor hole, nylon bristles impregnated with 320 grit silicon carbide, Osborn Korful E Ringlock brush #3810 or equivalent. Reference 50800197 for mandrel.

10207266 Brush, 1" Ø, 3/32 Ø shank, extra still bristle, converging double section, Dixon #BR419.

10207268 Abrasive brush, 3" Ø x 7/8" thick with 5/8" arbor hole, nylon filaments, heavily impregnated with #120 silicon carbide abrasive grit. Osborn Korfil E abrasive brush #22253. No substitutions.

10207269 Abrasive brush, 3" Ø x 7/8" thick with 5/8" arbor hole, nylon filaments, heavily impregnated with #80 silicon carbide abrasive grit. Osborn Korfil E abrasive brush #22252. No substitutions.

10207270 Abrasive brush, 3" Ø x ½" thick with 5/8" arbor hole, nylon filaments, heavily impregnated with #320 silicon carbide abrasive grit. Osborn Korfil E abrasive brush #22251. No substitutions.

10207285 Cross hole deburring brush .063" Ø, 304 SST bristles having .002 diameter .025+.010/-.000 extended tip past brush. For deburring small tapped holes.

10207286 Cross hole deburring brush 0.189" Ø, 304 SST bristles having .003 Ø .025+.010/-.000 extended tip past brush. For deburring tapped holes. Brush Research Mfg. or the Mill Rose Co.

10207287	Cross hole deburring brush 0.250" Ø, 304 SST bristles having .003 Ø. For deburring tapped holes. Brush Research Mfg. or the Mill Rose Co.
10207290	Cross hole deburring brush .097" Ø, nylon bristles having .003 Ø 0.025+.010/-.000 extended tip past brush. For deburring tapped holes. Brush Research Mfg. or the Mill Rose Co.
10207291	Cross hole deburring brush .109" Ø, nylon bristles having .003 Ø .025+.010/-.000 extended tip past brush. For deburring tapped holes. Brush Research Mfg. or the Mill Rose Co.
10207292	Cross hole deburring brush .142" Ø, nylon bristles having .003" Ø .025+.010/-.000 extended tip past brush. For deburring tapped holes.
10207295	Cross hole deburring brush .250" Ø, nylon bristles having .005 Ø. For deburring tapped holes. Brush Research Mfg. or the Mill Rose Co.
10207298	Cross hole deburring brush .510" Ø, 304 SST bristles having .005 Ø .025+.010/-.000 extended tip past brush. For deburring small tapped holes.
10400002	Non-woven nylon belt, aluminum oxide, #220-320 grit, blue color, ¼" wide by 18" long, Dynabrade P/N 90228, (20 belts per package – Sell by each). No substitutions.
10400003	Non-woven nylon belt, aluminum oxide, #150-180 grit, maroon color, ¼" wide by 18" long, Dynabrade P/N 90229, (20 belts per package – Sell by each). No substitutions.
10400005	Sanding belt, non-woven nylon, #320-600 grit, silicon carbide, gray color, 18" long, ¼" wide, Dynabrade #90158, supplier - R.F. Hughes only. No substitutions.
10400006	Sanding belt, non-woven nylon, #320-600 grit, silicon carbide, gray color, 18" long, ½" wide, Dynabrade #90159, supplier - R.F. Hughes only. No substitutions.
10400007	Sanding belt, silicon carbide, #120 grit, 18" long, ¼" wide.
10400008	Sanding belt, silicon carbide, #120 grit, 18" long, ½" wide.
10400018	Sanding belt, non-woven, A-MED grit, aluminum oxide, 18" long, ½" wide, 3M, R.S. Hughes/N 08857, 20/cs.
10400019	Sanding belt, non-woven, #150–180 grit, aluminum oxide, 18" x 5/8" wide, Dynabrade # 90293, 20/cs.
10400035	Abrasive belt ¼" x 24", #180 grit abrasive belt, Dynabrade Model No. 90423, or equivalent. For use with Dynafile.
10400101	Belt, aluminum oxide, 1" X 42", #120 grit, R228 aluminum oxide resin bond belt.
10400288	2½" x 48" - #50 grit, Three-M-Ite resin bond belts.

10400289	Belt resin 2½" x 48" - #100 grit, Three-M-Ite resin bond belts.
10400352	Belt cloth 3" x 24", #100 grit, garnet sander cloth belt.
10400398	Sanding belt, 4" x 36", #80 grit, wet or dry, silicon carbide, 3M or equivalent.
10400404	Sanding belt, 4" x 36", #240 grit, wet or dry use, silicon carbide, ref Buelhler P/N 16-5200-240-010.
10400406	Abrasive belt, silicon carbide, 4" x 36", #320 grit, Buehler Cat #BL165200320010. For wet and dry operation.
10400411	Belt sanding 4" x 54" - #60 grit, type C-4 Porter-Cable wet sander belt with cloth backing.
10400525	6" x 48" #50 grit garnet cloth sander belt.
10400527	6" x 48" #80 grit, garnet on cloth sander belt.
10400651	Belt sanding 9" x 107", #80 grit aluminum oxide, sanding belt, resin bond, polyester backing, wet or dry.
10400920	#100 grit, ½" x ½" abrasive bands.
10400923	#36 grit ¾" Ø x 2" long Three-M-Ite cloth Evenrun Abrasive band.
10400925	#120 grit ¾" Ø x 2" long Three-M-Ite cloth Evenrun Abrasive band.
10400950	Resin bond abrasive sleeve, #100 grit, ¼" Ø x 5" long.
10400955	Abrasive sleeve, garnet paper, (formerly #2/0) ½" Ø x 9" long. Resin bond #100 grit.
10400960	Abrasive sleeve, garnet paper, #2/0 3/4" Ø x 6" long.
10500350	9" X 13-3/4" #4/0 Behr Manning emery paper (100 sheets = 1 package) #2000 grit = 4/0
10500502	Finishing paper, garnet, D weight, #80 grit 3M 05114410033 (50 sheets = 1 package)
10500901	Cloth, Al Oxide cloth, aluminum oxide, #80 grit, ¾" wide, utility roll, (roll = 50 yards)
10500902	Cloth, Al Oxide cloth, aluminum oxide, #120 grit, 1½" wide, utility roll, Electro Cut 3-M-Ite, (roll = 50 yards)
10500903	Cloth, Al Oxide cloth, aluminum oxide, #180 grit, 1½" wide, utility roll, Electro Cut 3-M-Ite, (roll = 50 yards)

10500904 Cloth, Al Oxide cloth, aluminum oxide, #240 grit, 1½" wide, utility roll, Electro Cut 3-M-Ite, (roll = 50 yards)

10500905 Cloth, Al Oxide cloth, aluminum oxide, #320 grit, 1½" wide, utility roll, brown, 3M OR Carbo brand, (roll = 50 yards)

10500906 Cloth, aluminum oxide, #400 grit, 1½" wide utility roll, Elektro Cut 3-M-Ite, (roll = 50 yards).

10500907 Cloth, emery, #80 grit, 1½" wide, (roll = 50 yards).

10500908 Cloth, aluminum oxide, #400 grit, ½" wide utility roll (roll = 50 yards).

10501206 Diamond wheel, Horico #H304-110, normal grit, 11.0mm Ø (.433") - 3/32" shank, 1¾" OAL.

10501207 Diamond disc, Horico #H355F-160, extra fine grit, .15mm thick, double sided, flexible,16.0mm Ø (.630") 3/32" shank, 1¾" OAL.

10501600 Crocus cloth, 9" by 11".

10502100 #280 grit sand screen cloth, Bay State #C-280 or equivalent.

10502120 #320 grit sand screen, grit cloth.

10502421 #320 grit, aluminum oxide, cloth-backed abrasive sheet, J weight, closed coat (brown/reddish-brown color). 9" by 11" sheet; Norton Metalite only.
No substitutions.

10502422 #240 grit, aluminum oxide, cloth-backed abrasive sheet, J weight, closed coat (brown/reddish-brown color), 9" by 11" sheet; Norton Metalite or 3M Three-M-Ite Elek-Tro-Cu T only. No substitutions.

10502423 #180 grit, aluminum oxide, cloth-backed abrasive sheet, J weight, closed coat (brown/reddish-brown color), 9" by 11" sheet; Norton Metalite or 3M Three-M-Ite Elek-Tro-Cu T only. No substitutions.

10502424 #150 grit, aluminum oxide, cloth-backed abrasive sheet, J weight, closed coat (brown/reddish-brown color), 9" by 11" sheet; Norton Metalite or 3M Three-M-Ite Elek-Tro-Cu T only. No substitutions.

10502425 #100 grit, aluminum oxide, cloth-backed abrasive sheet, J weight, closed coat (brown/reddish-brown color). 9" by 11" sheet; Norton Metalite or 3M Three-M-Ite Elek-Tro-Cu T only. No substitutions.

10502426 #80 grit, aluminum oxide, cloth-backed abrasive sheet, J weight, closed coat (brown/reddish-brown color), 9" by 11" sheet; Norton Metalite or 3M Three-M-Ite Elek-Tro-Cu T only. No substitutions.

10502427	#120 grit, aluminum oxide, cloth-backed abrasive sheet, J weight, closed coat (brown/reddish-brown color) 9" by 11" sheet; Norton Metalite or 3M Three-M-Ite Elek-Tro-Cu T only. No substitutions.
10502850	#180 grit, silicon carbide, wet or dry abrasive paper. C weight, closed coat (grey/black color), 9" by 11" sheet; 3M Tri-M-Ite or Norton Tufbak Durite or Carborundum Fastcut only. No substitutions.
10502851	#240 grit, silicon carbide, wet or dry abrasive paper. A weight, closed coat (grey/black color), 9" by 11" sheet; 3M Tri-M-Ite or Norton Tufbak Durite or Carborundum Fastcut only. No substitutions.
10502852	#320 grit, silicon carbide, wet or dry abrasive paper. A weight, closed coat (grey/black color), 9" by 11" sheet; 3M Tri-M-Ite or Norton Tufbak Durite or Carborundum Fastcut only. No substitutions.
10502853	#360 grit, silicon carbide, wet or dry abrasive paper. A weight, closed coat (grey/black color), 9" by 11" sheet; 3M Tri-M-Ite or Norton Tufbak Durite or Carborundum Fastcut only. No substitutions.
10502854	#400 grit, silicon carbide, wet or dry abrasive paper. A weight, closed coat (grey/black color), 9" by 11" sheet; 3M Tri-M-Ite or Norton Tufbak Durite or Carborundum Fastcut only. No substitutions.
10502855	#500 grit, silicon carbide, wet or dry abrasive paper. A weight, closed coat (grey/black color), 9" by 11" sheet; 3M Tri-M-Ite or Norton Tufbak Durite or Carborundum Fastcut only. No substitutions.
10502856	#600 grit, silicon carbide, wet or dry abrasive paper. A weight, closed coat (grey/black color), 9" by 11" sheet; 3M Tri-M-Ite or Norton Tufbak Durite or Carborundum Fastcut only. No substitutions. (50 sheets = 1 package.)
10502860	Abrasive paper “Unigrit” #1000 grit sanding paper, silicon carbide, 5½" x 9" sheets. Order no. S1025. (Packaged 25 sheets per sleeve or package.)
10502861	Abrasive paper “Unigrit” #1500 grit abrasive sanding paper, silicon carbide, 5½" x 9" sheets. Order no. S1525. (Packaged 25 sheets per sleeve or package.)
10502880	Paper strips #80 grit 3" x 11" adhesive-backed AB Handimet paper strips, silicon carbide grit only. 100 per bx.
10502881	Paper strips #180 grit 3" x 11" adhesive-backed AB Handimet paper strips. Carborundum or Norton. Must be silicon carbide (non-standard item from Buehler). Beaver Drill says min. is 5 boxes of 100 ea.
10502900	Paper strips #240 grit, 3" x 11" adhesive-backed AH Handimet paper strips. Buehler No. 30-5160. No substitutions. Must be silicon carbide.
10502910	#320 grit, 3" x 11" adhesive-backed AB Handimet paper strips. Buehler No. 30-5160, No substitutions.

10502920	#400 grit, 3" x 11" adhesive-backed AB Handimet paper strips. Buehler No. 30-5160, No substitutions.
10502930	#600 grit, 3" x 11" adhesive-backed AB Handimet paper strips. Buehler No. 30-5160, No substitutions.
10507000	Emery board, 6¾" to 7" long, coarse on one side, fine on other side. Cutex #33, Chesebrough-Pond #9500-40.
10507001	Emery board, ¾" wide x 6-7/8" long. No substitutions. (100 per package). Also, reference item 10507000 prior to ordering.
10507002	Emery board, approx. 4" long, coarse on one side, fine on other side. "Trim" standard length (pkg of 10).
10507016	Emery cord, 0.012" dia., 25 yards per spool, Mitchell Deburring #66.
10509702	Disc, ½", adhesive-coated back, #240 grit.
10509703	Disc, 1" Ø disc, 1" Ø, adhesive-coated back, #240 grit.
10509704	1" abrasive disc, adhesive-coated back, grit #400.
10509705	Disc, 1" adhesive-coated back, #80 grit.
10509706	Disc, 1" adhesive-coated back, #180 grit.
10509707	1" dia. abrasive disc, adhesive-coated back #320 grit. 3M.
10509708	Disc, 1½" #80 grit, adhesive-coated back.
10509709	1½" sides, octagon-shaped hand polishing disc to be used on spot welder electrodes model #107.
10509710	Disc, 1½", #180 grit adhesive-coated back.
10509712	2" disc, adhesive-coated back #180 grit.
10509713	2" diameter abrasive disc, adhesive-coated back #80 grit.
10509714	McCauly Tool Flash-On 2" disc, adhesive-coated back #320 grit.
10509715	Disk Flash-On 2" disc, adhesive-coated back #400 grit.
10509730	Abrasive sanding disc, #320 grit, 2" Ø, adhesive back.
10509736	Abrasive sanding disc, #320 grit, 1½" Ø, adhesive back.
10509737	1½" Ø, press-on disc, Type A, #320 grit, Falcon Order No. PD13.
10509738	Abrasive sanding disc, #320 grit, 1¼" Ø, adhesive back.

10601203 3/16" x ½" x 3" Norbide Dresser Sticks.

10601703 ½" x ½" x 6" 370150 KV Norton Dresser Sticks, unfinished.

10601901 Dresser stick, 1" x 1" x 6" unfinished vitrified dresser stick. Norton 37-C-24-SV or Carborundum C-24-VD-UF.

10602000 Gesswein ruby midget file set 420.

10602001 Miniature abrasive stone, .010" x .125" x 2" Gesswein ruby midget flat file #406 or equivalent.

10602006 Pencil stone kit, No. 23.

10602007 Ruby stone, 0.0781" diameter x 4" OAL, Gesswein No. 404.

10602008 Dura-pink mounted stone from Shofu Dental Corp. Shofu Part #471A, Shape #1. Packaged 1 dozen per box.

10602009 Coral mounted stone from Shofu Dental Corp. Shofu Part #481A, Shape #1. Packaged 1 dozen per box.

10602010 Contact burnishing tool for cleaning electrical contacts and deburring miniature parts.

10602011 Shofu Dura-Green stone, HP shank, silicon carbide grit, Shape #IC5, Shofu #0018.

10602012 Shofu Dura-Green stone, HP shank, silicon carbide grit, Shape #TC4, Shofu #0042.

10602013 Shofu Dura-Green stone, HP shank, silicon carbide grit, Shape #WH6, Shofu #0048.

10602014 Shofu Dura-Green stone, HP shank, silicon carbide grit, Shape #CNl, Shofu #0002.

10602015 Shofu Dura-Green stone, HP shank, silicon carbide grit, Shape #CY2, Shofu #0006.

10602016 Shofu Dura-Green stone, HP shank, silicon carbide grit, Shape #FL2, Shofu #0010.

10602017 Shofu Dura-Green stone, HP shank, silicon carbide grit, Shape #IC2, Shofu #0015.

10602019 Shofu Dura-Green stone, HP shank, silicon carbide grit, Shape #TC1, Shofu #0039.

10602020 Shofu Dura-Green stone, FG shank, silicon carbide grit, Shape #IC2, Shofu #0105.

10602021 Shofu Dura-Green stone, FG shank, silicon carbide grit, Shape #TCl, Shofu #0109.

10602022 Shofu Dura-Green stone, HP shank, silicon carbide, Style WH3.

10602023 Shofu Dura-Green stone, HP shank, silicon carbide, Style WH4.

10602024 Shofu Dura-Green stone, HP shank, silicon carbide, Style Wh5.

10602025 HP shank, Shofu Greenie WH6, dental point, silicon carbide polishing wheel, Shofu #0276 Henry Schein #1954674.

10602026 Shofu Dura-Green stone, HP shank, silicon carbide, Style IC1.

10602027 Shofu Dura-Green stone, HP shank, silicon carbide, Style IC2.

10602028 Shofu Dura-Green stone, HP shank, silicon carbide, Style IC3.

10602029 Shofu Dura-Green stone, HP shank, silicon carbide, Style IC4.

10602030 Shofu Dura-Green stone, HP shank, silicon carbide, Style IC5.

10602031 Shofu Dura-Green stone, HP shank, silicon carbide, Style IC6.

10602032 Quasite mounted disk, shank CA, Shofu, P/N 0294.

10602036 ¼" hard Arkansas triangular stone, 3½" long, #HF113.

10602037 Shofu dental point, alum/oxide, HP shank, Style 209.

10602038 Dental point, alum/oxide, HP shank, Style 208.

10602039 Dental point, alum/oxide, HP shank, Style 204.

10602040 India points, FF 723, fine grit, 3" x 5/16" base. Norton P/N 614636-86740.

10602041 Royal Mechanical Services mounted dental point, Arkansas stone 3/32" shank, Deco part number 4523, 12/bx, Henry Schein order #1426299.

10604000 3" x ½" x ½" sq. HF-43, Norton Hard Arkansas File.

10604020 4" x ½" x 1/16" India Silver SMI THS stones #FF 444.

10604035 4" x 9/16" medium grit, No. MT-134 India Diamond File.

10604036 4" x 9/16" x 3/16" fine grit, FT134 India Diamond File.

10604040 India Points, FF 723, Fine grit, 3" x 5/16" base. Fig. 189-4.

10604050 4" x ½" x ¼" taper round India stone, grade “FF” 644 Norton or equivalent.

10604105 4½" x 1-3/4" x 3/8" x 1/8" FS 34, Norton India Round Edge Slips.

10604106 4½" x 1-3/4" x 3/8" x 1/8" MS 34, Norton India Round Edge Slips.

10604107 4" x ½" MF244, Norton India Round File.

10604110 4" x ½" MF 144, Norton India Triangular File.

10604111 4" x ¼" MF 114, Norton India Triangular File.

10604112 4" x ½" MF 44, Norton India Square File.

10604200 5" x 2" x 3/4" IB 45 Norton India Oil Stone.

