CHAPTER IV

Sharpening Single-Point Tools (Cemented Carbide)

Although the cemented carbides are harder than high-speed steel and cast alloy cutting tool materials, no difficulty need be experienced in grinding carbide single-point tools if the three basic requirements are met, namely

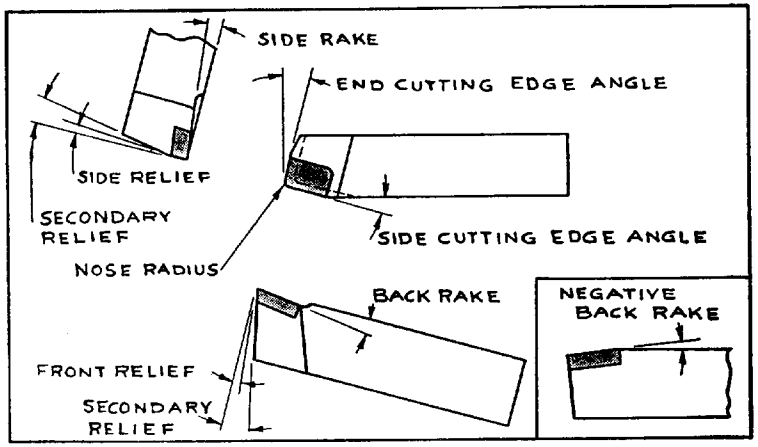
1. Suitable grinding machines.
2. Suitable grinding wheels.
3. Operators trained in the correct grinding methods.

Grinding Rules

The most important requirement in grinding carbide tools is to avoid practices that subject the tip to thermal shock caused by sudden changes in temperature. While the cemented carbide alone may be resistant to this effect, when a carbide blank is brazed to a steel shank, there is a possibility of damage unless reasonable care is exercised.

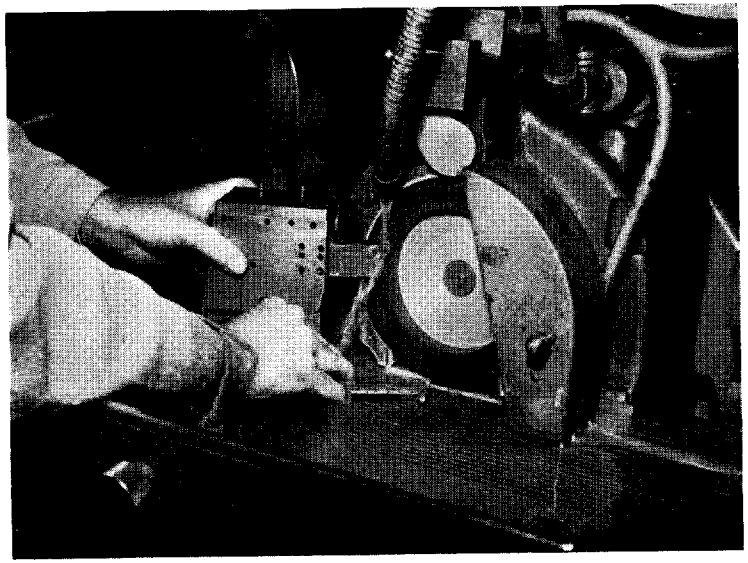
Most grades of carbide, when heated, expand about half as fast as steel does and if the tip and shank are overheated to the same degree in grinding, excessive strains may be set up in the tip. This condition is worse if the shank is raised to a higher temperature than the tip.

There are certain fundamental rules that should be observed by everyone grinding carbide single-point tools:



TOOL ANGLE NOMENCLATURE

- Always grind the top surface of the tool first. Next, rough grind the side relief angle, followed by the front relief angle. Grind the chip breaker (if called for), finish grind the side and front relief angles and, finally, grind the nose radius.
- Grind with the wheel running down into the cutting edge.
- Keep the tool constantly in motion.
- Grind dry and with suitably soft grade wheels, unless the machine is capable of supplying a generous, steady stream of coolant covering the entire working surface of the tool. A small or intermittent flow of coolant results in alternate heating and quenching of the tool which may crack the tip.
- Never quench the carbide tip in water to cool it after grinding. This is likely to crack the carbide and render it unfit for further use.



