CHAPTER I

Wheels for Tool Room Grinding

The Abrasives

The abrasives used in most Norton grinding wheels may be classified into two general groups—the aluminum oxide abrasives, designated by the trade-mark ALUNDUM, and the silicon carbide abrasives, designated by the trade-mark CRYSTOLON. Both are products of the electric furnace, but differ materially from each other. Silicon carbide is both harder and "tougher" (higher body strength) than aluminum oxide. This difference in properties makes each of the two general types of abrasives particularly suited to grinding different kinds of materials.

Thus, silicon carbide or Crystolon abrasive is better suited for grinding very hard and dense materials like cemented carbides and ceramics; also most nonferrous metals and nonmetallics, as well as cast iron. The penetration hardness and fracture characteristics of aluminum oxide or Alundum, on the other hand, make this abrasive better suited for grinding steel, both hard and soft. It does not dull as rapidly as silicon carbide on this material, and is more easily fractured, thereby constantly exposing new, sharp, cutting points to the work.

Norton Company manufactures several types of Alundum abrasives which have the trade-marks "Alundum" (commonly referred to as "regular"), "19 Alundum," "32 Alundum," "38 Alundum," "44 Alundum" and "57 Alundum." They possess individual characteristics, principally with respect to friability

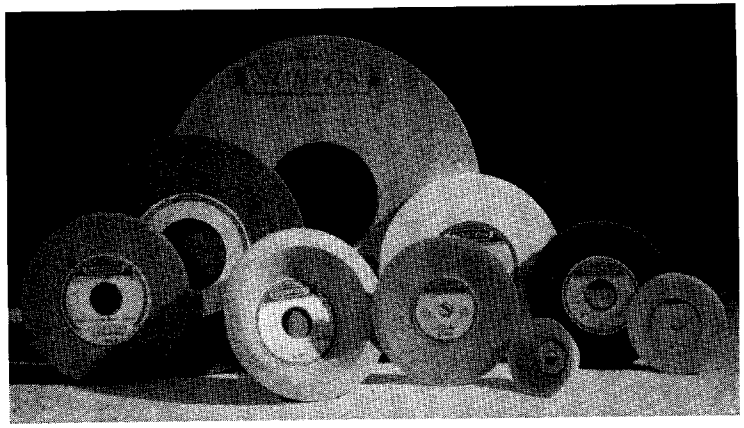
and resistance to point dulling which make each abrasive adaptable to different classes of work. For example, "38 Alundum" because of its porous nature, is more friable than regular "Alundum," which is tough and capable of heavy duty grinding. As a result, "38 Alundum" has a cool cutting and almost self-dressing action. It has long been a popular type of abrasive for tool room wheels.

"19 Alundum" and "57 Alundum" abrasives may be described as having a grinding action intermediate between "Alundum" and "38 Alundum" abrasives and as such are sometimes used for such tool grinding and other operations where the regular Alundum abrasive is too tough.

The basic requirements of the ideal abrasive are resistance to point dulling and ability of the grain to fracture under normal grinding pressures before serious dulling occurs. Norton "32 Alundum" fulfills both of these requirements to an exceptional degree.

In the available grit range, namely 16 to 220, "32 Alundum" wheels are ideally suited to grinding tool steels. On such tool room operations as cutter sharpening, surface grinding, and internal grinding, "32 Alundum" wheels of proper specifications will grind faster and cooler, last longer and require fewer dressings than other abrasive wheels. Throughout this handbook "32 Alundum" wheels have been recommended for the majority of precision tool steel grinding operations. When converting to "32 Alundum" abrasive, specify the same grit size and grade as white or red tool grinding wheels now in use.

There are two types of silicon carbide abrasive produced by Norton Company under the trade-mark Crystolon. In addition to the familiar gray—almost black colored 37C Crystolon, there is a green-colored variety, 39C, which is widely used for grinding cemented carbide tools.



Commonly used types of tool grinding wheels

The Bonds

There are five popular processes of bonding grinding wheels, namely, vitrified, silicate, resinoid, rubber and shellac. Each type of bond imparts distinct characteristics to the grinding action of the wheel. With this variety of bonds, therefore, Norton Company is in a position to provide wheels that will most effectively meet specific grinding requirements.

Vitrified Bond—Most grinding wheels are made with a vitrified bond, which consists of a mixture of carefully selected clays. At the high temperatures produced in the burning kilns, the clays mixed with the abrasive grain fuse into a molten glass condition. On cooling, a span of this glass attaches each abrasive grain to its neighbors and supports them while they grind.

To provide a still closer fitting of the wheel to the work, Norton Company offers three different types of vitrified bonds, namely, "G" bond, "BE" bond and regular vitrified bond. While all three types may be used in wheels for tool room

grinding, "G" bond wheels in particular are recommended.