10604303 Shofu Durawhite stone, friction grip No. 1C2.

10604306 Mounted dental point kit; consists of ¼" Ø inverted cone, .200" Ø cylinder and .125" Ø cone, Shofu Dura coral stone with 1/16" Ø friction grip shank, 1½" OAL. Shofu Product No. 0489. 72 pieces per set.

10604500 Gesswein Model 18P white polishing stone, #400 grit aluminum oxide, 3/32 shank. No substitutions.

10604800 Cratex stick, 6" long, 3/8" Ø No. 066C, coarse.

10604801 Cratex stick, 6" long, 3/8" Ø No. 066M, medium.

10604804 Cratex stick, 6" long, 3/4" Ø No. 0126C, coarse.

10604807 Cratex block, 6" long, 1" wide, 3/8" thick, No. 6603M, medium.

10604811 Abrasive stick, 1" x ¼", fine, Cratex No. 3802F or equivalent.

10604817 Fine abrasive filled mounted rubber dental point, mini-point with 1/16" friction grip shank, Shofu Greenie No. 414B.

10604818 Fine abrasive filled mounted rubber dental point, mini-point with 3/32" contra-angle shank, Shofu Greenie No. 0404.

10604819 Medium abrasive filled mounted rubber dental point, mini-point with 1/16" friction grip shank, Shofu Brownie No. 0413.

10604820 Cratex rubberized abrasive #8-F. 3.

10604821 Medium abrasive filled mounted rubber dental point, mini-point with 3/32" contra-angle shank, Shofu Brownie No. 0403.

10604822 Abrasive, rubberized, /bullets/ Cratex No. 8F or equivalent.

10604823 Medium abrasive filled rubber cups 3/32" contra-angle shank, Shofu Brownie No. 0401.

10604824 Fine abrasive filled rubber cups 3/32" contra-angle, Shofu Greenie No. 0402.

10604828 Brownie floppy disks (Shofu).

10604829 Quasite mounted disk, shank CA Shofu No. 0294, No substitutions. S.S.J. dated 9-9-81.

10604830 Bullet - Ceramiste Ultra bullet with C.A. shank, Shofu No. 0254.

10604831	Wheel - Ceramiste Ultra WH6 with HP shanks, Shofu No. 0266.
10604832	Knife wheel - Ceramiste Ultra KN7 with HP shanks, Shofu No. 0264.
10604833	Knife wheel - Ceramiste Ultra knife with C.A. shank, Shofu No. 0255.
10604834	Wheel - Ceramiste Ultra wheel with C.A. shank, Shofu No. 0256.
10604835	Abrasive filled rubber dental cup, 0.0938" Ø HP shank, 2" OAL, Shofu Brownie or equivalent.
13800304	Brush, .003" to .005" Ø SS bristles x 3/8" bristle length, 1½" long, ½" wide, 7" OAL Kennedy's Van Brush MFCO. Cat. No. HP8307S.
14503202	Scraper, Red Devil, Size No. 3010.
48000727	Angle-hooked knife, 60° hook, 1/16" wide x 1" long neck, 6-1/4" OAL.
48000732	Scraper made from extra narrow "O" cut pillar file.
48000733	Scraper made from extra narrow "O" cut pillar file.
48001507	Angle-hooked knife, 60° hook, x .031" wide x 1/16" long neck, ¼" Ø shank, 4" OAL.
48001702	Triangular knife, 3/16" Ø straight shank, 4" OAL, C2 carbide, made from Gorton cutter blank.
48001703	Triangular knife, ¼" Ø straight shank, 4" OAL.
48001704	Triangular knife, 3/16" Ø straight shank, 4" OAL.
48001705	Triangular knife, 5/32" straight shank, 4" OAL.
48001706	Triangular knife, 1/8" straight shank, 4" OAL.
48001707	Triangular knife, 1/16" dia. blade x 7/8", 1/8" shank, 4" OAL.
48001709	Triangular knife, narrow blade 11/32" blade length, ¼" Ø shank, 4" OAL.
48001710	Same as above, but 3/16" shank.
48001712	Flat point deburr knife, 30° included angle, 3/32" neck x 1/4" long, 1/8" shank, 4" OAL.
48001738	Oval knife, .060" Ø x 1" long neck, 1/8" Ø shank, 4" OAL.
48001747	Flat point burr knife, 20° included angle, .065" Ø x 1¼" neck, 1/8" Ø shank, 4" OAL.
48001767	Oval knife, .100" Ø x .250" long neck (tapered), ¼" Ø shank, 4" OAL.

48001768 Oval knife, .100" Ø x .250" long neck, ¼" Ø shank, 4" OAL.

48001778 Protective shield.

48002258 Deburr kit (consists of 36 different items).

48002265 Triangular knife, 5/32" Ø x 1" long blade, ¼" dia. shank, 4" OAL.

48002266 Oval knife, 15° angle, .093" Ø shank, 4" OAL.

48002267 Oval knife, 1/16" Ø blade, 1/8" 4" OAL.

48002268 Oval burr knife, 5/32" Ø x 7/8" long blade, ¼" Ø shank, 4" OAL.

48002269 Angle-hooked knife, 90° hook having .025" radius .100" wide x 1¼" long blade, ¼" Ø shank, 4" OAL.

48002270 Angle-hooked knife, 90° hook having .025" radius, .200" wide x 1¼" long blade, ¼" Ø shank, 4" OAL.

48002271 Triangular knife, .075" Ø neck x 11/16" long, 3/16" Ø shank, 4" OAL.

48002272 Oval knife, 1/8" Ø blade straight shank, 4" OAL.

48002273 Special cone end, special burr knife, ¼" Ø end, .100" Ø x 7/8" long neck, ¼" dia. shank, 4" OAL.

48002274 Triangular knife, .037" Ø neck x 7/16" long, .156" Ø shank, 4" OAL.

48002275 Special tip knife, 30° point x .030" thick, 1/8" shank, 4" OAL.

48002276 Angle-hooked knife, 90° hook x .005" wide and 1/4" long, Ø shank, 5½" OAL.

48002277 Flat-point burr knife, 30° included angle, 5/16" Ø blade 1/8" shank, 4" OAL.

48002278 Flat-point "T" end burr knife 30° included angle, 1/8" T, 1/16" Ø X 7/16" neck, 1/8" Ø shank 4" OAL.

48002279 Angle-hooked knife, 45° hook with 8° taper, 3/32" Ø x 7/8" neck, ¼" Ø shank, 4" OAL.

48002280 Angle-hooked knife, 45° hook, tapered sides (10°) 1/16" Ø neck, 1/8" shank 4" OAL.

48002281 Pin vise, modified version of 52103020.

48002284 Burr knife with 12° point angle, tool made from #12 die sinkers regular rifflers file #6 cut, 6" OAL.

48002285 Burr knife, Dixon-Norustain #50 wax carver with sharpened edges, 4" OAL.

48002286	Oval knife, 3/32" Ø neck 15° angle 3/4" long, 3/16" Ø shank 4" OAL.
48002290	Angle-hooked knife, 30° hook, 72° point angle, .0905" Ø x .95" long neck, 1/8" Ø shank, 4" OAL.
48002560	Brush arbor, .188" shank, for .125" wide brush.
48002589	Brush arbor, .125" shank, for .125" wide brush.
48002590	Brush arbor, .188" shank for .250" wide brush.
48002624	Expanding collet for .039" Ø or larger holes.
48002625	Expanding mandrel, 1/8" Ø.
48002626	Expanding collet for .078" Ø or larger holes.
48002814	Brass jaw pin vise similar to 48002281.
48002821	Brass collet for pin vise 52103010.
48002822	Brass collet for pin vise 52103010.
48002914	Expanding collet for .062" or larger holes.
48002915	Expanding collet to hold parts on I.D. of parts. This is for Ø .094" or larger.
48002916	Deburr knife for deburring miniature gear teeth.
48002996	Hook-like burr knife for deburring hard-to-reach areas, 0° hook, 0.013" wide hook.
48002997	Hook-like burr knife for deburring hard-to-reach areas, 0° .013"wide hook.
48002998	Hook-like burr knife for deburring hard-to-reach areas, 45°, 0.013" wide hook.
48004199	3/32" Ø gray abrasive filled rubber dental tool made from 10204835.
48004200	3/32" Ø green abrasive filled rubber dental tool made from 10204820.
48004201	3/32" Ø brown abrasive filled rubber dental tool made from 10204836.
48100067	Angle-hooked knife, 60° hook.
50800140	#4 Cratex mandrel.
50800195	3/32" Ø plain mandrel, for unmounted brushes, felt wheels, etc. Dixon #303.
50800196	Mandrel, ½" Ø, ¼" shank, 1 3/4" O.A.L. Osborn brush Code No. 75009 or equivalent.
50800197	Mandrel, 5/8" Ø ¼" shank, 1 3/4" O.A.L. Osborn brush Code 1745 or equivalent.

50800200	Flexible disc holder, ½" Ø x ¼" Ø shank.
50800201	3/4" Ø x ¼" Ø shank, flash-on disc holder.
50800202	Flexible disc holder 1.0" Ø x ¼" Ø shank.
50800204	Flexible disc holder 1½" Ø x ¼” shank.
50800206	2" Ø x ¼" shank flash-on disc holder.
50951700	Burr Quick Set (#500).
50951715	Blades for Royal deburring tool, B series, standard duty, style B-10 or equivalent.
50951731	Burraway tool, Cogsdill, Type “A” for 3/16" Ø holes, blade size 3/16".
50951732	Burraway blade, Cogsdill, double cutting for 3/16" Ø holes, Type A.
50952018	Micro tool handle, Circon No. MT-2 or equivalent.
50952019	Micro knife, Circon #MT-C185 or equivalent for micro tool handle.
50952020	Diamond point Circon #MTC-451 or equivalent. For micro tool handle.
50952021	MicroHook 180°, Circon No. MTC-120 or equivalent.
50952022	MicroHook 180°, Circon No. MTJ-120 or equivalent.
50952023	MicroHook, 90° Circon No. MTC-115 or equivalent.
50952026	Probe, hook end, 5½", Grobet USA.
50952027	MicroNeedle, ultra, high strength tungsten alloy, Circon No. MT-C100 straight or equivalent.
50952028	MicroNeedle, ultra, high strength tungsten alloy, Circon No. MTF-100 90° bend or equivalent.
50952029	MicroNeedle, ultra, high strength tungsten alloy, Circon No. MTJ-100 30° bend or equivalent.
50952036	MicroChisel, Circon No. MTC-200 or equivalent.
50952053	#1/2 wax carver, Dixon CVHH or equivalent.
50952060	#5 wax carver, Fig. 59-11. CV-5 or equivalent.
50952065	#6 wax carver.
52103000	Pin vise, double end – 0" to 2.5mm IN. Ref: Jules Borell- Cat. #PV657

52103001	Pin vise, double end - .000 to .081", .045" to .081", length 4¼", Dixon #67-2, or equivalent.
52103010	Pin vise, set of 4 min. capacity 0 to .040", .030" to .062", .050" to .125" & .115" to .187", Dixon No. 162 E, Lufkin No. 197S, or General No. S 94 and D 221 X.
52103034	Plug gage handle, Dalworth Tool #30–270. (To hold parts being deburred.)
52103037	Collet bushings for gage handles, .02"–025" size range, Royal Oak Products #1W-.025".
52103038	Collet bushings for gage handles, .025"–030" size range, Royal Oak Products #1W-0.030.
52506190	3" long x .014" thick screw head file with tang. Grobet No. ZYT 33 or equivalent.
52506195	3" long x .024" thick screw head file, with tang. Grobet No. ZYT 33 or equivalent.
52506205	4" long x .036" thick screw head file with tang. Grobet No. ZYT 40 or equivalent.
52506212	4" 2nd cut, Nicholson Warding File #16540.
52506215	Equaling file, special thickness, length of cut--4" width 13/32" approx. thickness .014" stubs iron wire gauge #26, #2 cut.
52508055	5½" needle file, #2 cut, Grobert equaling needle file #2301.
52509000	Square edge joint file, cut on edges only, parallel in width and thickness, 4" length of cut x .028" thick x #2 cut (Glardon Swiss File).
52509600	6" bastard-cut file/flat mill.
52509606	6" 2nd cut, 3/16" Ø round straight file. Grobet #ZRP-62.
52509620	6" type A, Nicholson half round, double cut file, for aluminum.
52509624	6" smooth cut, mill file flat.
52509629	6" #6 cut, extra narrow, XF Swiss pattern pillar file (Nicholson, 0.076" thick).
52510000	UMV needle files/jeweler files/jeweler files/ #23-701-set of 12 assorted, cut #4 OAL 5½", length of cut 2½"
52510003	5½" or 6½" #2 cut, Swiss needle file set.
52510004	6¼" #0 cut, Swiss needle file set (12 files/case).
52510005	6¼" #2 cut, 3 square needle file (tapered .019 to .122").
52510045	5½" OAL pillar escapement file #4 cut.

52510055	5½" OAL pillar escapement file #8 cut (.035" thick).
52510060	5½" half round escapement file #8 cut (tapered .020" to .051").
52512603	7½" X. F. Silvercut rifflers, style 10, flat 0 cut.
52556004	3/8" x 3½" #15 Nicholson bearing scraper.
52556010	Safety scraper, razor blade type, Warner #GS-107, Red Devil #32-23 or equivalent.
52620057	No 4 size, .059 Ø, dental carbide burr ball with friction grip shank, .062 Ø, short shank.
52620190	3/16" Ø x ½" cutter face rotary file with ¼" Ø shank Grobet #28025 or equivalent.
52620194	¼" x 90°, incl. angle carbide rotary burr. SCTI No. SK-1. ¼" Ø head, ¼" Ø shank.
52620449	Countersink, Mastercut, .1875" Ø, 2.000 OAL, 15 FL, RHC, carbide, .1875 round shank, 2 end, 90° angle, medium flute style, .0500 Small Ø, Atrax, #R-21
52620452	3/8" x 3/4" tree shape, pointed end, med. cut, rotary file, ground from solid No. 28870 Grobet.
52620454	3/8" Ø ground burr, style Q5, medium cut, ball shape, rotary file, Nicholson or equivalent. Identify tool with code number.
52620458	3/8" Ø x 3/4" carbide burr, Shape C, burr #C-121 fine cut.
52620470	Cutter, 7/16" Ø severance HS deburring, Style GB-45, 31 teeth per inch, or equivalent. Severance DWG. 1DC-631110.
52620475	Round or ball-shape burr sets, 3/32" Ø shank, 15 burrs per set, Dixon #108-7.
52620480	Bud-shaped burr sets, 3/32" shank, 15 burrs per set, Dixon #108-9.
52620485	Hart shape burr sets, 3/32" Ø shank, 15 burrs per set, Dixon #108-10.
52620486	Burr tool, Hart shape, 3/32” Ø shank, Size 20, Grobert #18.520 or equivalent.
52620487	Burr tool, Hart shape, 3/32” Ø shank, Size 4, Grobert #18.504 or equivalent.
52620488	Burr tool, Hart shape, 3/32” Ø shank, Size 13, Grobert #18.513 or equivalent.
52620490	Cone pointed shape burr sets, 3/32" Ø shank, HHS, 15 burrs per set.
52620491	Brasseler-Finish Carbide part number H379UF-018-Shank 31 deburr tool OAL .750"; shank Ø .062"; ultra-fine 30-blade; egg shape .071" Ø.
52620496	Ball shape burr set, five HSS per set of the following sizes, 4.75, 6.0, 7.0, 8.0 and 9.0 mm Ø, fine pitch teeth.

52620498	Burr tool, carbide, ultra-fine, oval shape, 2.3mm wide, .062 shank, .750 OAL; Brasseler H379UF.31.023 OS1UF.
52620502	9/32" Ø ball burr, fine cut, 33 teeth per inch, 1/8" Ø shank, Grobet #BU6A7.
52650561	Outside-inside tube deburring file for 1/8" Ø x 1/16" I.D. tube. McMaster-Carr Catalog No. 4327A11 or equivalent.
52620565	½" x 90° cone-shaped, ground from solid rotary file medium pitch, Grobet GC-45 or equivalent.
52620569	½" Ø cut HS rotary file, ground from solid with ¼" shank screw on type/Grobet 28513 F or equivalent.
52620570	5/8" Ø coarse, ball shape rotary file, hand cut, high speed steel. Grobet 11516R or equivalent.
52621215	3/4" Ø ball burr, solid carbide shape, D brazed ¼" Ø steel shank.
52621300	Special 1" Ø x ¼" length of cut, titanium nitride coated HSS, double 45° angle, rotary file with a ¼" shank. Severance Tool Number-LCX.
52621305	1" x 1" Atrax #A-201, rotary file, standard cut, solid carbide with ¼" Ø shank.
55300502	Prober, style No. 1, straight stainless steel, Beau-Tech No. SH-141 or equivalent.
55300504	Prober, style No. 6, 90° bend, stainless steel, Beau-Tech No. SH-116 or equivalent.
55300506	Prober, style No. 17, 90° hook, 30° bend, stainless steel, Beau-Tech No. SH-117 or equivalent.
55300508	Prober, style No. 23, curved, stainless steel, Beau Tech No. SH-123 or equivalent.
55390000	Optical comparator set, surface roughness scales, standard machine, grit blast, shot blast and EDM finishes. (DO ALL Catalog No. 605-022912, Stock No. G-4 or equivalent.
99013198	Steel crochet hook, size #10 (for removing chips from small holes).
99013199	Steel crochet hook, size #14 (for removing chips from small holes).

Tools and Techniques for Hand-Deburring (by Feature)

The following instructions and techniques describe specific methods for deburring specific features. They were developed by LaRoux Gillespie while he worked at Honeywell back in the 1970s and 1980s and are excerpted from the four-part Training Manuals he produced. Other than some improvements and updates, these instructions (and the text presented in this section) have changed very little from those early training manuals.

The instructions are fairly specific and should be used as a guide, particularly by individuals who are new to hand deburring. They are a good starting point to acclimate you to the world of deburring miniature precision-machined parts. As you become more comfortable with the process, you will develop your own techniques that work for you.

Deburring Holes

Holes are among the most commonly deburred features. For example, normal deburring addresses the following types of conditions:

- Large through hole
- Small through holes
- Small through holes with 0.0002-inch tolerance
- Small through holes with 8 micro inch finish
- Small through holes with 0.003-inch maximum radius
- Small blind holes
- Intersecting holes
- Holes intersecting slots
- Holes having counterbores

Although we have not defined “small” and “large,” it should be obvious that a large hole, e.g., a 6-inch diameter hole, requires a different approach than a small hole. These are typical holes sizes on precision parts:

- One inch or larger diameter
- 0.250-inch diameter
- 0.062-inch diameter
- 0.025-inch diameter
- 0.010-inch diameter

Basic Approaches for Deburring Holes

Assume a part having no close tolerances, no close finishes, and no edge breaks. The part has a 0.25-inch diameter hole going entirely through the part, and the part is flat. The following is a normal approach for deburring the hole in this situation:

a) Sand or stone the flat surface.

b) Use a burr ball or countersink to provide a small radius or break around the edges of the hole.

c) Use an abrasive-filled rubber bullet to provide a smooth blend at the hole entrance and exit.

d) Blow off the loose particles and chips that are now on the hole.

e) Clean the part.

f) Scrutinize the hole to ensure that the burrs were removed.

g) Repeat steps a) through f) as required.