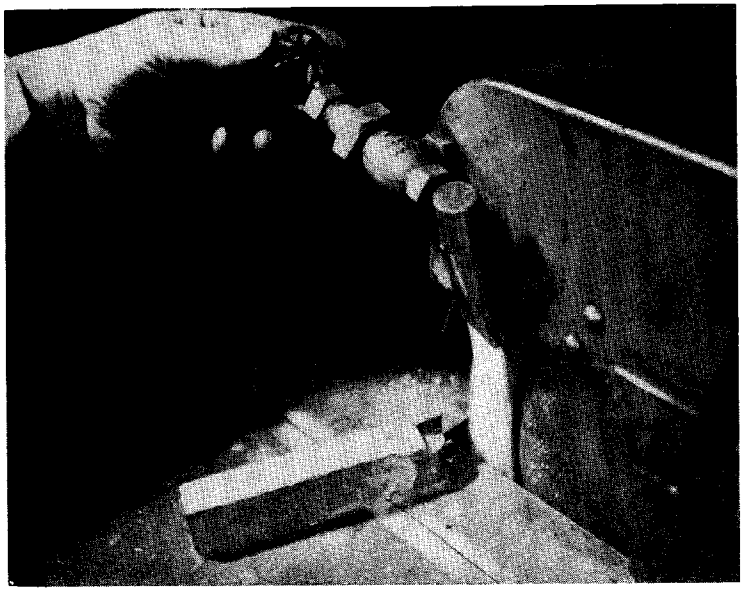
Precision grinding a carbide form tool on a template type, single point tool grinder equipped with diamond wheel

- Dress the Crystolon wheels frequently with a star dresser to keep them sharp and cool cutting. If allowed to become excessively dull or glazed, the wheel may overheat the carbide sufficiently to crack it.
- When using diamond wheels, always use a coolant to keep the wheel face clean and sharp and thereby obtain the best cutting efficiency and maximum wheel life. Dress (clean) the diamond wheel whenever necessary, using lump pumice or a very fine and soft Crystolon stick, 37C400-HV, on resinoid bonded wheels and a suitably coarser and harder Crystolon stick on metal and vitrified bonded wheels.

- After sharpening, protect the keen cutting edges during transportation to the tool crib and to the job by storing the tools in wooden trays provided with individual tool compartments. Giving the head of the tool a plastic dip coating is another effective and inexpensive means of protecting the cutting edges.

Procedure in Grinding Typical Tools

From the standpoint of grinding procedure, all carbide single-point tools may be grouped into three classifications, namely, (1) ordinary dull tools which can be resharpened sev-



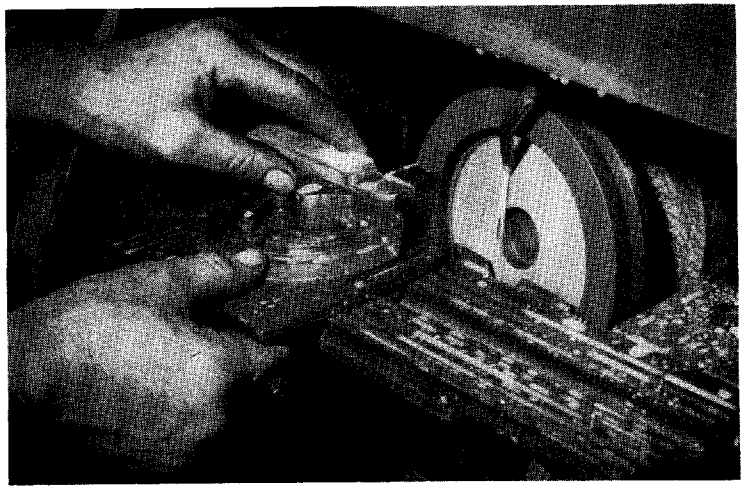
When grinding wet on a silicon carbide wheel, use a generous flow of coolant directed to point of grinding

eral times by simply touching up on a fine grit diamond wheel, (2) tools chipped or broken and requiring extensive grinding in order to recondition them for further use and (3) so-called standard design tools whose shape and cutting angles have to be altered before using; also new "milled and brazed" tools. Both of these last two types of tools require complete rough and finish grinding.

The grinding procedure for each of the above three classifications of carbide tools will be discussed in detail.

Ordinary Dull Tools

It should be the aim of every user of carbide tools to so control their use that they will be returned to the tool grinding room for resharpening when the cutting edge is simply dull; in other words, before it has broken down completely and per-



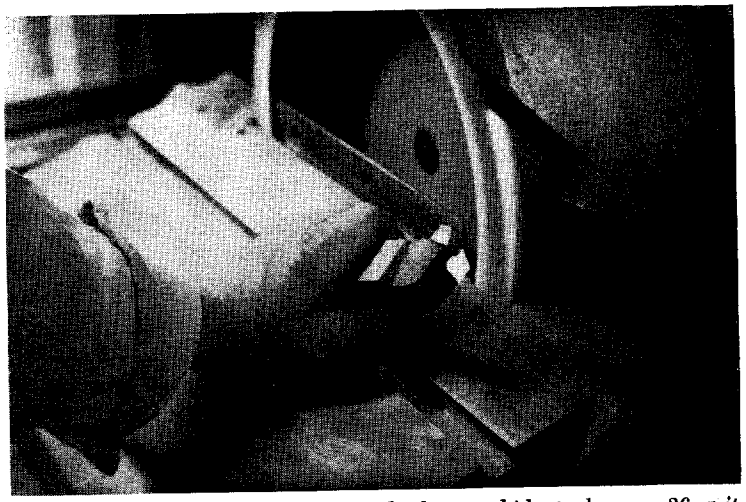
Resharpening a normally dull carbide tool on a 220 grit vitrified bonded diamond wheel

haps chipped or broken. Some plants consider a carbide steel-cutting tool dull when it shows about .030" wear below the cutting edge. As dulling of a carbide tool proceeds beyond the normal dulling point, tool pressure increases rapidly, power consumption becomes greater, tool wear is faster, accuracy is reduced and the work, if fragile, may be sprung out of line and cause chipping of the cutting edge.