The deburring of this hole begins with sanding or stoning the surface, because—after the hole is drilled—there is either a burr or a hump of raised metal at the entrance and exit of the hole, as shown in Figure 43. Sanding or stoning the surface removes the large amounts of metal at these locations. You might hand-stone or hand-sand these surfaces, or you might use an abrasive disc mounted in a hand motor (illustrated in Figure 44).

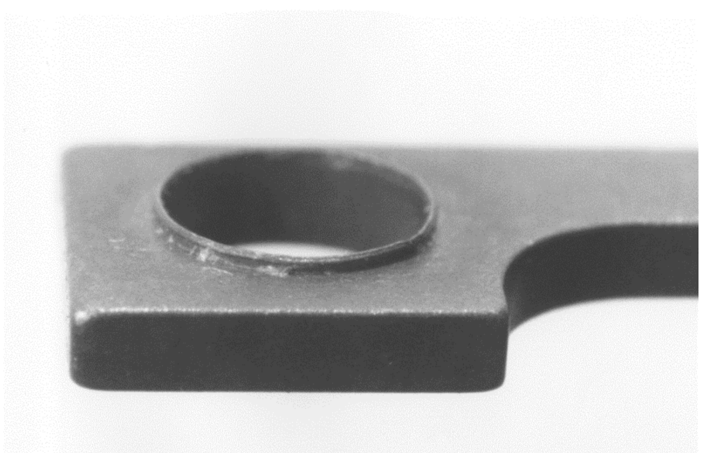

Figure 43: Raised Metal Produced by Hole Drilling

Figure 44: Abrasive Disc Used to Remove Raised Metal Around Hole Edges

The burr ball or the countersink tool provides a small amount of edge break. This is necessary to prevent the part from cutting or marking its mating part. The abrasive-filled rubber product provides a smooth blend to the small burr left by the burr ball or the countersink tool, as shown in Figure 45.

Whenever sandpaper or abrasive-filled products are used on parts, a considerable amount of debris is left by the tools. Although the easiest debris-removal method is blowing the debris off with a small blast of air into one of the vacuum system adapters, this method fails to remove all the residue. Typically, the part is dipped in a small can of alcohol, and the moisture is blown off again.

At this time, after the surface is clean and believed to be burr-free, scrutinize the part to verify that it is, in fact, burr-free. Otherwise you run the risk of overlooking some burrs. It takes only one small particle on one portion of one edge of a single part to cause a failure in subsequent assemblies or a reject by inspection. About 20 percent of the time, after deburring and cleaning, you will find that the burr or raised metal has not been totally removed, and you must repeat steps a) through g).

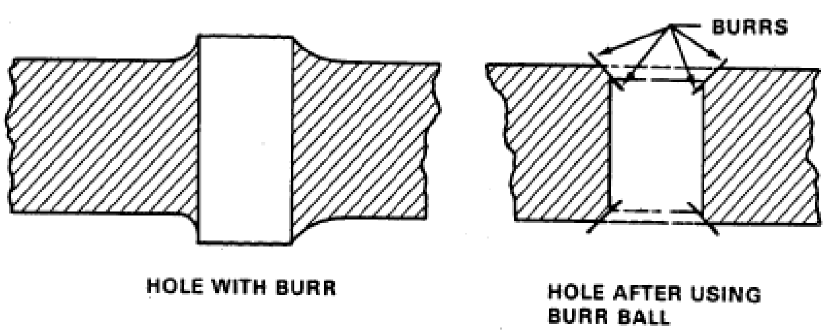

Figure 45: Smaller Burrs Produced by Burr Balls and Countersinks

Now assume a different situation: A part has no close tolerances, no close finish, and no precision edge break to maintain. The part has a hole 3 inches in diameter running entirely through the part and, once again, it is a flat part. In this case, consider the following reasonable approach to deburring:

a) Sand or stone the surface.

b) Use a burr knife or a hand-held stone to chamfer the edge.

c) Use abrasive paper or a power brush to blend the edge to provide a smooth radius.

d) Blow off the loose particles.

e) Clean in a liquid if necessary.

f) Scrutinize for burrs of raised metal.

g) Repeat steps a) through f) as required.

The only major differences for this situation are in steps b) and c). On a large hole, it can be easy to remove a heavy burr by maneuvering a knife, scraper, or even a hand stone to scrape around the edges. Large holes also make it easy to use abrasive paper (for sandpaper-like products) or even our miniature power brushes.

In the first example, the use of a burr knife or scraper was not discussed. Typically, rotary burs or burr balls are the easiest and quickest ways to remove burrs. Nevertheless, some operators still prefer to use a small knife rather than a burr ball or countersink tool on small holes (even on very miniature holes). Either approach is acceptable, and both approaches have advantages, but—for the individual new to deburring—burr balls or countersinks are the easiest tools to use.

Now assume a third condition: A part has a 0.020 plus or minus 0.0002 inch diameter tolerance; it has a 0.003 maximum edge break radius. The hole goes entirely through a flat part.

At this point it is important to recognize how small a 0.020 diameter hole is. As shown in Figure 46, a 0.020 diameter hole is the size of a miniature lead pencil—much smaller than a conventional wooden pencil lead. It is also important to acknowledge, again, what close tolerances imply. This case involves a 0.0002 inch diameter tolerance. This is very tight tolerance. (To put things in perspective: A tolerance of this size is only 1/15th the thickness of a human hair.) Unless you are careful, you could easily increase the diameter beyond this tolerance. The 0.003 inch maximum break is also difficult to maintain. Essentially, you must make sure that the part is burr-free and—at the same time—no thicker than a hair, chamfer, or radius at the edges. See Figure 47.

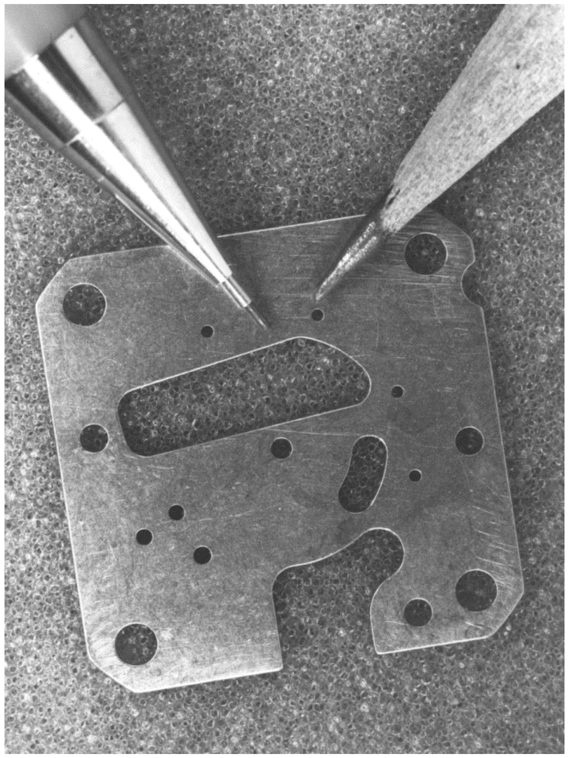

Figure 46: Part with a .020-inch Diameter Hole

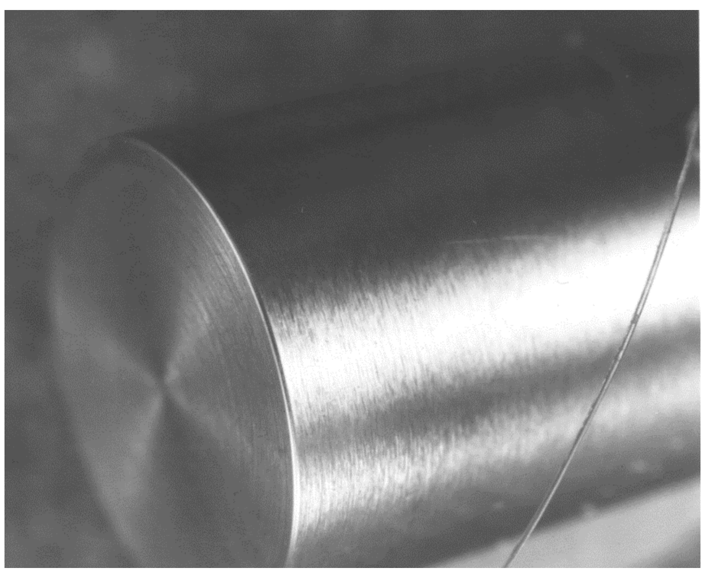

Figure 47: Example of .003-inch Chamfered Edge

An approach to deburring very small holes is as follows:

a) Stone or sand the surface of the work piece.

b) Gently use a small burr ball.

c) Use a toothpick or, if allowed, a small reamer.

d) Use an abrasive-filled rubber dental point.

e) Clean the part.

f) Scrutinize for burrs.

g) If allowed, use a “go” gage.

In this instance, note the added use of a reamer, a toothpick, and an abrasive-filled miniature rubber point. Whenever a burr ball is used, it generates two burrs. The burr ball removes one large burr and produces two smaller ones, as shown in a previous illustration. A reamer run through the hole will remove the small burr inside the hole, as shown in Figure 48. In many cases a toothpick will also do the job, with less possibility of damage to the hole. An inexperienced person using a reamer is likely to enlarge the hole beyond the allowable tolerance and, at least, scratch the precision hole surfaces. A toothpick will not do this under normal conditions. A toothpick is soft enough that it will deform before it enlarges the hole size. In such situations, ask the supervisor if a reamer can be used to remove the burr down in the hole.

The miniature dental points are the smallest soft tool available for providing a smooth radius in the holes. For example, Figure 49 illustrates the quality of the hole after the use of one of these dental bullets. As previously indicated, it is easy to overlook a burr in a hole. If a plug gage is allowed (once again, a supervisor will indicate the size of "go" gage that should be used in the hole), use it to indicate whether or not a burr is present.

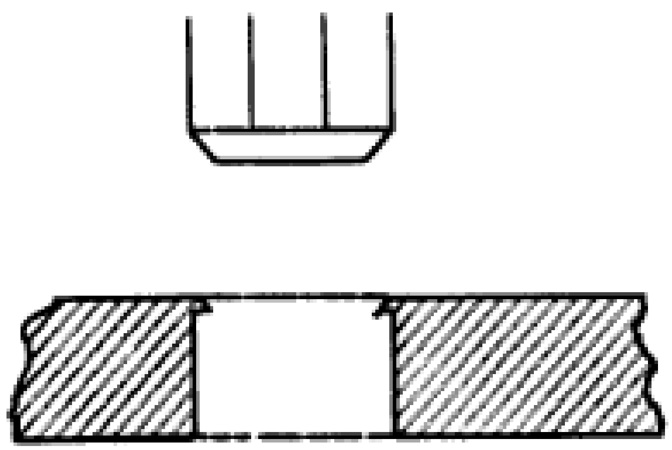

Figure 48: Reamer Removes Burrs Rolled Over Into a Hole

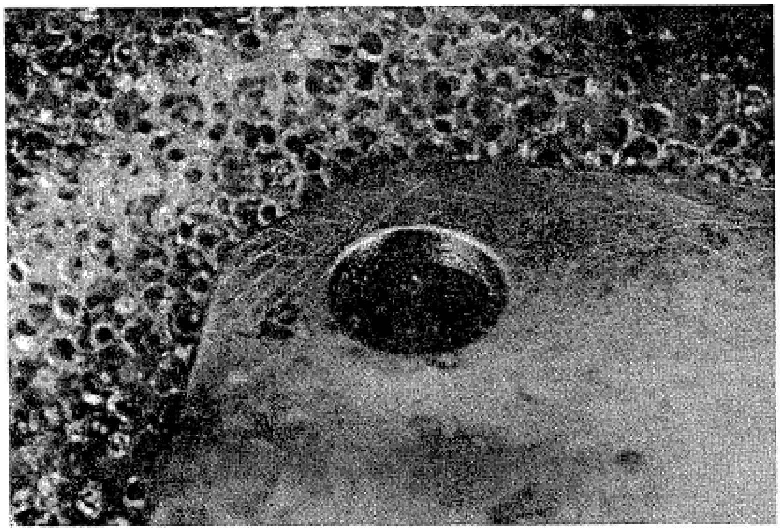

Figure 49: Small Hole Edge Deburred with a Rubber Bullet

Again, it is possible to use a miniature burr knife in place of the rotary burr tool to remove the heavy burr. Some individuals will use a knife on every hole. (For extremely small holes, a knife raises the possibility of scratching the hole's interior surface.) The approach described above is one basic approach that is logical and frequently adequate, but it is not the only way to deburr these holes. Each individual develops his or her own technique based on these approaches.

Basic Approaches for Deburring Counterbored Holes

Now assume a hole that has a counterbore at one end as shown in Figure 50. On the counterbored hole are three surfaces that must be deburred, and one of them is relatively difficult to reach. In this situation, if the hole is large enough, you could:

a) Stone the flat surfaces.

b) Use a countersink or burr ball on the three round surfaces.

c) Use a knife if necessary, particularly down in the bottom of the counterbore.

d) Use an abrasive-filled rubber bullet, a special counterbore tool, or a reamer.

e) Clean the part.

f) Scrutinize.

g) Repeat steps a) through f) as necessary.

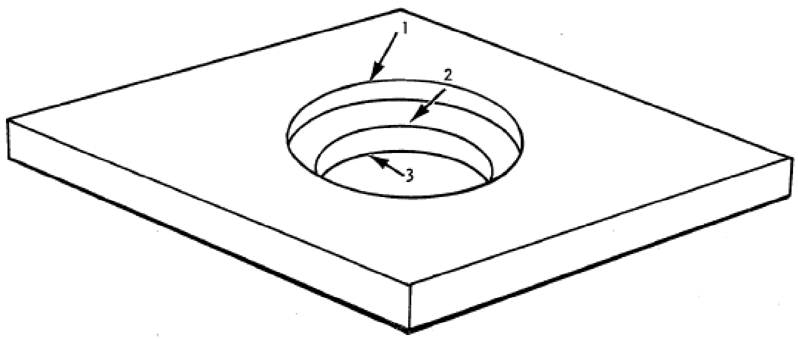

Figure 50: Counterbored Hole Edges

Note that the hole at the bottom of the counterbore (edge number 2) is the most difficult area to deburr, particularly if the counterbore is very shallow. In some cases, a reamer is necessary. In other cases, a specially designed counterbore tool will work. In still other cases, sandpaper can be used to reach the difficult diameter. Again, on very small holes you may want to use a wooden toothpick to provide the necessary radiusing, to move the burrs, and to verify that burrs are absent.

Basic Approaches for Deburring Intersecting or Cross Holes

Consider now the intersecting holes shown in Figure 51. Note that the intersection of any two holes presents a 3-dimensional surface, as shown in the 3D representation of two intersecting holes in Figure 52. Because of this, deburring and providing a consistent edge break may be difficult. This is a typical approach for deburring intersecting holes:

a) Stone the flat surface of the hole.

b) Use a deburring knife for the hole intersection.

c) Use an abrasive-filled rubber bullet or miniature dental bullet.

d) Clean the part.

e) Scrutinize the part.

f) Repeat steps a) through e) as required.

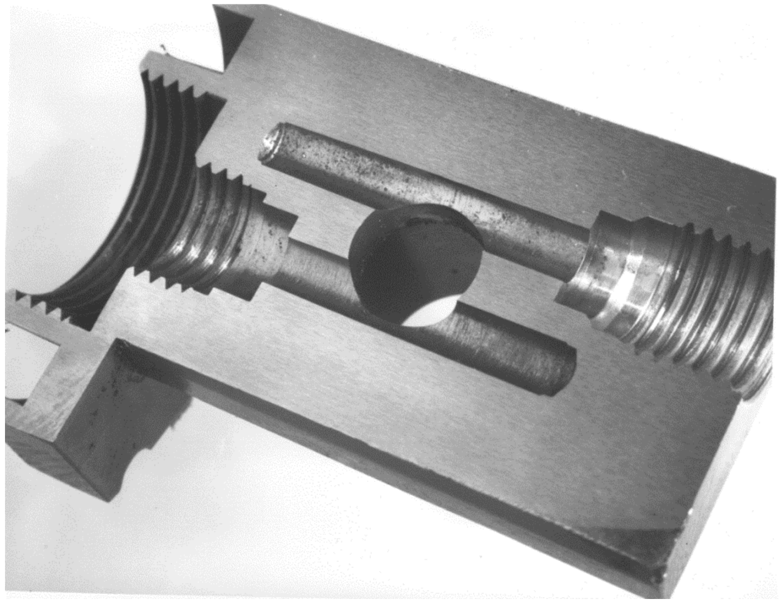

Figure 51: Example of Part with Intersecting Holes

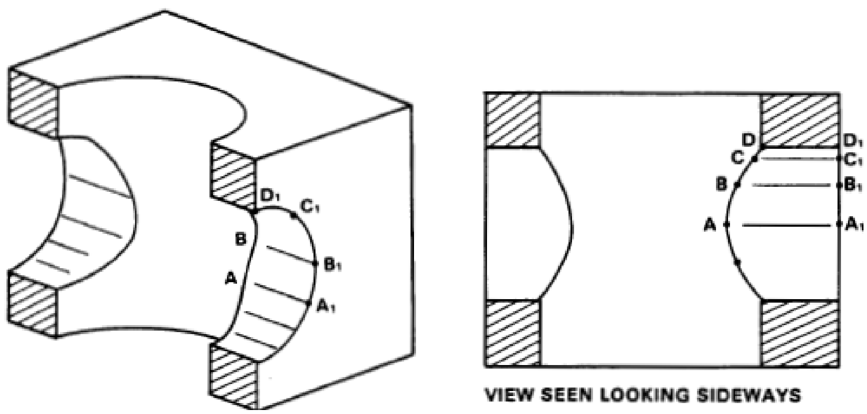

Figure 52: 3-Dimensional Representation of Two Intersecting Holes

In the case of intersecting holes, burr balls will not provide a uniform break around the intersections. For this reason, burr knives and/or hand motors are used for this type of situation. In a few cases, such as that shown in Figure 53, the intersections are so far from the surfaces and in such small holes that cannot be reached with a burr knife or any other standard deburring tool. In cases like these, the process engineer will have to find or develop a tool or process to enable the removal of burrs at the intersection. In some cases, rather than using abrasive-filled products, you may want to use a sandpaper-like product at the hole intersection. If the holes are large enough (for example, one-half of an inch in diameter or larger) then the abrasive paper products may work well to blend the intersecting edges after use of the knife or deburr motor.

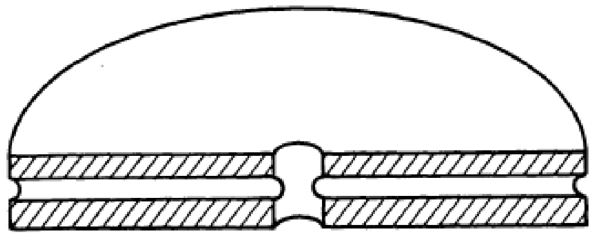

Figure 53: Intersecting Holes Not Accessible with Standard Deburr Tools

Areas of Concern for Deburring Holes

When deburring holes, remember these four “don’ts”:

1. Don’t change the hole size.
2. Don’t exceed the allowable edge break.
3. Don’t damage precision surface finishes.
4. Don’t change the thickness around the hole.

A typical deburring operation doesn’t affect the hole size, because you are working at the edges rather than in the diameters of the hole. Edge breaks are critical on many components. Some parts require edge breaks as small as 0.003 inch maximum. This size break is very difficult to maintain for someone unfamiliar with precision deburring. This is one of the reasons this document was written—to provide you with the knowledge required to produce precision edge breaks. While it may not be obvious why certain edge break requirements are needed, remember that parts will be scrapped and production delays will occur if these edge breaks are exceeded.

On miniature parts, the surface finish in holes and on surfaces adjacent to holes is one of the most frequent types of problems faced. Figure 54 shows a part with precision surface finishes on the flat surface as well as within the hole. If you use an abrasive paper product that is too coarse, or use a knife indiscriminately and scratch the surface, then the parts will be rejected and in many cases cannot be reworked satisfactorily. This would then be a cause for scrapping the part.

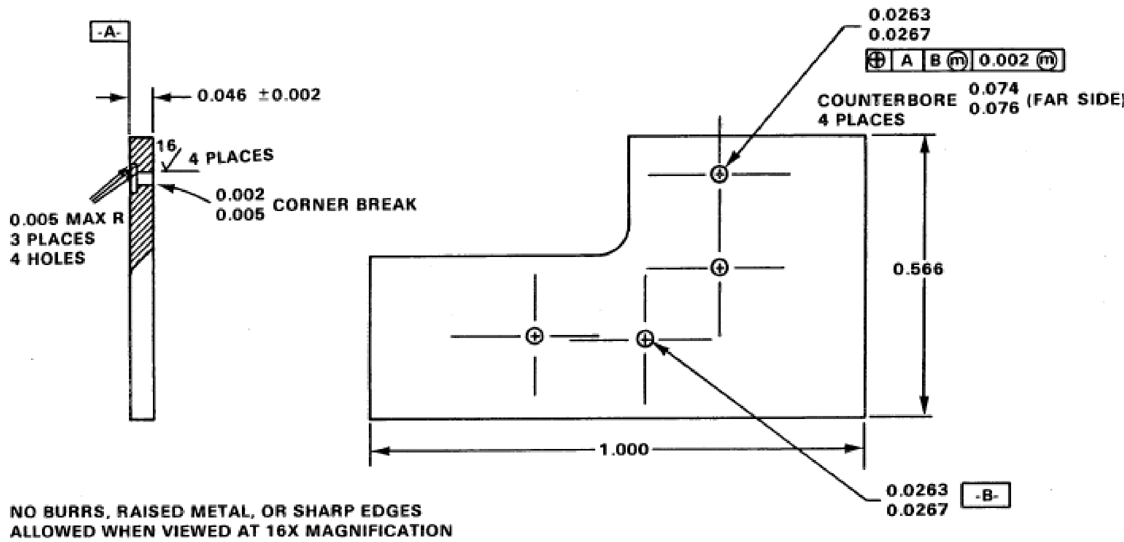

Figure 54: Part Drawing with Precision Finishes in Holes

<u>Deburring Threaded Features</u>

Deburring threads is one of the most difficult problems faced on miniature parts. Several portions of the thread must be burr-free. Threads themselves come in a variety of part geometries and in a variety of sizes. The tiny miniature threads are not only difficult to deburr, but are also extremely difficult to hold without damage. Threads represent unique problems, not only for deburring but also for parts assembly. Unless threads are burr-free, a burr can shear off and interfere with many precision mechanisms.

Types of Burrs Found on Threads

These five basic types of burrs or configurations must be removed when deburring threads:

1. Raised metal on the top surface
2. Burrs on the crest of the threads
3. Burr or chip at the bottom of a bind hole
4. Chips or oil in roots of threads
5. A bent first thread

Figure 55 illustrates the first of the listed conditions—raised metal on the top surface. The illustration shows a small hump of metal (commonly referred to as "raised metal”) on the top surface of the hole. In many cases, this small swell of metal is almost invisible until you become accustomed to looking for it.

This condition is not permitted because it causes mating parts to stand above their normal flat surface. See Figure 56. This raised metal must be removed to provide a uniformly flat surface or a depressed area at the hole entrance, as shown in Figure 57. Most product standards specified for use in this plant require that threaded holes have a chamfer equal in diameter to the largest diameter of the thread, as shown in Figure 58.

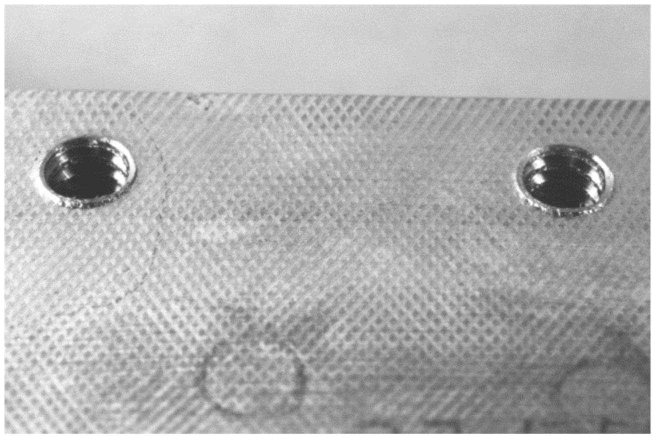

Figure 55: Raised Metal on the Top Surface

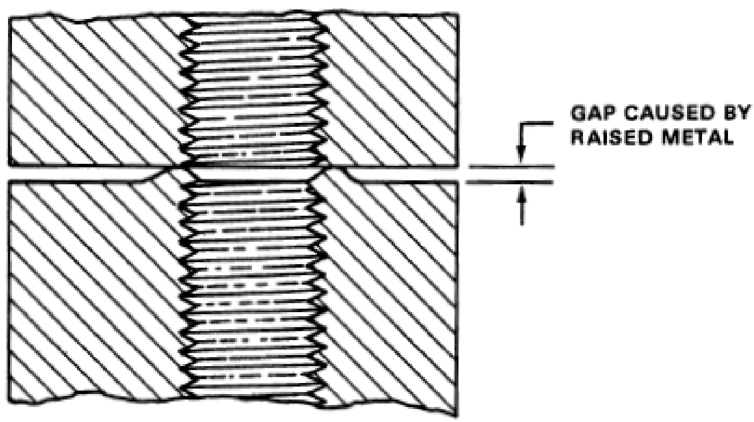

Figure 56: Raised Metal Prevents Proper Assembly

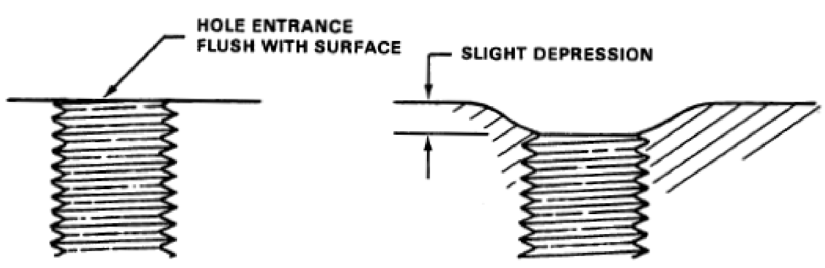

Figure 57: Allowable Chamfered Thread Relief Condition

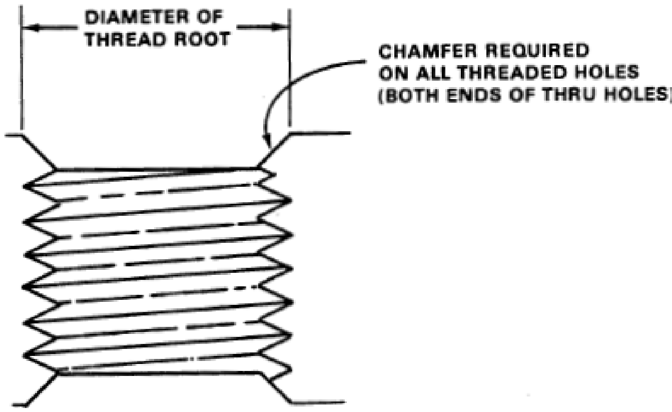

Figure 58: Required Chamfer Size on All Threaded Holes

Figure 59 shows a large burr or chip at the bottom of a blind tapped hole. In many cases, this chip would not affect the function of the hole. In many other cases, however, mating screws are inserted and removed many times, and these screws are of varying lengths. It is therefore possible for the chip to break loose and, ultimately, fall out into the assembly. For this reason, we must do everything possible to remove these types of chips. This is very difficult. As seen in Figure 59, the chips are on the side wall and in a deep hole—almost impossible to reach without specially designed tools.

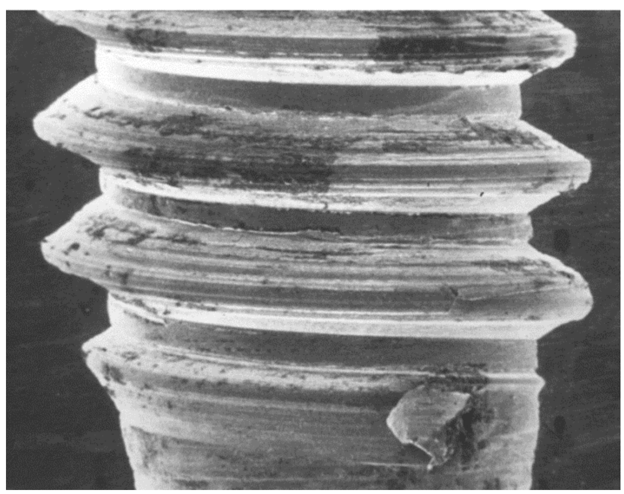

Figure 59: Example of Large Burr at Bottom of Blind Hole

Figure 60 shows an example of burrs commonly found on the crest of threads. In this instance, there are burrs on both sides of the crest at the top. These must be removed and some radius provided on the crest of the thread. Figure 61 shows chips and loose particles in the bottom or root of the thread. These also must be removed. (In many cases, loose particles or burrs in these areas might be masked by chips, dirt, and oil.)

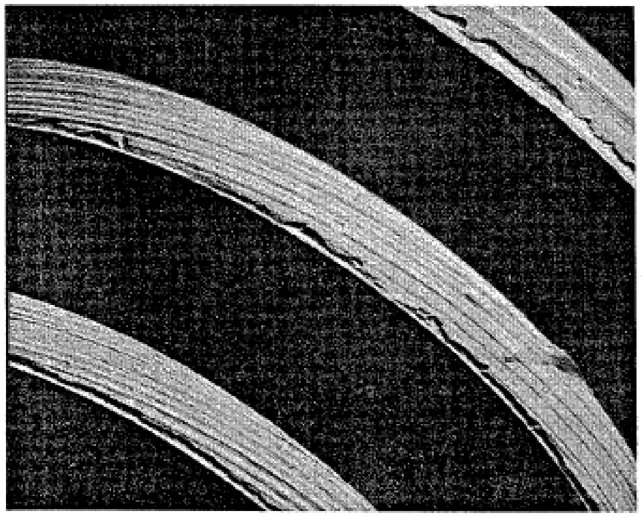

Figure 60: Example of Burrs on Thread Crests

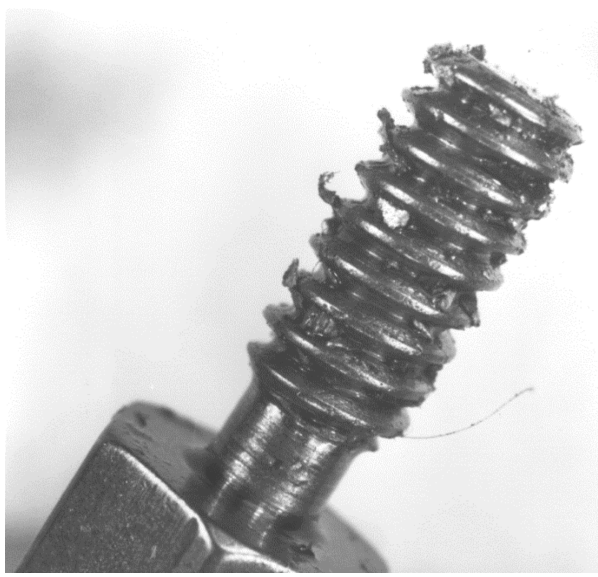

Figure 61: Thread Roots with Chips and Loose Particles

Figure 62 shows a bent first thread. In this instance, the metal is literally pushed into the root section of the thread. In some cases this would not affect the function. In others, because of the nature of the mating parts, the metal would be torn loose and, again, would fall into the assembly.

Figure 62: Example of Bent First Thread

Figure 63 illustrates another example of the same type of bent first thread. In this instance the bent thread is a tiny flap of metal. In the Figure 63 example, the total diameter of the screw is smaller than a pencil lead. Note that, while Figures 62 and 63 are of screws rather than holes, the same damaged first thread condition occurs on holes. If there is any chance that the first thread will be bent or deflected in assembly, the flexible part must be removed.

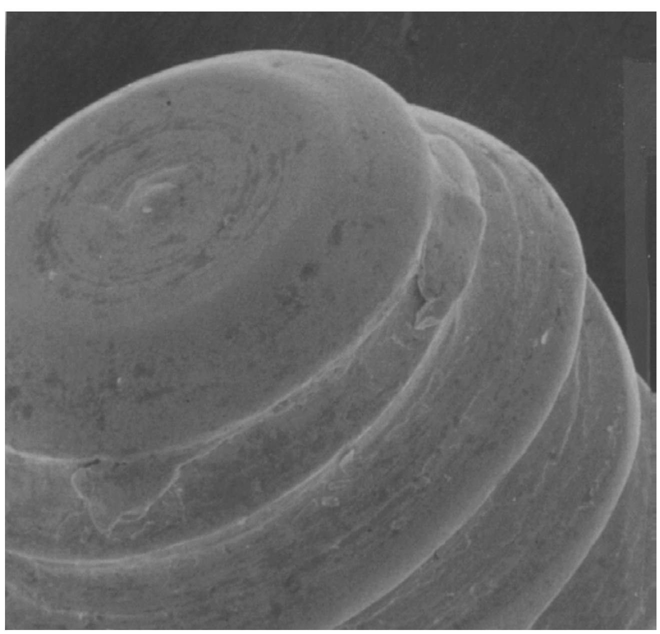

Figure 63: Example of Bent First Thread on Tiny Thread

Three types of internal threads are generated at Honeywell, and each type has different burrs. The thread types are as follows:

1. Single point and thread mill threads
2. Tapped threads
3. Formed threads

Single point and thread mill threads are generated by a tool that has the actual thread form, or triangle shape, built into the tool. A numerically controlled machine is required to drive this tool to generate the thread, by removing tiny amounts of material as it rotates and moves up and down inside the hole. Several passes with the tool are needed to completely generate the threads in the hole. Because the threads are produced in this manner, the thread surfaces look much smoother and tend to have fewer burrs than either the tapped or formed threads.

Unless they are extremely deep, internal threads 4-40 or larger are generally single point- or thread mill-generated. (Extremely deep internal threads have to be tapped.) Any thread smaller than this will also be tapped, either by a cutting or a forming tap.

Although tapped threads are also cut, they are cut in a different manner than the single point threads. The tap used to generate these threads looks a lot like a drill, but with a specific thread form built into it. It does not require a numerically controlled machine to generate the threads. As a tap turns and starts into a pre-drilled hole, the first three or four threads—called “lead in threads”—catch in the hole and start cutting threads while the tap pulls itself into the hole. These first few threads are the only part of the tap that actually cuts the threads in the hole. The rest of the thread form on the tap engages the previously cut threads to help pull the tap through the hole. This means that the tap engages the thread form all the way down the total length of the threaded hole and, therefore, rubs on the thread surfaces more, which generates more burrs and debris than that in the single point- and thread mill-threaded holes. Figure 64 shows an example of the burrs generated in a tapped hole.

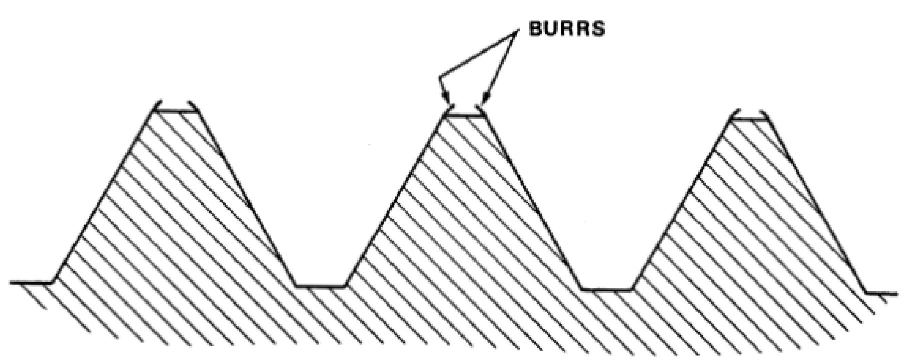

Figure 64: Cross Section of Tap Cut Thread

Figure 65 illustrates the crest configuration of threads produced by cold forming taps. Since form taps actually form the threads, not cut them, the threads have a U-shaped pocket at the top of the crest and the ends of the U are often very ragged.

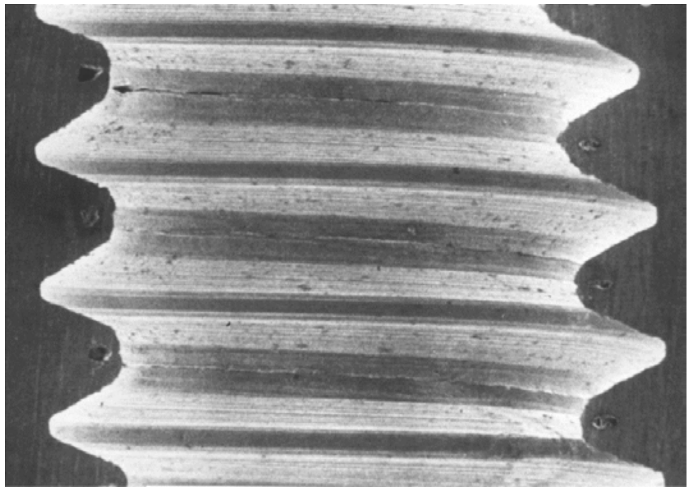

Figure 65: Thread Produced by Express Tap

Figure 66 illustrates the idealized shape of cold formed threads as shown in many current workmanship specifications.