On the other hand, resharpening a carbide tool after normal dulling increases the number of regrinds possible during the life of the tool and decreases the time required to restore the sharp cutting edge. For these reasons, it is good practice to check the wear of a tool from time to time in the machine so that it may be changed before excessive dulling develops.

In some production shops the tools are changed as soon as they have done a predetermined amount of work or have been in the machine a certain number of hours. On very long runs it is suggested that a safe minimum number of work units per grind be set and then take all tools out of the machine for resharpening when that number has been completed. Assuming the carbide tool is simply dull—not chipped or broken—it can be quickly resharpened by grinding it offhand as follows on any standard make of carbide tool grinder designed to use diamond wheels.

1. If the tool has been used on steel, grind the top of the carbide tip, if necessary (to remove any crater), followed by the side and front relief angles, taking care to remove all crater and abrasive marks produced in cutting. It is not necessary to regrind the chip breaker until its width has been reduced to the point where the chip is breaking too tight. One or two resharpenings are usually possible before this occurs.
   Use a fine grit diamond cup wheel such as a 220 grit



Cutting back the steel shank of a broken carbide tool on a 36 grit, 32 Alundum wheel

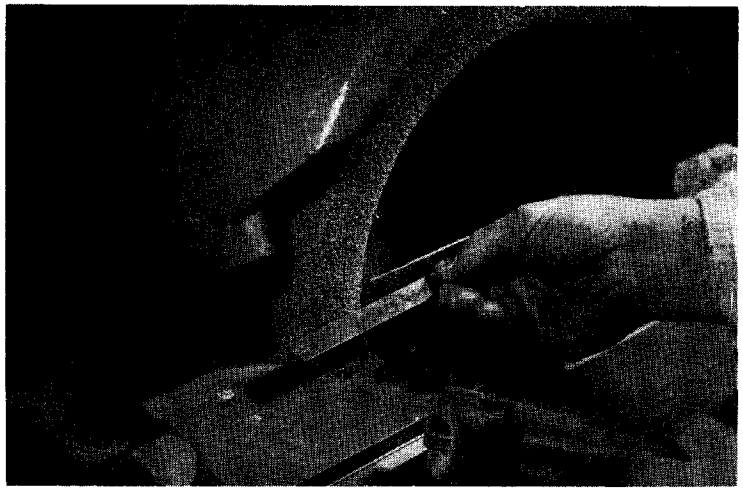
vitrified bonded wheel. Complete marking: SD220-P50V$\frac{1}{16}$. This wheel is capable of producing a very keen and durable cutting edge and a fine surface finish.

Chipped or Broken Tools

Very often such tools can be reconditioned by first grinding back the steel shank and then hogging off the broken portion of the carbide tip. From this point on, the same procedure is followed as in rough and finish grinding a newly brazed tool.

The step-by-step procedure in grinding a typical broken carbide tool is outlined here:

1. With an Alundum wheel—the same as used for grinding high-speed steel tools—grind back the steel shank below and beside the broken portion of the tip. Grind on the corner of the wheel and try to hold approxi-



Crowning the rim of the wheel and dressing it roughly with a star dresser will speed up the cutting action

mately the same relief angles as were originally on the tool.

Next, relieve the steel behind the carbide tip on the top of the tool. The tool is now ready to be rough ground on a Crystolon wheel.

2. The rough grinding may be done either on a straight wheel or on a cup wheel. The cup type wheel offers the advantages of a uniform cutting speed (s.f.p.m.) throughout its life and more accurate control of tool angles by presenting a flat area of contact to the tool.

Use a 60 grit Crystolon wheel, such as 39C60-I8VK, On 10″ and 14″ carbide tool grinders, porous or open structure type wheels have proved very successful. A popular specification in this type of roughing wheel is 39C60-G+8VKP.

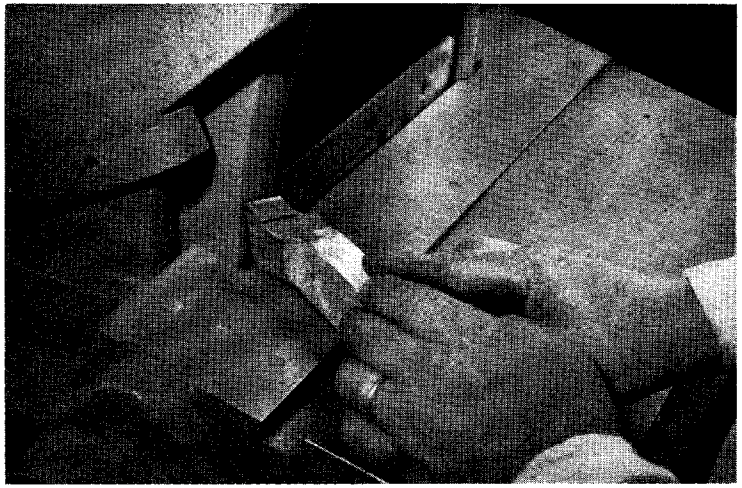
With a star dresser, crown the wheel about $\frac{1}{16}$" and at the same time dress it rough by holding the dresser loosely, taking care, however, not to let the wheel get bumpy or out of true. A roughly dressed wheel cuts faster and cooler, thus minimizing any danger of injuring the carbide.

3. Hog off the broken end of the carbide tip. For this operation, the table is used only as a tool rest and, therefore, may be set at a fairly steep angle, say 20° to 25°, so that the tool can be firmly gripped. Throughout the grinding operation keep the tool constantly in motion by (a) moving it back and forth across the wheel face, (b) rocking it and (c) tipping it up and down slightly. The entire tip of the tool is now ready to be rough ground.

Rough Grinding

Start with the top face, always, and follow with the side and front reliefs. By grinding these surfaces last, it is possible to obtain a keener cutting edge inasmuch as minute flaking at the cutting edge is avoided.

1. To rough grind the top face, first set the table at the desired rake angle. Be sure the wheel is rotating down into the cutting edge. Use the outer portion of the crowned rim of the wheel to avoid grinding into the steel shank in back of the tip.
   Hold the tool against the wheel with relatively light pressure and remember to keep moving the tool constantly. Continue grinding until the top face is cleaned up evenly.



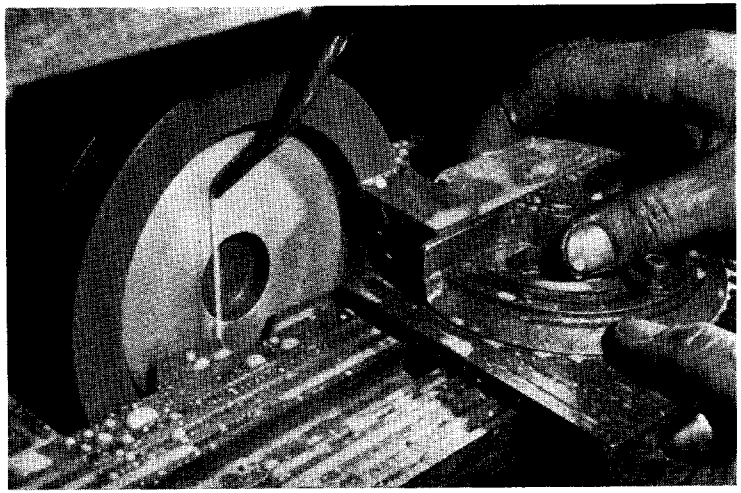
Hold the tool lightly against the Crystolon wheel and keep moving the tool constantly to avoid overheating it

2. Next, rough grind the side of the tool. It is good practice to use double relief angles, so that only the tip is ground when finish grinding. Accordingly, rough grind both the tip and the shank to a secondary relief angle of about three degrees greater than the primary relief angle called for on the tip.
   Keep the tool moving back and forth across the wheel. Do not hesitate to dress the wheel at the first signs of glazing or dulling.
3. With the table still set at the secondary relief angle, rough grind the front of the tool. This operation is done on the other side of the cup wheel and the direction of wheel rotation has to be reversed so that the wheel will turn down into the cutting edge. Keep the tool moving back and forth across the wheel face.

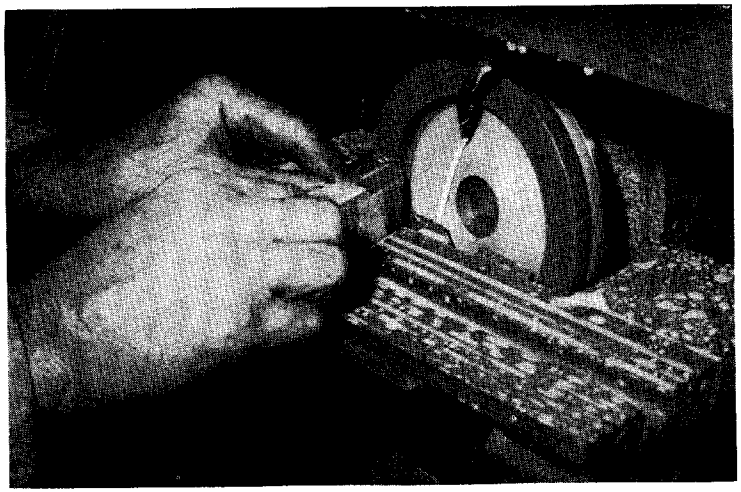
Should the tool become too hot to hold while grinding dry, lay it aside and work on another tool. Never cool the tool in water or oil.