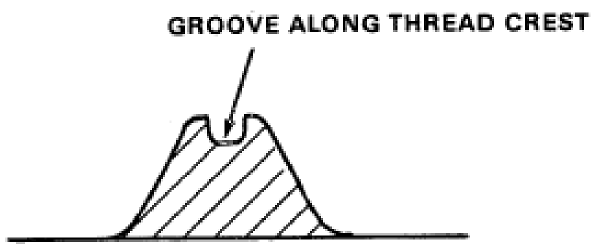

Figure 66: Cold Formed Thread Form

Although Figure 67 is an example of an actual cold formed thread, certain different materials might look better than that shown in the example. Figure 65 illustrates the type of idealized thread that can be produced with careful attention by the machinist producing the thread. In this instance, the “U” at the top of the crest is actually closed shut, and there is a small black spot just below the crest. This black spot is actually a hollow area that runs just underneath the crest and around the thread.

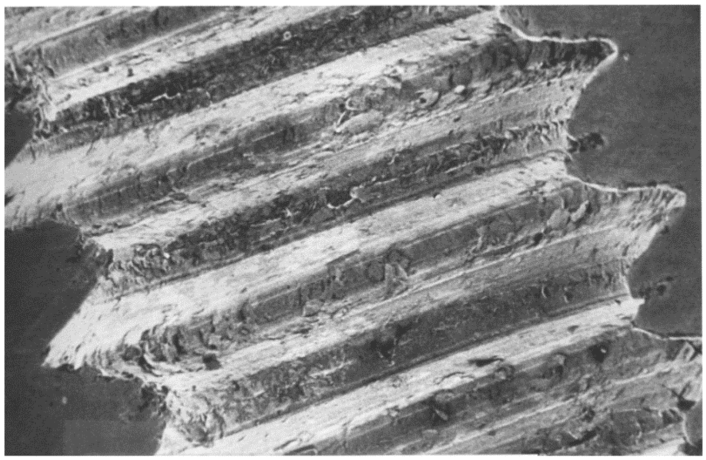

Figure 67: Example of Cold Formed Miniature Threads

Again, threads must be burr-free. As just indicated, burrs are left on the crests of all threads, whether they are produced by cutting, tapping, or cold forming. On external threads, these fine burrs can be easily removed from most parts by sanding, tumbling, or brushing. See Figure 68.

Figure 68: Example of Deburred Thread Quality for Precision Miniature Parts

Although internal threads are more difficult to deburr, they too can appear as burr-free as external threads, particularly in the larger thread sizes. On the smaller threads (such as 1.0, 0.8, and 0.6mm) it is important to ensure that thread size is not affected by re-tapping or using thread gages to “clean" threads.

On 0-80 UNF and smaller threads, it is generally impossible to achieve the same levels of internal burr-free crests as on larger sizes. Consequently, inspection is less demanding on these minute features. The mating external threads can be “clean” and are expected to be that way. The fact that one of the two threaded components has entirely burr-free crests, that gages have been threaded into the internal threads, and that a significant effort has been made to remove all loose particles significantly reduces the possibility of burr-related problems.

It is more difficult to remove burrs from cold formed threads and threads in aluminum. In threads as rough as those in Figure 67, it is important to use cross-hole deburring brushes to remove all loose particles.

In fact, *all* internal threads should be brushed to remove any loose particles.

General inspection practice is to use 7X magnification to inspect most threaded features produced in the miniature machining department. (Up to 20X magnification is used on some components.) Similarly, parts having very close tolerances (0.002 inch) or whose features are very small (0.040 inch) are typically inspected under magnification to look for burrs. In contrast, threads whose diameter is 3 or 4 inches will seldom be inspected under microscopes unless a specific concern is raised. Although such a policy on use of scopes may seem inconsistent, remember that minute crest burrs present a larger problem to the small precision parts than they present to larger or less critical parts.

Workmanship specifications do not require that the lead in or lead out threads be partially removed. Nevertheless, in practice, it is essential to remove enough of these thread ends to ensure that this thin thread portion cannot be bent over or otherwise damaged. Inspection practice is to reject any threads in which this thin fin is bent or in any way damaged. (The specifications *do* require the leading edges of external threads to be chamfered, which minimizes some of the “fin.”)

Workmanship specifications require that all threaded holes be chamfered. The reason for this is that a small swell of metal occurs at the hole entrance and exit during the machining process. Although those producing the threaded holes are generally responsible for chamfering them, those performing the deburring may occasionally have to add the feature.

Basic Deburring Approach for Threaded Holes

Assume a threaded hole without any close tolerances or close edge breaks. The hole is one inch in diameter, and it is through a flat part. The following is a typical deburring approach:

a) Stone and sand the top flat surface.

b) Use a knife to cut away any bent portion of the first thread.

c) Use a knife or burr ball to provide a chamfer or to enlarge a chamfer.

d) Using a wheel-like brush, radius the hole entrance.

e) Use a cross-hole deburring brush to clean out the threads.

f) Clean the part.

g) Scrutinize.

h) Repeat steps a) thru g) as required.

As with all holes, the easiest way to remove raised metal is to stone or sand the flat surface. The only successful method of removing bent first threads is by actually cutting them out with a knife. The amount of material that can be removed varies. Typically, all of the thread that is bent or may be easily bent is cut away. As previously mentioned, all threaded holes must have a chamfer of approximately the size shown in Figure 58. Usually the machinist chamfers the part before it reaches deburr. Sometimes, however, the chamfer may be absent. For this reason, many individuals often use a burr ball to provide the proper chamfer. This is a very fast operation, and the amount of chamfer can be easily controlled by the size of the burr ball and the amount of pressure applied.

On miniature parts, it is a deburring requirement that all threaded holes have a cross-hole deburring brush passed through them. Figure 69 illustrates some of the deburring brushes and their minute sizes. (These brushes are inserted into the thread and turned by hand.) In most cases, the production routing indicates the brush that should be used. If too large a brush is used, the small fibers in the brush will break loose and become wedged in the bottom of the threaded hole. On through holes this might not present a problem, but on a blind hole it may be harder to remove a small wire fiber than the burrs themselves. A nylon brush, rather than a stainless steel wire brush, is sometimes available for this purpose.

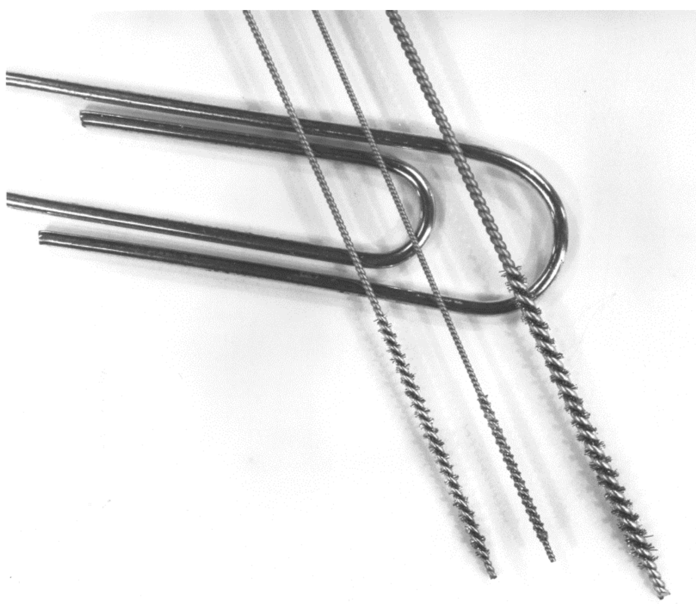

Figure 69: Cross Hole Deburring Brushes

To ensure a smooth entrance to a large diameter hole, a bench motor brush should be passed back and forth over the hole surface to blend it. In most cases, an abrasive-filled nylon brush will be used for this purpose. All holes must be cleaned to verify that all burrs have, in fact, been removed.

On some large threads, it is desirable and permissible to use a cutting tap to remove large burrs. Because threaded holes have two levels of thread quality, the engineer should specify on the routing which tap should be used, if one is permissible.

Assume that a part with a number 4-40 thread (0.097 inch diameter) in a blind hole requires deburring. (Note that a number 4-40 thread is approximately the same diameter as a normal wooden writing pencil.) The following sequence would probably be used to deburr inside the hole.

a) Stone or power sand the flat surface.

b) Use a countersink or burr ball.

c) Use a knife to remove a bent first thread.

d) Use a knife to wipe away any burrs produced by the burr ball or countersink tool.

e) Use a reamer to remove burrs on crests.

f) Use a cross-hole deburring brush.

g) Use a “go” gage.

h) Dig out any chips in the bottom of the threaded hole.

i) Ultrasonic-clean the hole.

j) If necessary, use the hole flushing unit on the ultrasonic cleaner

k) Scrutinize the hole.

l) Repeat steps a) through k) as required.

Note that in this instance a knife was used to remove the burrs produced by the burr ball. Also note that a “go” gage was called out to verify that burrs were adequately removed from the crest of threads. The tool used for digging out the chip from the bottom of the thread was not specified. Figure 70 shows one example of such a tool, and Figure 71 shows how the tool is used. The only successful way of cleaning small threads is to use an ultrasonic cleaner. In a few cases, a threaded hole may be entirely packed with wire-like chips. These chips may have to be removed with tweezers or a small knife, before beginning any of the other methods.

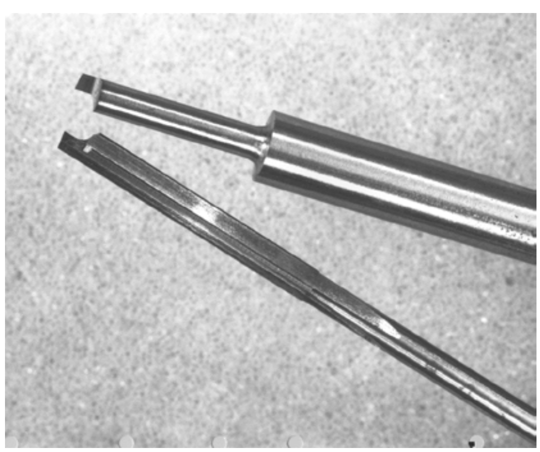

Figure 70: Example of Tools Used to Remove Chips from Bottom of Threaded Blind Holes

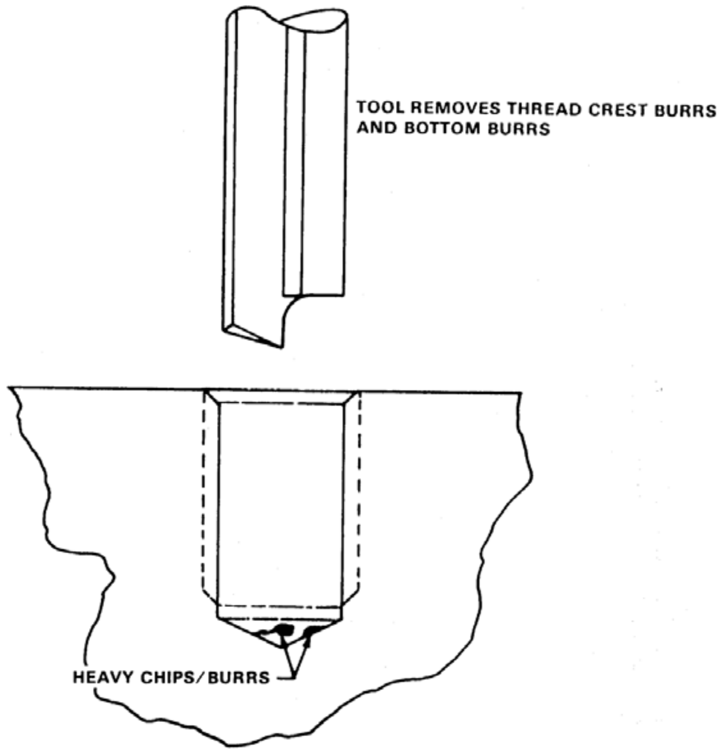

Figure 71: Descriptive View of Blind Threaded Hole Tool

It is extremely easy to overlook burrs in blind threaded holes. Small holes, in particular, do not allow adequate light for viewing what's inside the hole. For this reason, the light intensity on the coaxial light source of the microscopes will most likely have to be increased.

Now assume that the blind hole to be deburred has a 0.024-inch diameter thread. In addition, we must not provide more than a 0.003 inch chamfer. The following is an approach for such a situation.

a) Stone or sand the top surface.

b) Gently use a burr ball or knife to chamfer the hole.

c) Use a cross-hole deburr brush.

d) Use a rubber-filled abrasive dental point to provide a smooth radius at the hole entrance.

e) Dig out chips from bottom of hole.

f) Clean the part.

g) Scrutinize.

h) Repeat a) thru g) as required.

In this case, the hole is one-third the diameter of the hole described earlier. This kind of hole can easily be overlooked, since such small holes are often not threaded. This example emphasizes that care must be taken to avoid exceeding a 0.003 maximum edge break on such a feature. The hole must have some small chamfer, but the requirement here is that the chamfer be very small.

It is occasionally permissible to use a small reamer in the hole to remove burrs on the thread crests. Table 1 lists some recommended reamer sizes. In the case of the last example, the threads are so extremely small that a reamer might easily remove too much material and thus scrap the part. For this reason (unless a reamer is specified on the production routing), the individual performing the deburring should always ask the engineer if a reamer is allowed and—if so—which size may be used. Again, on miniature holes, it may be necessary to use a "go" gage to verify that the hole is sufficiently burr-free to avoid causing a mating part to stick.

Table 1: Recommended Reamers and Brushes for Class 2A Threaded Holes

Thread Size	Maximum Allowable Minor Diameter (Inch)	Recommended Maximum Reamer Size (Inch)	Recommended Reamer Number	Recommended Brush Number	Recommended Flat Bottom Drill Number
0.6mm	0.0198	0.0193	50100800		
0.8mm	0.0263	0.0255	50310775	10207238	
1.0 mm	0.0327	0.0320	50311066	10207238	50101903
1.2 mm	0.0406	0.0401	50311346	10207226	
0-80	0.0514	0.0509	50311871	10207226	
2-56	0.0737	0.0732	50313020	10207227	
4-40	0.0939	0.0934	50314018	10207237	50108520

There is also a potential problem with using cross-hole deburring brushes. Figure 69 illustrates that brush fibers do not extend all the way to the end of the brush. This means that a small length of the brush lacks fibers. On extremely shallow holes, the hole depth may not be any deeper than this non-fiber area of the brush. As a result, the cross-hole deburring brush will not be beneficial. Also, cross-hole deburring brushes wear very quickly. As they wear, the fiber area becomes tapered. The tapered portion of the fiber area does not adequately remove material from the lower portion of the threads. For this reason, avoid using worn cross-hole deburring brushes; they will not successfully clean the threads.

Potential Problem Areas in Threaded Holes

Again, it is easy to change the size of miniature threads to the point that they fall out of the allowable tolerance while deburring. This is particularly true when using small reamers or "go" gages. The frequent insertion of any tool in the threads can wear them to the extent that they will no longer be functional in the assembly.

Another potential problem area is that even the very miniature threads require the first thread to be removed if it is bent or flimsy. This is still an essential requirement, despite the fact that some threads are very small.

The small size of the miniature threads often makes it very difficult to ensure the desired thread quality. Nevertheless, careful attention to each of the items discussed here will provide the necessary background and approaches for handling these miniature threads.

Basic Deburring Approaches for Threaded Shafts

Honeywell produces many different threaded shafts and screws. These features are found on a variety of components, in addition to the commercially purchased screws. The threaded shafts are much easier to deburr and handle than threaded holes. It is also easier to see whether the crests, roots, and first threads have been adequately deburred. In addition, it is possible to use a bench motor and brush to develop a small radius at the crest of all the threads.

The following example describes a method for deburring a number 4-40 thread:

a) Cut away any bent first threads.

b) Brush the thread.

c) Clean the thread.

d) Scrutinize.

e) Repeat steps a) thru d) as required.

This basic approach is used for most threads regardless of their size. (Again, for miniature threads, extensive brushing with the wrong brush can change threads beyond their allowable limits.) It is also possible to use a mechanized deburring process, such as barrel rumbling, to deburr threads.

Potential Problem Areas for Male Threads

There are three principal concerns when deburring male threads. First, it is very easy, when using knives, to scratch or damage threads to the extent that they may be unacceptable. A second concern is that—if the threads are brushed too much—the crest will have an excessively large radius or break. The third basic concern is that too much brushing can change the thread dimensions to an unacceptable extent. Although these problems will not occur on most parts, the possibility of such damage is much higher on extremely miniature parts.

Deburring Turned Parts

Turned parts are another "family" of parts that must be deburred. Roughly 70% of the parts deburred in this plant are turned parts.

Basic Types of Turned Parts

The term “turned” implies that the part is basically round and was produced by turning it on a lathe-type machine. Turned parts can be simple pins, as shown in Figure 72, very large cylinders having a number of diameters, or parts that begin round but become machined into a variety of hard-to-define shapes along the way. If a part has any obviously cylindrical features, then it will usually be called a “turned part.” Threaded shafts, screws, bolts, and even nuts are considered to be turned parts.

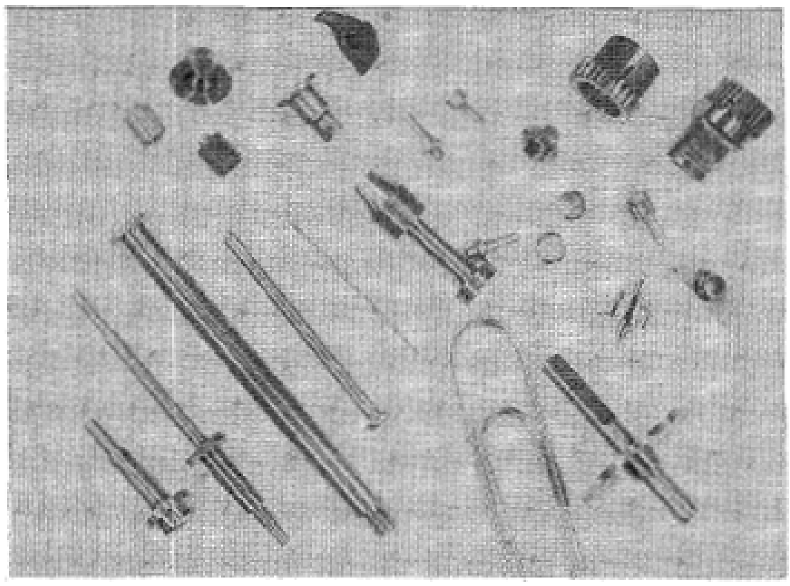

Figure 72: Example of Turned Parts

Holding Turned Parts

The first deburring requirement in turned parts is selecting a method for holding them. The four holding methods used most often are as follows:

1. Holding by hand
2. Holding in a pin vise
3. Holding in an expanding mandrel
4. Holding in a bench motor

Note that Figure 73 shows a pin vise designed to hold cylindrical objects. This is the ideal holding tool for many smaller turned parts. Use extreme care when tightening the vise, and always verify that no burrs or chips exist that could damage the part.

An expanding mandrel has a small shaft that expands outward radially when the mandrel is tightened. See Figure 74. Mandrels are used to hold parts that have a hole in the center. See Figure 75.

A part can also be placed in a bench motor as shown in Figure 76, as long as the part is not squeezed too tightly. In the example shown, the deburring tool is hand-held against the part rather than the part being hand-held against the rotating tool.

Immediately after obtaining a new pin vise, expanding mandrel, bench motor chuck, or even tweezers, determine if the tool has burrs on it. Typically, these types of tools have several burrs on their holding edges. Such burrs will indent even hard materials if tightened excessively. Therefore, the first requirement is to inspect and deburr the tools that are used to hold the parts.

Figure 73: Examples of Parts That Can Be Held by a Pin Vise

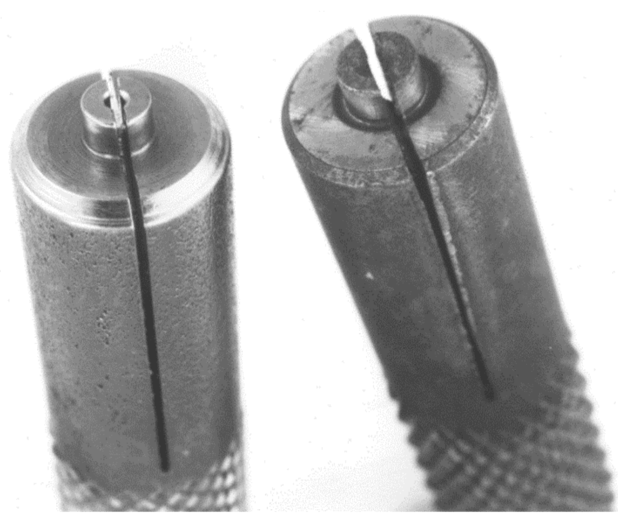

Figure 74: Examples of Expanding Mandrels

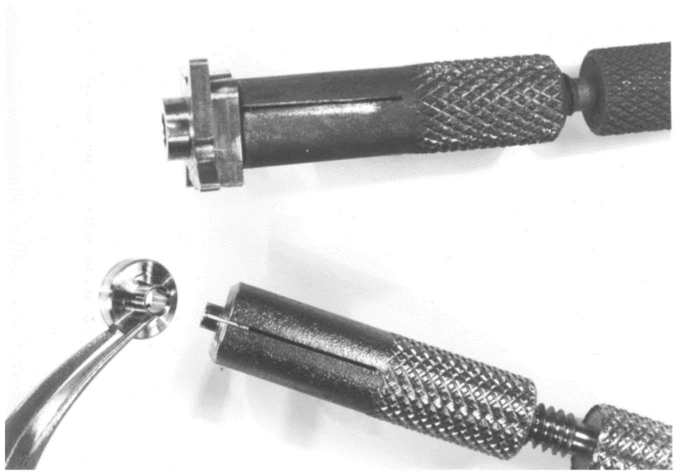

Figure 75: Example of Expanding Mandrel Holding a Part

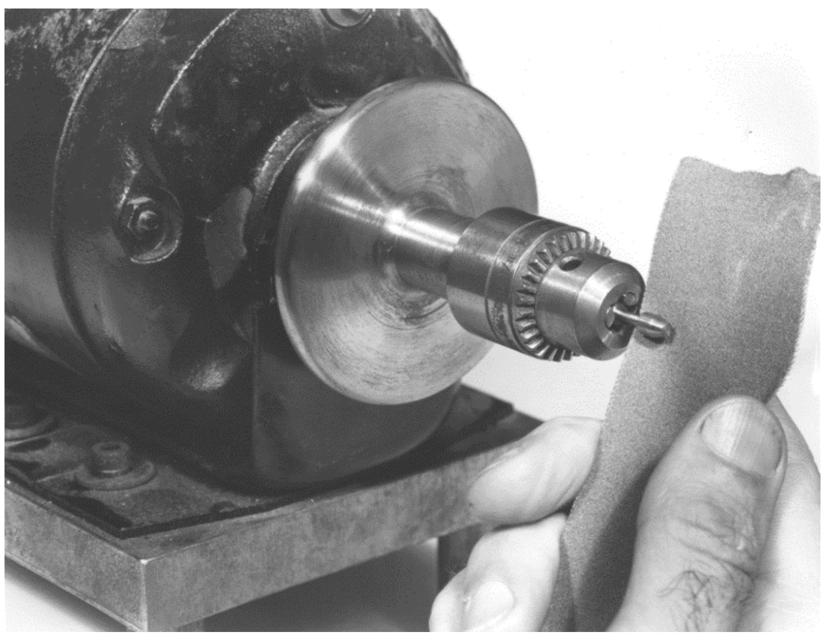

Figure 76: Example of a Part Held by a Bench Motor

Basic Approaches for Deburring Turned Parts

The basic approach for any turned part is to rotate the part, since all of it can be finished in this manner. Frequently, small pieces of sandpaper are used and held against the edges. In this case, a large sheet of sandpaper is cut into 1-inch squares for more convenient use on the miniature parts. An operator will begin with a large stack of these 1-inch squares, perhaps even folding them into four smaller pieces for use on very small parts. Abrasive-filled rubber products are also widely used on this type of part. Brushes are widely used to provide a final blending and to remove any particles left on the part.

Approaches for Specific Sizes of Turned Parts

Assuming a very large turned part (6 inches in diameter), a typical approach would be to perform the following operations:

1. Hand-hold the part.
2. Use a scraper if the burr is small enough.
3. Use a large file if the burr is too big for the scraper.
4. Use a burr knife, as necessary, for the hard-to-reach areas.
5. Use sandpaper manually or a sanding disc.
6. Use an abrasive-filled rubber bullet mounted in a bench motor for all holes.
7. Clean the part.
8. Scrutinize.
9. Repeat steps as necessary.

Figure 77 illustrates the use of a scraper on a large aluminum part. On this size of part, a scraper can readily traverse the edges. Some large parts, however, have very small or intricate cutouts that prevent use of a scraper. In these cases, deburring knives and the abrasive paper products must be used instead.

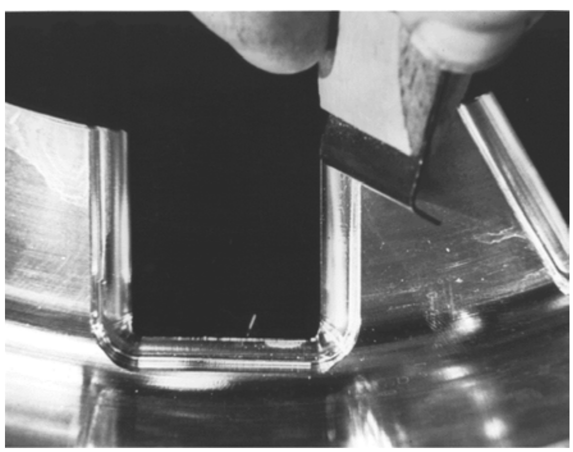

Figure 77: Scraper on a Large Aluminum Part

Assume that a part is only 0.125 inch in diameter. Provided that the part is a simple turned shape, the following operations would be performed:

1. Place the part in the collet of the bench motor.
2. Turn on the motor.

3. Use abrasive paper or abrasive-filled rubber tools on the edges.
4. Clean the part.
5. Scrutinize.
6. Repeat steps as required.

An alternate approach is as follows:

1. Put the part in the pin vise.
2. Put the pin vise in the bench motor.
3. Turn on the motor.
4. Repeat the steps in the previous listing.

A pin vise is used to hold the part, because many pin vises have brass jaws that are less likely to damage the part. A common problem with small turned parts is that they can easily be damaged or "marked" by the jaws, which is unacceptable. Most bench motors have large steel jaws that can easily mark or mash the precision parts, even to the point that they become egg-shaped.

The advantage of putting a part in the bench motor is that rotating the part or tool is much faster than hand-holding or hand-rotating the part. Nevertheless, many parts must be placed in a pin vise to provide the necessary part movement.

Cutoff Burrs on Turned Parts

One type of burr—the cutoff burr—is much larger and more difficult to remove than other types. See Figure 78. This is not a "burr" in the true sense, because it is material that has been left on the part as a result of the tool failing to completely cut the part off the bar stock. Cutoff burrs (despite their name) result from a part breaking off rather than being cut off. Cutoff burrs should be removed, unless the production routing specifically states otherwise. In some instances, particularly in the case of brass or aluminum, the cutoff burrs may be removed with a knife or a small file. In contrast, stainless steel parts generally require the use of side cutting pliers. These pliers have a scissors action that will cut off most of the burr. (It may be necessary to smooth the edges of the remaining stub of material.)

In most cases, the deburring operation will occur after the cutoff burr has already been removed. For example, the part may be machined on one end, cut off from the bar stock, then flipped around and machined on the other end. In this type of process, the cutoff burr is removed from the part by the machine after the part has been flipped around. Again, if the cutoff burr is not removed at the machine, it is possible to use a hand-held stone such as an Arkansas stone to hone down the cutoff burr and smooth the end of the part.

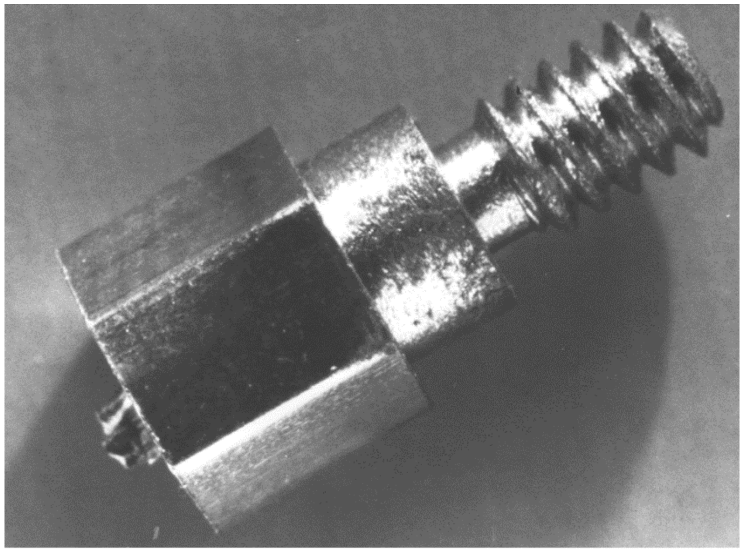

Figure 78: Example of Cutoff Burr

Potential Problems in Deburring Turned Parts

Turned parts present at least four areas of concern. (1) It is easy to damage precision surface finishes during deburring operations. The part print in Figure 79 shows the surface finish required at the end of a gear shaft. A single slip of a knife, or the use of the wrong sandpaper, can damage the surface. (2) When using sandpaper on a turned part, it is very easy to change the diameter of the part by 0.0001 inch or more. In addition, holding abrasive paper against the diameter of the part will change it by this amount in only 1 to 5 seconds if the part is rotating in a motorized spindle. (3) Edge breaks are also important on many of the miniature turned parts. Again, it is very easy to exceed radii or breaks such as 0.003 inch maximum. (4) The final area of concern is part damage caused by chucking or colleting devices. Never over-tighten them, and always verify that the devices have no burrs or chips that could damage the parts.

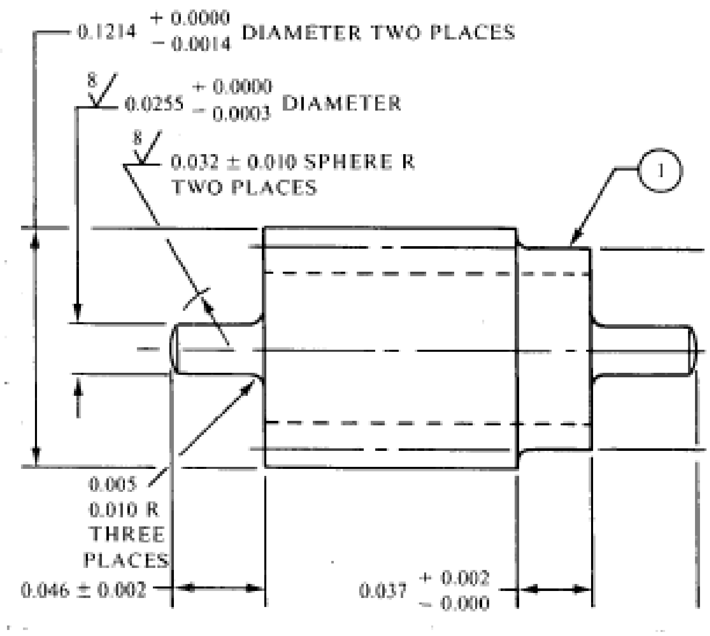

Figure 79: Example of Surface Finish Requirements of a Part

Mechanized Processes for Turned Parts

In general, turned parts lend themselves well to the mechanized processes that allow more economical deburring. Engineers who prepare the production routings usually determine in advance whether the mechanized processes are adequate. (In many cases, the mechanized processes have unusual limitations, not physically visible, that restrict their use.)

<u>Deburring Flat Parts</u>

Flat parts are another common configuration of parts that must be deburred. See Figure 80. The flatness of these parts allows the use of many tools and makes the parts more amenable to deburring. Many flat parts are larger than turned parts, and are therefore easier to hold, easier to deburr, and easier to inspect.

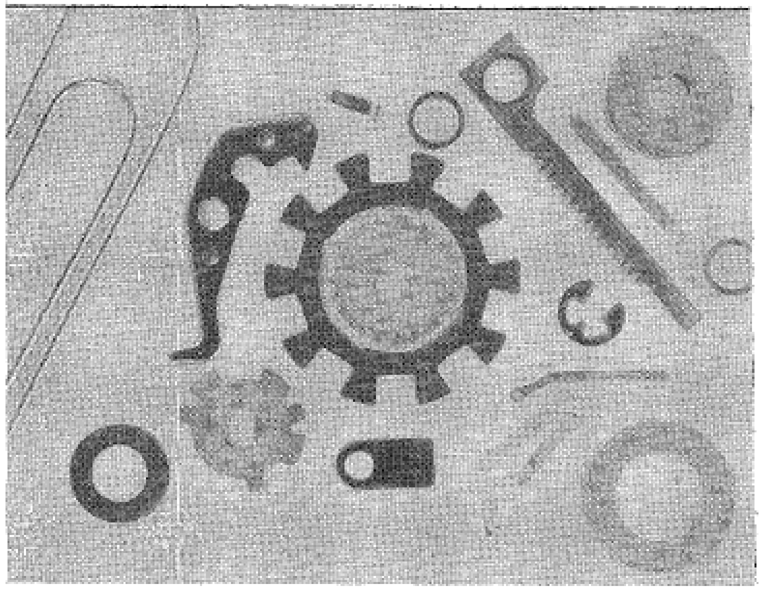

Figure 80: Example of Flat Parts

Basic Types of Flat Surface Parts

Typically, a flat part is much longer and wider than it is thick. For example, it might be 20 times as long or wide as it is thick. A number of our parts, however, have chunky boxlike configurations that—though basically flat surfaces—are thicker than most of the parts shown in the previous figure. Figure 81, for example, shows a rather chunky, yet basically flat-surface, type of part.

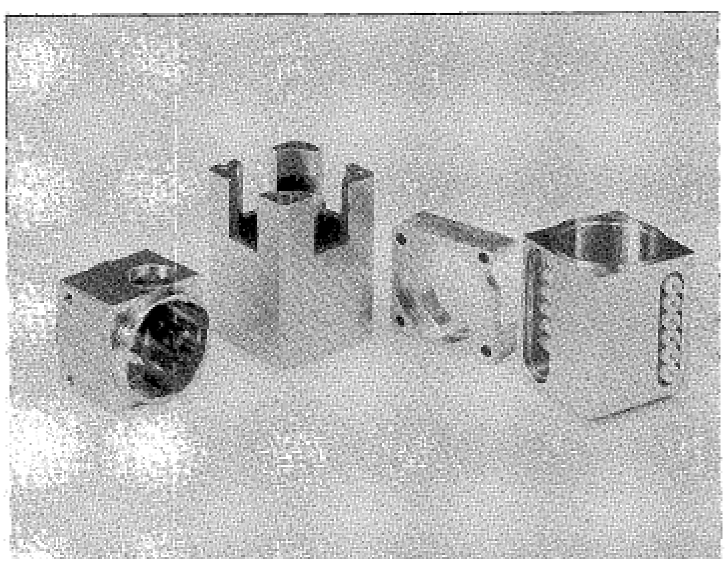

Figure 81: Examples of Chunky Flat Parts

Basic Approaches for Flat Parts

Assume a part that is 1-inch square and 0.05 inches thick. Further assume that it has no holes or other unusual features. It is basically a square part, 0.0500 inch thick. Three products can be used to deburr this part:

1. Abrasive paper products such as sandpaper-like items
2. Abrasive paper products that have adhesive on the back and attach to a rotating mandrel
3. Abrasive-filled rubber products

On very small square parts, a 1-inch-square piece of fine sandpaper is used to finish the edges. (It is actually faster to use an adhesive-backed disc, shown previously in Figure 44, because the motorized tool is the fastest method of deburring.) It is also possible in some instances to tape a sheet of sandpaper to the top of the workstation, as shown in Figure 82, and flat-sand the work piece using a figure-eight motion.

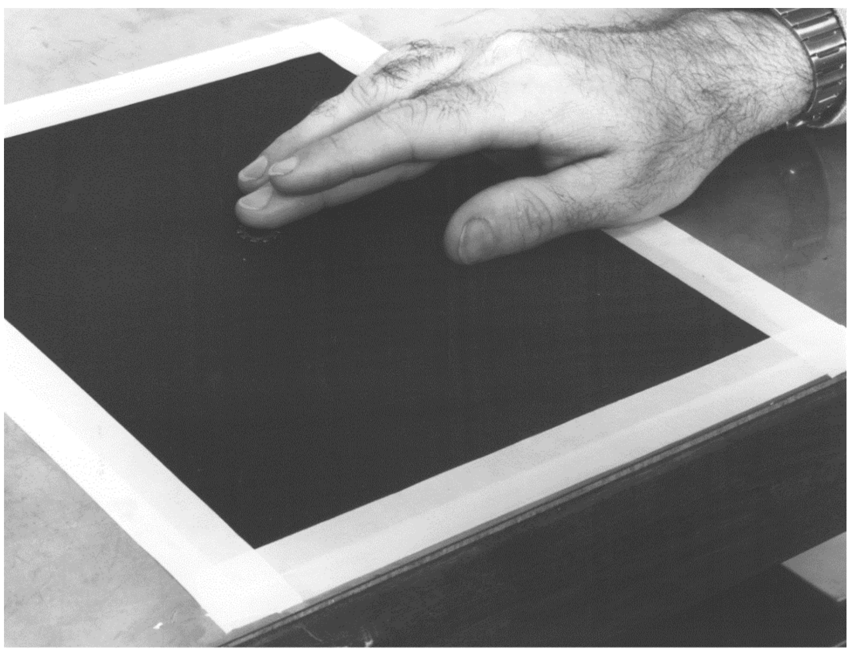

Figure 82: Flat Sand Deburring with Abrasive Paper Taped to Table Top

On larger parts, it is even possible to use a jitterbug, orbital, or belt sander not only on the surfaces, but also on the edges (if the tolerances allow).