Finish Grinding

While carbide single-point tools are sometimes finish ground on fine grit silicon carbide wheels, diamond wheels preferably should be used, particularly on tools to be used for machining cast iron and nonferrous metals for which a very keen cutting edge is desirable. The very low rate of wear of diamond wheels and ability to hold shape, combined with their fast and cool cutting qualities, makes them a decidedly economical type of wheel to use for finish grinding. Fairly large tools can be finish ground on the popular 6″ and 10″ diamond cup wheel shapes.



The use of a protractor work holder insures accurate tool angles



Finish grinding the front relief angle on a 220 grit vitrified bonded diamond wheel

Using a standard carbide tool grinder designed to accommodate diamond wheels, the procedure in finish grinding our typical carbide single-point tool is as follows:

1. Select either a vitrified or metal bonded type of diamond wheel, according to whether fast rate of cut or durability and long wheel life is the primary consideration, and of a suitable grit size to meet the finish requirements.

   For our typical tool, we will select a vitrified bonded diamond wheel, 220 grit, which insures a very keen cutting edge and fine surface finish and yet cuts at a satisfactorily fast rate. The complete marking of this wheel is SD220-P50V$\frac{1}{16}$.

   For large, roughing tools on steel, 150 grit may be fine

The nose radius should be accurately ground and blended into the side and front cutting edges

enough; in a combination roughing and finishing wheel, a D120-N50M$\frac{1}{16}$ metal bonded or SD150-P50V$\frac{1}{16}$ vitrified bonded diamond wheel is frequently used.

On the Norton Bura-Way machine mounting a 7″ cup wheel, a SD320-P50V$\frac{1}{16}$ vitrified bonded diamond wheel is recommended.

2. Start with the top face, as before. Set the table at the desired rake angle. Be sure the diamond wheel turns down into the cutting edge and a generous flow of coolant strikes the wheel face. Hold the tool so that the entire top surface of the carbide tip is flat against the wheel.

   Keep the tool moving back and forth across the wheel face in order to distribute the wear evenly and obtain

the best possible finish. Should the wheel become glazed or loaded (from the shank steel), clean it, using a Crystolon stick like the sample supplied with the wheel and flushing the wheel with a good flow of coolant.

3. If the tool is to have a chip breaker, it should be ground at this point, before finish grinding the side and front reliefs. In this way any minute nicks that might develop in the cutting edge during the chip breaker surface grinding operation are removed in the subsequent relief grinds.

4. Finish grind the side and then the front of the tool with the table set at the desired primary relief angle. It is not necessary to finish grind the full thickness of the carbide tip; grind off only enough so that the primary relief angle will extend below the cutting edge about $\frac{1}{16}$″. By following this practice of leaving a small land at the cutting edge and using double relief angles, the secondary relief grind on the shank will have to be repeated only occasionally in subsequent regrinds.

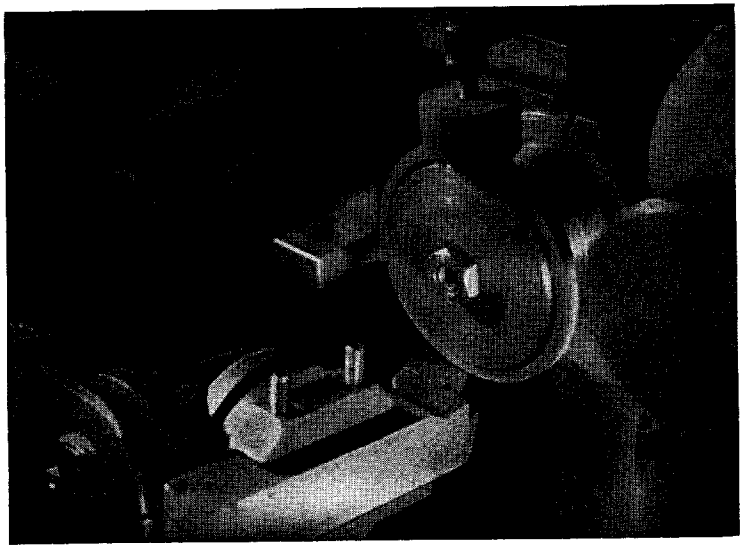
5. Finally, grind the nose radius. Hold the tool very lightly against the diamond wheel and rotate it in a full arc across the face of the wheel so that the radius blends into the front and side cutting edges. Large radii as required on round-nose roughing tools should be checked with a template or radius gage.