Approaches for Specific Parts

Assume a part like that shown in Figure 83. In this example, the part has some square edges, some contoured edges, and several holes. It is basically a flat part 1 inch square and 0.0500 inch thick, and is made from a material that is somewhat softer than steel. A basic approach on this type of part, depending on the size of the burr, would be to use sandpaper on the edges and an abrasive-filled rubber product or small nylon brush coated with an abrasive. The small holes would require the use of a burr ball or countersink tool and, probably, the use of an abrasive-filled rubber dental point. The contour areas, which are neither round nor straight, might require use of a knife followed again by the use of an abrasive-filled rubber product.

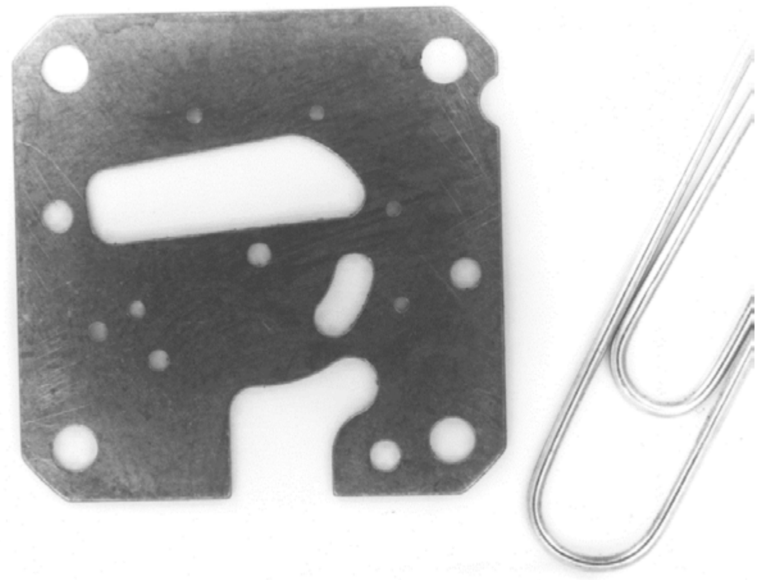

Figure 83: Example Flat Part (1 inch square by .050 inch thick)

With a much larger flat part such as that shown in Figure 84, it may be possible to use a file to remove the heavy burrs, then use a brush to blend out the sharp edges left by the file.

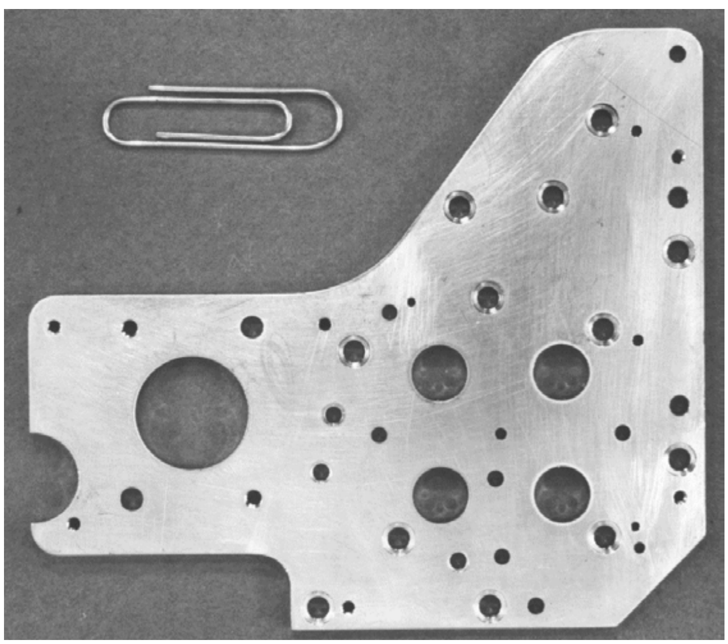

Figure 84: Example of Larger Flat Part

Mechanized Processes for Flat Parts

Some flat parts can be deburred with mechanized processes. For example, a small sanding belt will sand the flat surfaces of flat parts, as opposed to edges only. Processes such as barrel tumbling or vibratory deburring may also be used to deburr flat surfaces, provided that there are no intricate cutouts or very small holes in the surface.

Note that some jitterbug sanders will tend to concentrate all of the sanding action on the outside edges of the part, as shown in Figure 85, even though it appears that the whole surface is being sanded. Nevertheless, if the parts are large enough that this sanding-concentration problem doesn't occur, this is a very quick way to remove burrs.

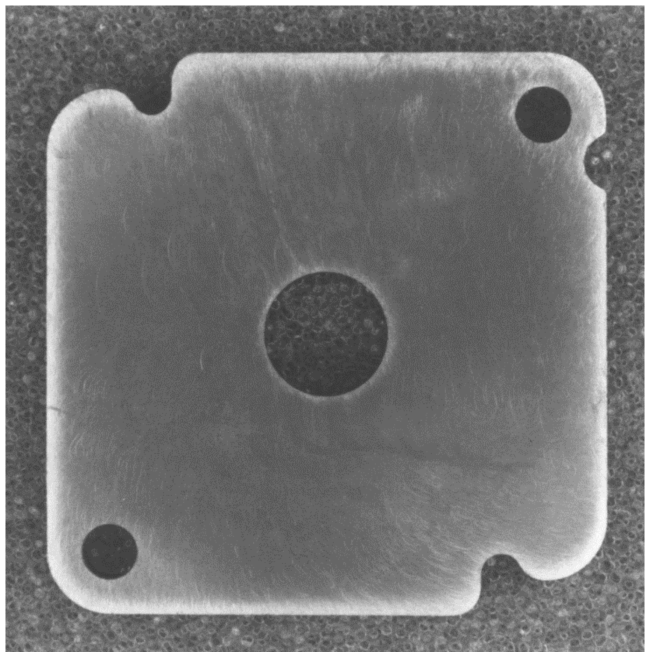

Figure 85: Example of Part Sanded with Jitterbug Sander

Potential Problem Areas

As with turned parts, flat parts present three significant concerns during deburring:

1. Part thickness must not be reduced.

2. Surface finish on flat surfaces must not be degraded.

3. Edge breaks must not be exceeded.

Although it is possible to dent, scratch, mar, or otherwise damage flat surfaces, these are not normal circumstances. Care must be taken when sanding flat parts with sandpaper, because the part's thickness can be reduced quickly. Although this reduced thickness is usually not allowable on many precision miniature parts, very small thickness changes may be acceptable on larger parts.

The edge break is also critical on many small parts, particularly very thin parts. The use of sandpaper, abrasive-filled rubber products, and abrasive-filled nylon brushes limits the aggressiveness of the deburring tools. As a result, most of these tools are acceptable and, when used with moderate pressure and reasonable experience, will not exceed a 0.003 inch edge break.

Deburring Large Parts

Large parts generally have more relaxed workmanship requirements than do miniature precision parts, and are therefore inspected and deburred with less magnification. In fact, very large parts typically involve no magnification requirement at all. Although small burrs may be acceptable on these parts, this still depends on the drawing specification.

When magnification is needed on larger parts, a desktop lighted magnifier on an articulated arm works well. It can be moved around easily and has a built-in fluorescent light. The working area under the magnifier is large, and the power is about 3X.

Most tools required to deburr larger parts are the same as those used on the miniature precision parts, and they will be used in the same manner. The following tools will probably be used most often:

- Knives
- Large files
- Large burr balls
- Scrapers
- Countersinks
- Motorized tools
- Abrasive paper products
- Coarse abrasive-filled rubber products

Files are generally used to remove the very heavy burrs, while motorized abrasive paper sanders such as belt sanders, rotary disc sanders, and jitterbug sanders all work well for quickly deburring the not-so-heavy burrs on larger parts. In addition, hand motors with stone points and rotary disks are very effective on some burrs. Hand sanding with various grits of abrasive paper and abrasive-filled products can also be used to finish edges that were previously rough-deburred with the more aggressive tools.

Deburring Plastic Parts

Although the deburring of plastic parts is fairly similar to that for miniature metal parts, plastic parts are softer. This causes some peculiarities that need to be discussed here.

Types of Plastic Parts

Four basic types of plastic parts are manufactured at KCP. They are:

1. Thermoplastic (plastic-like)
2. Thermoset (hard plastic)
3. Reinforced plastics (e.g., glass-filled fiberglass)
4. Plastic encapsulation of metal components

Types of Burrs and Flash

Plastic parts not only have burrs on their edges (like metal parts), but also have an excess-material condition known as "flash." When the parts are molded, the liquid plastic material fills all the cracks and crevices in the mold. Because most molds are made of two halves that are pulled apart after the part is finished, the material fills all the small cavities at the parting or dividing line between the mold halves, as shown in Figure 86. Therefore, a very thin section of plastic is left projecting from the part, as shown in Figure 87. In most cases this is not allowable, because it is detrimental for the same reasons that burrs are.

Figure 88 illustrates flash that almost entirely covers the small gold-plated pins on an electronic component. This is unallowable, because most electronic components serve as electrical contacts or as posts around which to solder or to wrap other components. For this reason, all of this flash must be removed.

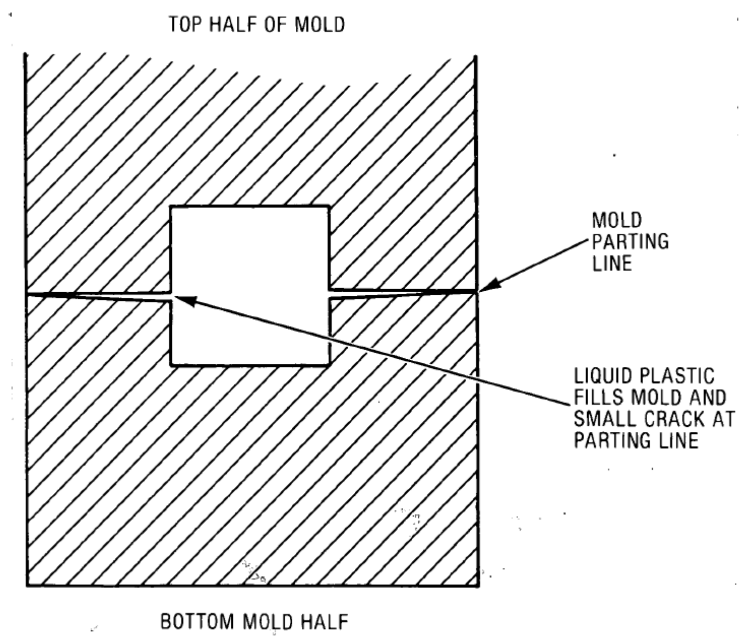

Figure 86: Parting or Dividing Line Between Mold Halves

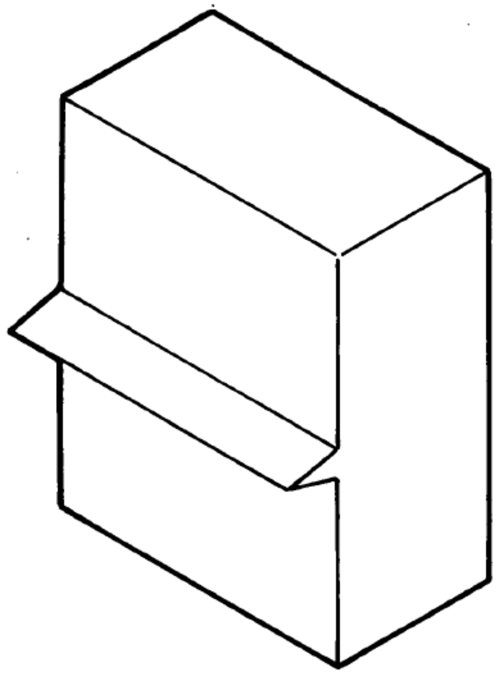

Figure 87: Example of Flash Created by Intersection of Mold Halves

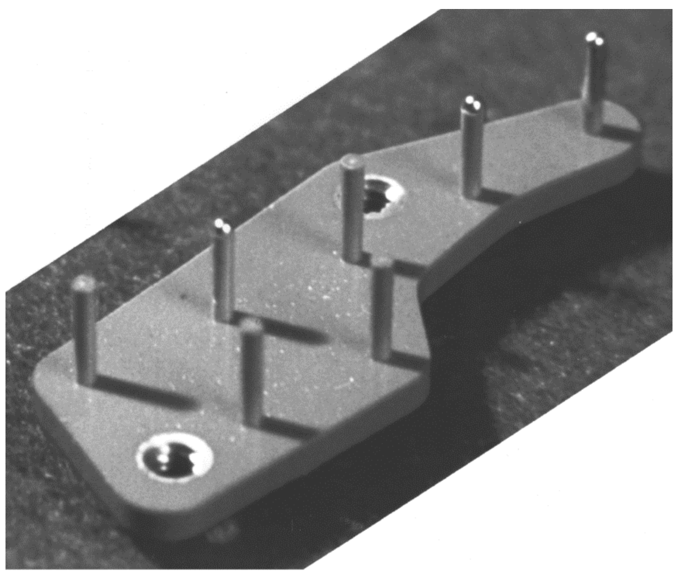

Figure 88: Flash on Small Gold-Plated Pins

Deburring Techniques for Plastics

Because of the thinness of most flash found on plastic parts, conventional deburr knives or other deburr products are not generally used. Instead, these tools are typically used:

- Scalpels
- Conventional three-cornered deburr knives

- Abrasive paper products (sandpaper)
- Countersink tools

Scalpels are most generally used on the soft, thermoplastic materials, and on some of the reinforced materials to sever all fibers projecting from the ends of the part. Scalpels work better than conventional burr knives because a thin scalpel can slice through this thin material with less force than a conventional burr knife. Thinness and sharpness present disadvantages, also: Scalpels are more dangerous to use, can easily generate excessively large edge breaks, and can easily result in a wavy surface.

Because the flash on the thermoset materials is so hard, conventional three-cornered deburr knives are used to scrape rather than cut the flash.

Abrasive paper products are also frequently used on thermoset materials to provide small edge breaks and a uniform edge. Abrasive paper products can also sometimes be useful on the very soft materials, because they will not remove any significant amounts of material from an edge.

When deburring small holes in plastic parts, the countersink tool shown in Figure 89 works well because it has a very sharp cutting edge and will not gouge the edges of the hole. However, scalpel blades are frequently used on holes larger than ½ inch in diameter, because the holes are large enough to allow access, and few countersink tools are available above this range.

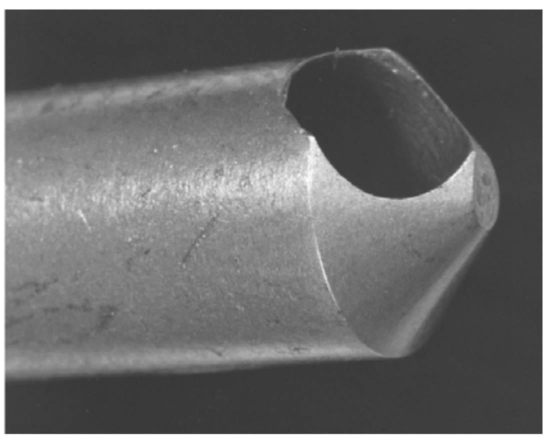

Figure 89: Countersink Tool for Deburring Plastic Part Holes

Effects of Abrasive Paper Products on Appearance of Thermosets

A color change occurs when sandpaper is used on a thermoset material. Most plastic products will be a glossy color before deburring but, after abrasive paper is used on them, will have a matte finish and will be lighter in color. In some cases this is detrimental. In other cases, it is only a difference in appearance and may or may not be desirable. Contact the engineer before using abrasive paper.

<u>Use of Borescopes</u>

Borescopes are basically miniature magnifying tubes that are used to look at the bottoms and the sides of holes as small as .090 inch in diameter, and as deep into the hole as the length of the tube attached to it. These tools also contain an integral lighting system. Alternative fields of view are made possible through changes to the end of the tool. A borescope and several of these field-of-view options are illustrated in Figure 90. Borescopes are also used by both inspection and production to verify workmanship in very deep holes and in other areas that are otherwise inaccessible.

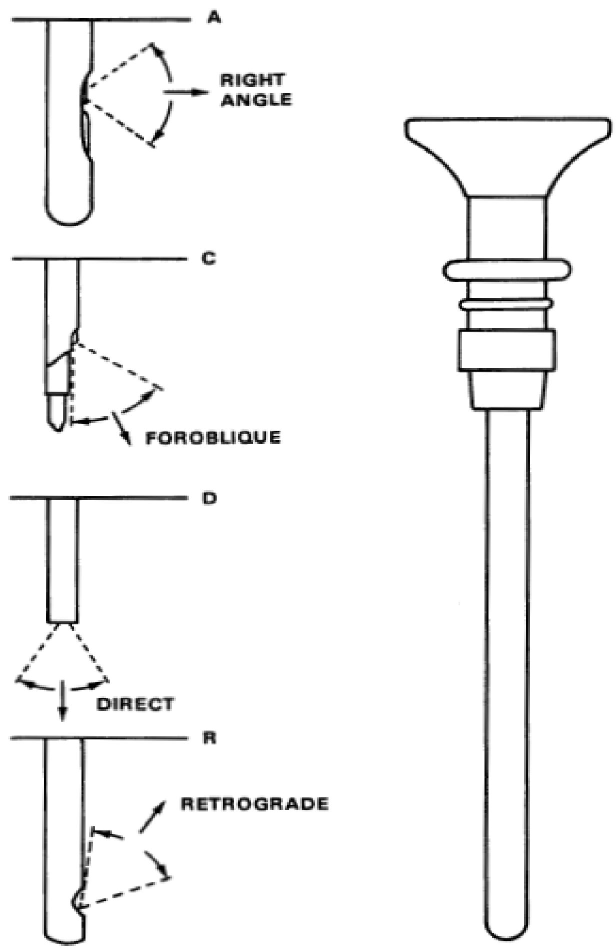

Figure 90: Borescope with Several Available Tube Variations

Special Tools

Earlier in this document we discussed some and listed virtually all of the standard deburring tools available at Honeywell FM&T. These are usually standard, off-the-shelf items readily available from outside manufacturers. For most applications, these general-purpose tools are all that is required to produce burr-free parts.

Nevertheless, some circumstances require the use of special-design tools and knives to reach burrs in areas where no other tool can reach. Some of these special-design tools are part-specific; others have uses on several similar parts and situations. If you encounter a deburring situation in an area for which no tool seems to exist, first contact your engineer to see if he or she knows of a tool, or if a special tool needs to be designed for the job. Figures 91 and 92 show some of the tools specifically designed for use on specific parts or in particular situations.