Grinding the Chip Breaker

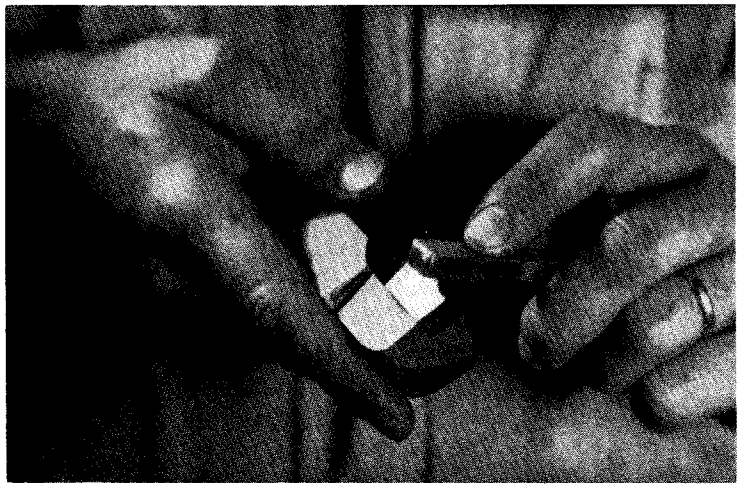
If in doubt as to the style and width of chip breaker to be used, start off with the recommendations of the carbide tool manufacturer. For our typical tool, we have selected a parallel

type of chip breaker to be ground on a small universal tool and cutter grinder. See the following chapter on "Chip Breakers" for detailed instructions on grinding procedure and wheel selection.

1. Clamp the tool in the vise, positioning it so that the step will be parallel to the top of the tool. This is done by adjusting the universal vise so that the top of the tip is horizontal.
2. Next, swivel the tool and vise in a horizontal plane until the cutting edge of the tool is parallel with the side of the diamond wheel. Clamp the tool in this position. If the angular type of breaker is called for, the protractor scale on the base of the vise is used and the tool and vise swiveled to give the desired chip breaker angle.



Set-up for grinding parallel type of chip breaker grinder. Note extra large flanges for vitrified bonded diamond wheel and oil-saturated felt wick



Honing the side cutting edge and nose radius lightly at a 45° angle to the top of the tool prevents flaking on heavy cuts

Honing the Cutting Edge

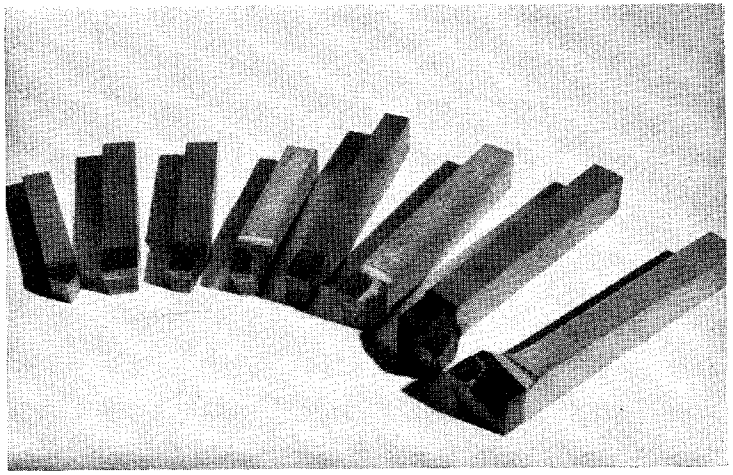
It has been found that carbide tools for rough turning of steel will stand up longer between regrinds if the cutting edge and nose radius are honed at a 45° angle to leave a chamfer about .005" wide. Scale and heavy chips are apt to make an extremely keen cutting edge flake off. Furthermore, honing removes any microscopically ragged edge that may have been left by the grinding wheel.

A popular stone for this purpose is a ¼ x ¾ x 4" 37C280-NV Crystolon or a ¼ x $\frac{7}{16}$ x 4", 320 grit, type DH1 diamond vitrified bonded hand hone. Complete marking: **D320-V$\frac{1}{16}$.**

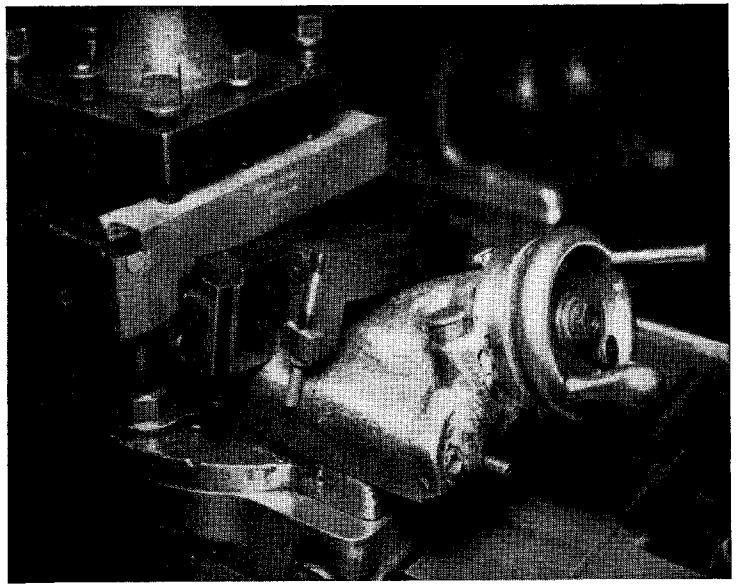
Milled and Brazed Tools

Practically all of the manufacturers of carbide cutting tools today offer so-called standard design tools in about ten different styles for general purpose use. While all these tools have been finish ground and are ready to be put to work, sometimes the user has to change the shape and cutting angles slightly to meet the specific job requirements. In other instances, the user makes his own single-point tools by brazing standard carbide blanks to the tool shanks.

The grinding procedure for both of these types of tools involves the same roughing and finishing operations previously described for reconditioning chipped tools, beginning on page 82.



Assortment of standard carbide-tipped tools



Typical ejector type carbide tools. Note triangular, square and round replaceable carbide inserts

Ejector Type Tools

So-called ejector or insert type carbide single-point tools are of relatively recent design. While it would be a mistake to call them a universal tool or a successor to the conventional brazed tool, they have been successfully applied on numerous operations, particularly on multiple tool set-ups and where negative rake angles are not prohibitive. The carbide bit or insert, either solid carbide or carbide tipped, is positioned vertically in the steel shank. The insert, depending upon its shape, has three or more cutting edges on each end, and can be turned end over end, or replaced entirely, without changing the set-

ting of the toolholder. Because of the fact that all rake and relief angles are built into the holder itself, grinding time as well as set-up time are reduced to a minimum.

The carbide inserts are made in four different styles or shapes, namely, square, rectangular, triangular, and round. Each style is particularly suited for certain machining operations. Triangular inserts, for example, are recommended for general purpose turning and turning to a square shoulder, while rectangular inserts presenting a ¾" long cutting edge can be used for heavier cuts.

The sharpening procedures on ejector type tools are somewhat different from carbide tools of conventional brazed design in that no part of the steel shank need be ground—only the carbide insert. When the cutting edge becomes dull, the insert is turned or "indexed" in the holder to present a new, keen cutting edge without disturbing the tool set-up. Finally, when all the cutting edges on both ends of the insert have become dull, the insert is replaced with a reground one. The accumulated dulled inserts are delivered periodically to the central tool grinding room for resharpening.

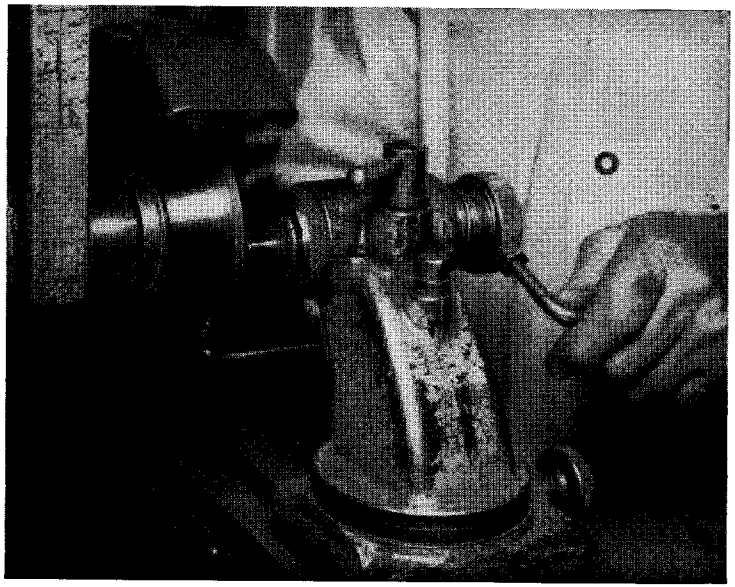
Grinding Procedure

If the carbide insert requires no chip breaker, it can be readily ground offhand on any carbide tool grinder by simply squaring off the end on the rim or side of a cup wheel. The work rest table is set at exactly 90° to the face of the wheel, and the sliding protractor is used to support the insert while moving it back and forth across the face of the wheel. A diamond wheel around 220 grit, such as Norton SD220-P50V vitrified bonded, is recommended for finish grinding. For rough grinding, either a SD100-P50V diamond vitrified or a 39C60-I8VK Crystolon vitrified wheel may be used.