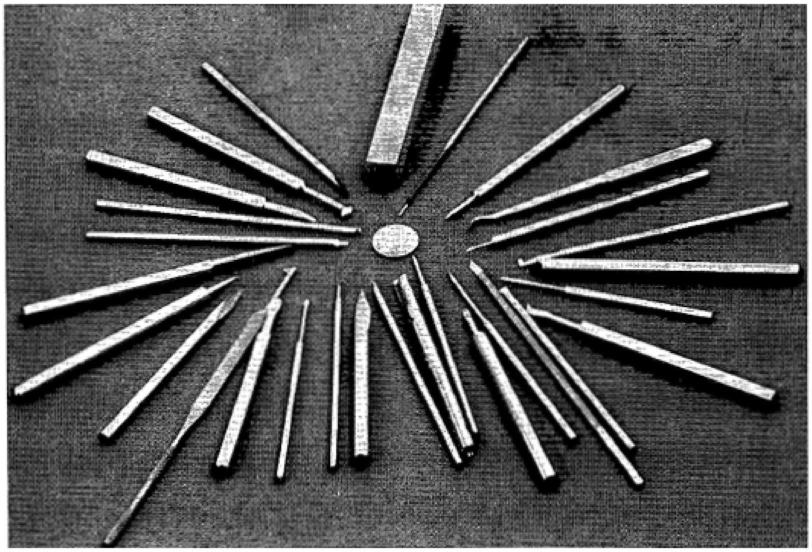

Figure 91: Special-Design Hand Deburring Knives

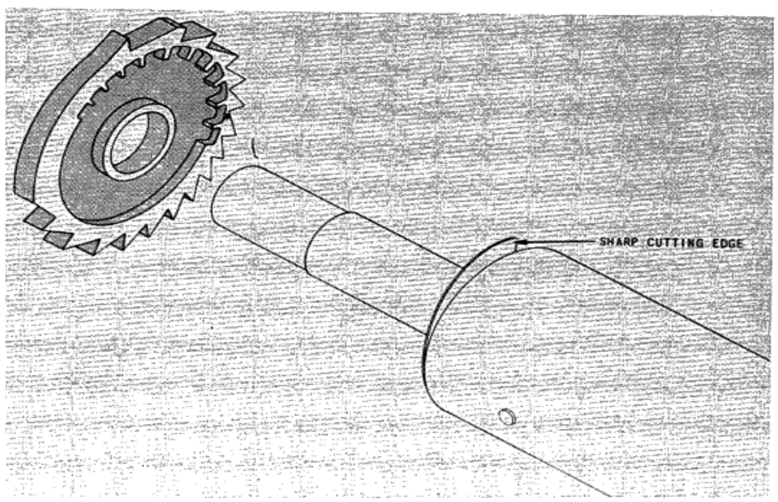

Figure 92: Example of Special-Design Hand Deburring Tool

Special tools are also occasionally required to hold parts during the deburring process. We previously discussed several standard types of part-holding tools that can grip specific types of parts. But again, there will always be the odd part too small to hold in your fingers, and no available fixturing to hold it adequately. That's when a special-design holding fixture will be required.

These special-design part-holders can either be made from scratch or made by modifying a standard part holder. Figure 93 shows an example of a special part-holder. It is an off-the-shelf pair of tweezers that has been modified to hold a specific part. As with special-design deburr tools, contact the responsible engineer when you have trouble holding a part and can't find anything readily available. Either describe your idea for a holder for the part, or ask the engineer to find or design a holder.

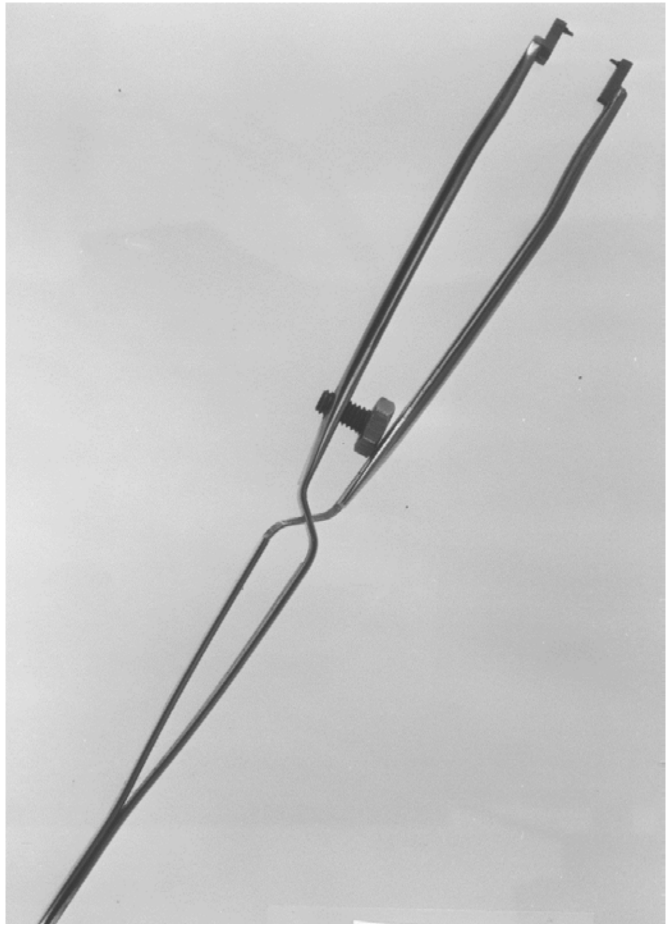

Figure 93: Special-Design Hand Deburring Part Holder

<u>Other Deburring Processes Currently Used at KCP</u>

Other types of deburring processes available at KCP include several vibratory deburring processes, a centrifugal barrel finishing process, and an extrude honing process. The first two of these processes are actually mass finishing processes. In other words, they can do large quantities of parts at a time. The third process can deburr from one to just a few parts at a time. All three of these processes are only for parts that have specific geometries that lend themselves to the capability of the process, and generally can't remove all burrs in every instance. A final scrutiny or deburring process is required afterward to ensure that all of the burrs have been removed and, if not, to remove them.

Vibratory Deburring

Vibratory deburr machines (often called "shakers") have tubs filled with a mixture of abrasive media, water, and soap. The tubs shake and vibrate. When parts are placed in them, these machines vibrate the contents, causing the abrasive mixture to engage the part edges and remove burrs, as shown in Figure 94. The plant has three types of machines. Although they vary slightly in size and in the way they shake the abrasive solution, the results are similar.

This process usually takes from one to several hours to remove burrs, depending on the machine size, the abrasive compound, and the size of the parts. Similarly, the quantity of parts that can be vibratory-deburred in a batch at the same time will depend directly on the size of the tub and the size of the part. This process works well for external feature parts like flat parts and shafts, and not so well with internal features like small holes and inside corners.

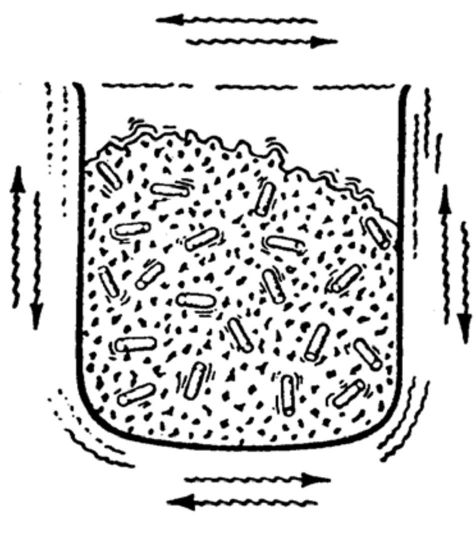

Figure 94: Vibratory Deburring Process

Centrifugal Barrel Finishing

Centrifugal barrel finishing, or “Harperizing” as it is known here at Honeywell, is actually a supercharged barrel tumbling process. The machine has two opposing tubs, each of which spins on its own central axis. The tubs also spin on an axis situated between them, as shown in Figure 95. The machine looks like a three-foot-span centrifuge with spinning barrels on each end, and uses the same abrasive media, water, and soap mixtures as the vibratory deburr process. The same quantity of parts and equal amounts of media are placed in each of the opposing tubs, so that the tubs are equally balanced.

With this process, the time required to remove burrs is about one-fourth that of vibratory deburring process. This is due to the higher forces applied to the parts and abrasive. (Again, the time required to remove burrs depends on the part size and geometry, abrasive media, and speed at which the tubs spin.) The tub volume and the part size are the limiting factors for the quantity of parts that can be processed at one time. Because this process is similar to vibratory deburring, it also works best with external features, and not so well with the internal ones.

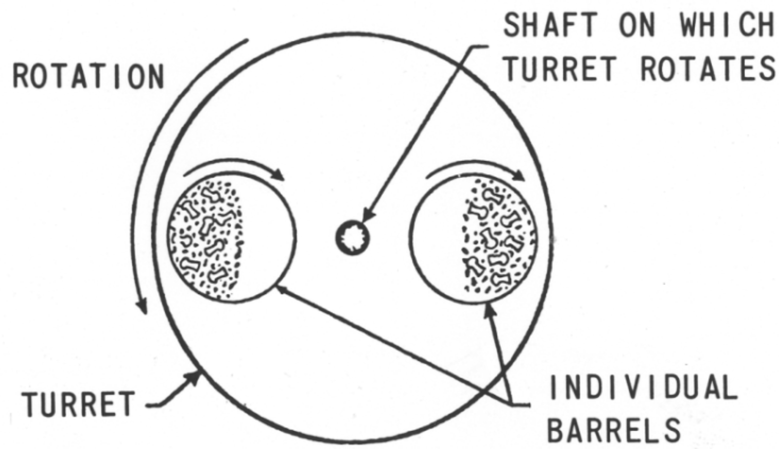

Figure 95: Centrifugal Deburring Process

Extrude Honing

The extrude honing machine uses opposing rams that push abrasive-filled putty back and forth through the part or parts in the holding fixture. This process works very well for internal holes, and is really one of the best ways to deburr hard-to-reach cross holes. Its drawbacks are that it requires a special holding fixture for each different part number run, and the putty is messy to clean up. It does a great job of removing internal burrs, but can also very quickly oversize the holes and over-deburr cross-hole edges. The number of parts run at the same time depends on the part size, but even the smallest ones are usually kept to a maximum of four parts per fixture because of the size and pressure of the ram.

<u>On-Machine Deburring</u>

On-machine deburring has been performed to some degree or another at Honeywell for quite some time. It is done in an effort to reduce both the size and quantity of burrs, and in some cases, to remove burrs completely on the parts, which reduces the workload in the deburr area and, therefore, improves the flow time of the parts.

Three types of on-machine deburring are performed at KCP. They are:

1. Using the cutting tools that actually machine the part to produce the edge breaks and to run deburr passes to reduce burrs during the machining process.

2. Using a rotating abrasive brush to “sweep” the part edges to remove burrs and generate breaks during the machining process.

3. Using a manual lathe to remove burrs and break the edges on turned parts at an in-process or final deburr operation, not in the deburring area.

On-Machine Deburring with Cutting Tools

When CNC machine tools are used to produce parts, the cutting tool paths can be programmed to accurately generate the outside edge break radii. Although good machining practice is to generate all the edge breaks possible, there's no guarantee that this will be done. If the cutting tool is programmed to generate the edge radius in one fluid movement (i.e., the tip of the tool is not lifted out of the cut as it generates the break), the burr will be pushed ahead of the cutting edge and deposited at the point at which the tool is pulled out of the material. Through use of this knowledge and modification of the NC program, the burr can be purposely moved to wherever it can most easily be removed in deburr. So, while this method does not entirely eliminate burrs, it does greatly reduce their size and quantity.

This process works best when the edge break is generated in the form of a radius. Although a chamfer can also be generated on the part edges to reduce the burr size and quantity, this tends to leave smaller burrs at each edge of the chamfer, which also needs to be removed.

In addition to breaking the part edges with the cutting tools, the tools can be programed to re-run tool paths at the finish part dimension to remove as much of the burr from the edge as possible. This works particularly well on single point machine-generated threads on a shaft. Although there's no way to actually break the thread edges with the cutting tool, using two alternating deburr passes—with the finish turn tool at the major thread diameter and the thread tool at full thread depth—will remove most burrs on the thread. Again, this process will not make burr-free surfaces and edges, but it will greatly reduce the size and quantity of burrs.

These on-machine cutting tool deburring processes are performed more often on CNC lathe machines, because turning tools lend themselves best to this type of process.

On-Machine Abrasive Brush Deburring

Abrasive brushes are the second type of on-machine deburring performed here at Honeywell. This process is generally executed on milling machines, where a brush can be mounted in a tool holder to be spun and pressed against the corners of a completed part. The success of the burr removal and the size of the edge break generated will depend on the part material, the size of the burr, the speed (RPMs) at which the brush is rotated, the feed rate at which it traverses the part edges, the brush size, and the size of the brush grit.

On-Machine Manual Lathe Deburring

Manual lathe deburring can be incorporated to deburr the outside edges on fairly simple turned parts. A part is chucked in the lathe collet, and then—as the part spins in the machine—sandpaper or a Cratex stick is used to carefully remove the burrs from the outer edges. For smaller parts, a miniature table-top lathe with an attached microscope is required so that the process can be performed under magnification.

Although this deburring process is usually much quicker than hand deburring, only certain part geometries work with this method. Nevertheless, it can be performed on more intricate turned parts when it is used in combination with a final hand-deburring operation. In other words manual lathe deburring may be performed on all accessible edges, then be followed with a final deburring to remove the remaining burrs.

Deburr Knowledge Preservation Projects

Two knowledge preservation projects discuss deburring. They are currently located in the Knowledge Preservation database available to KCP employees, and include several video clips that show the process and discuss different aspects of the deburring.

The first project is actually part of a larger project titled “Contact Block Manufacturing Process” (December 2002). It contains a subgroup named “Deburr,” which provides a detailed view of the process used to deburr the Contact Block. (This was a very small plastic part that was extremely difficult to deburr and to hold. Consequently, the holding fixture and the deburring tools had to be specially designed for it.) The videos demonstrate the actual deburring processes used and explain the special tooling required to complete the procedure.

The second project is titled “Precision Hand Deburr of Miniature Machined Parts” (January 2005). It provides a fairly high-level overview of the precision deburring process performed in the metal machining departments. The videos provide specific instructions on how to deburr certain features and how to select the tools for use.

Deburring from a Deburr Operator’s Perspective

The deburr operator is required to remove burrs and break edges on parts per the engineer’s instructions. It is therefore the engineer’s responsibility to provide all the specific information required to deburr the parts, including specifying the edges to be deburred, the size of the edge breaks, any critical surface finish requirements, any critical dimensional tolerances, and any special tooling and holding devices required for the process.

Although the requirements are generally to have burr-free parts at the end of the process, some in-process deburr operations require that only selected edges be deburred. All of this type of information should be included in the production routing, so that there’s no question as to what needs to be done.

If no specific instruction or specific tooling is called out on the routing, then the tool selection and the deburring method is left up to the deburr personnel. In addition, if no edge break or surface finish requirements are provided, then the requirements revert back to the general workmanship specification, 9900000, which allows .010 inch max breaks and 125 microinch surface finishes. Bear in mind, however, that most parts are covered by specifications with much tighter workmanship requirements, and this information will be supplied to the operator.

Always clean the parts before deburring so that the burrs can be seen more easily. Clean them again afterward so that—when the parts are verified—any remaining burrs can be detected and removed.

In addition, use the following techniques first for detecting burrs and then again after parts completion for verifying burr removal on part edges:

- Use different lighting angles.
- Use different lighting sources.
- Change the viewing angle.

- View edges and holes from both sides of the part.

- Always use a combination of both tactile and visual methods for burr detection.

Try to make the part edge breaks and surface finishes as consistent as possible. This applies not only on the part itself, but also from one part to the next within a job. Although a quick, light brushing with the bench motor brush is an easy way to blend part edges and surfaces into a nice even finish, tight tolerances and high surface finish areas will limit the use of this method. Finish and edge consistency are not a drawing requirement, but are desirable in the eyes of the customer.

Deburring from a Machinist's Perspective

Machinists are required to verify that the parts they produce meet all of the dimensional requirements called out in the production routing illustrations. To allow this, the edges of the features must be free of burrs that would interfere with the measuring equipment used for verification purposes. This equipment includes hard gages such as micrometers, calipers, indicator over base, etc., and even optical methods such as comparators and Hawk measuring microscopes. Because machinists are not required to deburr *all* part edges but only those required for verification purposes, some parts may require that almost all of their edges be deburred, while other parts won't require any deburring at all.

Another machinist requirement is to observe the size of the burrs produced on the parts during the machining process. The size of the burrs on the part edges should be kept as small as possible. If the burr size is large at set-up, the speeds and feeds need to be adjusted to reduce the size before production parts are run. In addition, if the burr size increases as parts are machined, a cutting tool change may be necessary. (Increasing burr size is a very good indicator that the tool is getting dull.)

Deburring from an Assembler's Perspective

Assemblers verify the parts that will be used for assembly to ensure that they are free of burrs and defects in order to limit problems in next assembly. Any part that might interfere with correct assembly is usually discarded.

Assemblers prefer parts that have consistent surface finishes, edge breaks, and no workmanship damage. However, just because a part lacks these attributes doesn't mean that the part is unusable. When screening parts for next assembly, avoid discarding inconsistent parts for cosmetic reasons only. Parts should be scrapped only when deemed unusable because of burrs and/or damage in areas that are critical to the function of the assembly.

In addition, bright edges and shiny specks on parts *might* indicate that burrs are present, but not necessarily. Again, be cautious when determining the presence of burrs, particularly because of these conditions, and use at least two different burr-detection methods (discussed earlier) to confirm or deny their existence.

Deburring from an Inspector's Perspective

The inspector's job is to verify parts to ensure that they meet all the drawing requirements. In most cases, a burr-free condition is one of those requirements. Therefore, parts are inspected not only for dimensional requirements, but also for burrs and other workmanship defects.

Inspectors (like assemblers) prefer consistency when it comes to surface finishes and edge breaks, including consistency in both the size and the finish of the part edges, and the surface finishes over the entire part. Although workmanship defects and burrs tend to stand out and are therefore easier to detect, this does not necessarily mean that parts with these types of inconsistencies are not acceptable—only that they may require increased scrutiny to identify workmanship defects. The inspection process should ensure that parts meet the drawing requirements, but take care to avoid rejecting parts for appearance only.

Inspectors (like assemblers) should generally be wary when they see shiny edge burrs, shiny speckle burrs, and burrs in general. Always use a minimum of two burr detection methods (discussed earlier) to confirm whether or not burrs are present.

Deburring from an Engineer's Perspective

The engineer's job is to provide—in the production routing—the specific information required to deburr the parts. This includes identifying the part edges to be deburred, the size of edge breaks required, and any critical surface-finish requirements. It also includes whether burrs need to be removed only on certain edges (as in an "in-process" deburr) or if the parts are to be completely burr-free (as in a "final" deburr). This information should almost always be provided as a pictorial illustration, because showing these requirements (and pointing to their locations) is better than trying to explain them in the narrative.

The engineer's job also includes specifying any special holding fixtures and/or deburr tools required to perform the required deburring process. If no special tooling is necessary, then the selection of deburring tools and methods is generally left up to the operator. (What works well for one person might not work as well for another.)

Future Work

This document will be updated in the future to report new deburring problems and their solutions, newly developed deburring techniques, and new/improved equipment as it becomes available at KCP.