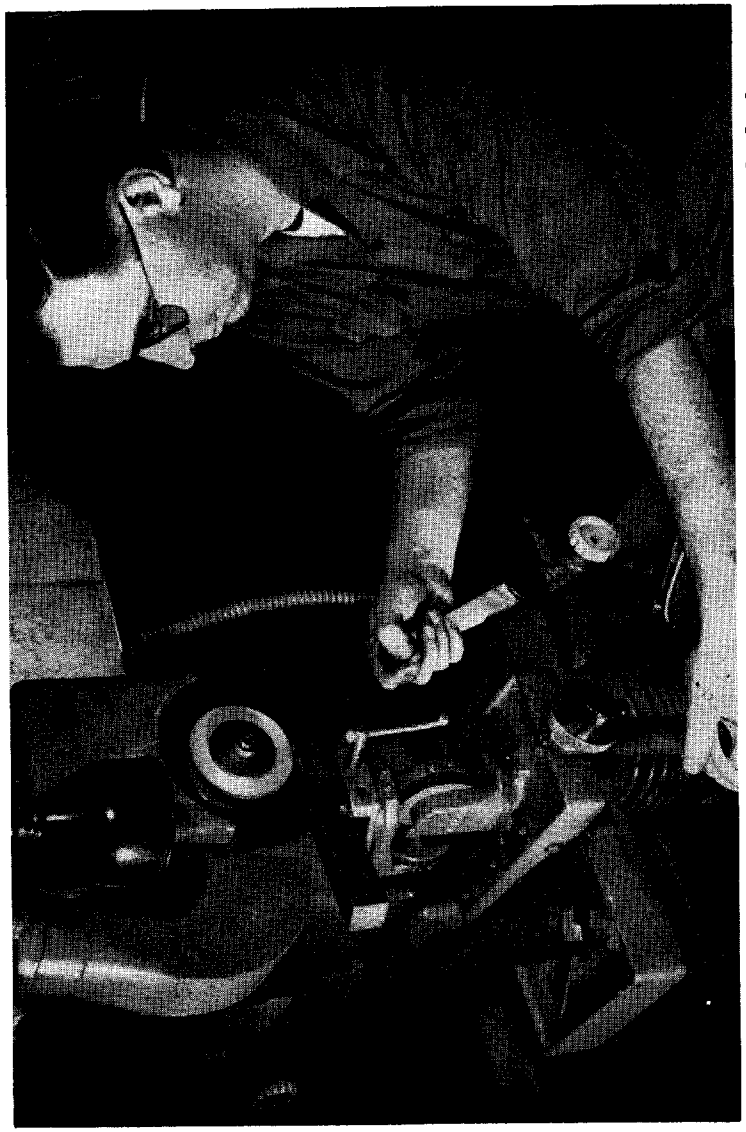
The carbide insert can also be machine ground on any small surface grinder or tool and cutter grinder, using a 6" or 7" straight diamond wheel about ¼" thick. The insert is clamped in a vise and traversed under the wheel, using a downfeed not exceeding .0005" per pass. The cut should be allowed to sound out (spark out) on the final passes to get the best possible finish.

Chip Breakers

The vertical ejector type toolholder is so designed that when the carbide insert is ground perfectly square across the



Grinding a chip breaker on a round carbide insert, using a homemade hand-operated fixture for rotating the insert



Grinding a chip breaker with a durable SD150-R100B11⅛ resinoid bonded diamond wheel

NORTON ABRASIVES

top, it presents a 7° negative back rake and 7° negative side rake. This is usually ample to control the chips on most steel turning jobs. However, where it has been found, after trial, that a chip breaker is necessary on triangular, square, or rectangular style inserts, these can be ground in the conventional manner on either a special chip breaker grinder, a small surface grinder, or a tool and cutter grinder, using a 4″ x ⅛″ or 6″ x ⅛″, SD150-R100 B11⅛ diamond resinoid bonded wheel.

The tool manufacturer's recommendations should be followed as to the style of chip breaker, depth, and width. These vary with the depth of cut, feed, kind of material being machined, and cutting speed. See the following section on "Chip Breakers" for suggestions.

When grinding a chip breaker on a round style insert, it is necessary to rotate the insert. Assuming a tool and cutter grinder is available, a simple method of supporting and rotating the insert is by clamping it in a spring collet that has been fitted into a bushing. The bushing, in turn, has a close sliding fit in the left-hand footstock on the cutter grinder. A bent steel rod serves as a crank. This simple homemade device is illustrated in the photograph on page 95. The diamond wheel is a type D11V9 (D11B) flaring cup in the specification SD150-R100B$\frac{1}{16}$ resinoid bonded.

A revolving collet-type fixture either motor driven or hand operated, was brought out by one of the manufacturers of carbide ejector type tools. The fixture can be used on either their own make of chip breaker grinder, or on any standard 6″ surface grinder. Round inserts can be rotated and triangular and square inserts readily "indexed" for any cutting position.