"G" bond was introduced early in 1953 as a distinctly new and superior bond for precision and semiprecision grinding. It possesses the unique ability of breaking down at just the right time in the grinding cycle to give the wheel, in the right grade, practically a self-dressing action. Its built-in free and cool cutting action makes it an ideal bond, in combination with one of the Alundum abrasives, for cutter sharpening.

Silicate bonded wheels have a milder cutting action than vitrified wheels and are still used to a limited extent for grinding edge tools. In the tool room they are found on some of the large wet tool grinders.

Resinoid bonded wheels are designed to operate at 9000 to 9500 surface feet per minute. Because of their fast cutting ability at these higher speeds, they are particularly suited for snagging castings and for other heavy duty operations. Resinoid bonded cut-off wheels are popular for cutting all kinds of materials. On proper equipment, such wheels can be safely operated at speeds as high as 16,000 s.f.p.m.

More recently, resinoid bonded wheels have been successfully applied to the grinding of large milling cutters. For this work they are operated at normal machine speeds.

Rubber bonded wheels also are capable of rapid stock removal when operated at high speed. Their grinding action is characterized by a certain smoothness and as a result, they are used to a large extent on work where a high quality of finish is required, as on ball and roller bearing races. In the tool room, they are used principally for fluting taps and for wet cutting-off operations.

Shellac bonded wheels grind with a burnishing or buffing action as a result of the bond softening under the heat of grinding. They are therefore capable of producing bright finishes such as are required on cold mill rolls and the sides of certain slitting saws. They are also used for grinding cutlery and for "gumming" saws in lumber mills.

Grinding Wheel Specifications

All grinding wheels are made up of three elements—abrasive grain, bonding material, and pores.

The first is the working element, the second determines the grade or hardness, and the third represents the voids between the grain required for chip clearance on most operations.

By the term "specifications" is meant the choice of these three elements which are described more fully as follows.

Grain Size (Grit)

A number is used to designate the size of individual abrasive grains in the wheel. This number corresponds to the meshes per linear inch in the screen employed in sizing the abrasive particles. For example, a grinding wheel of 30 grit contains abrasive grains that will just pass through a screen having 24 openings to the linear inch, but are retained on the next finer size screen, 30.

Grain Sizes of Norton Abrasives

Coarse	*Medium*	*Fine*	*Very Fine*
10	30	70	220
12	36	80	240
14	46	90	280
16	54	100	320
20	60	120	400
24		150	500
		180	600

The very fine sizes are classified by hydraulic separation. Combinations of various grain sizes are often used to produce a desired refinement in grinding action.

Grade (Hardness or Strength of Bonding)

The abrasive grains in a grinding wheel are held in place by "posts" of bond. If these bond posts are very strong and are capable of retaining the grains against the grinding forces tending to pry them loose, the wheel is said to be of a hard grade. On the other hand, if only a small force is needed to release the grains, the wheel is said to be of a soft grade. Thus, with a given type of bond, it is the relative *amount* of bond in the wheel which determines its grade or hardness.

In the Norton method of marking wheels, which conforms to the system now standard throughout the industry, the grade letters for all types of wheels range from A to Z in the order of increasing hardness.

Soft	*to*	*Hard*
A, B, C, D, E, F, G, H, I, J, K, L, M, N, O, P, Q, R, S, T, U, V, W, Z		

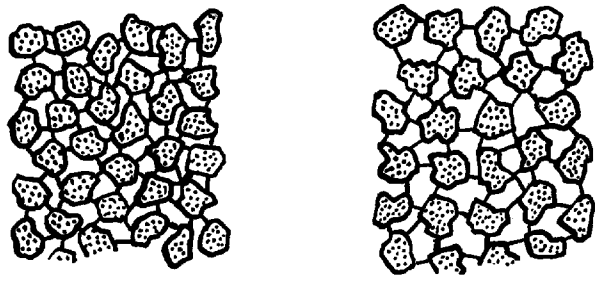
It should be understood that grade is not an exact value. Actually, it is a range between narrow limits, and all wheels that come within the range designated by any particular letter are considered to be of one grade and carry the same grade letter.

Structure (Grain Spacing)

Two wheels of the same grain and grade, but differing in the spacing of the abrasive grains, obviously will not grind alike. "Controlled structure" is a term used to indicate accurate control over the grain spacing in Norton wheels.

The spacing of the abrasive grains—or the structure—is designated by a number. When the grains are close together, relative to their size, the wheel has a dense structure as expressed by a low structure number such as 3. In some types of wheels the structure number is omitted even though the grain spacing is controlled.

	Close Spacing	*to*	*Wide Spacing*
Structure Number	0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12		



Close abrasive spacing *Wide abrasive spacing*

A diagrammatic sketch to show how two wheels may be identical in grain size and grade (strength of bonding) but differ in grain spacing or structure

In the larger sizes of Crystolon cup wheels, such as 10″ and 14″ diameter, for offhand rough grinding carbide single-point tools, wheels made with an extra wide grain spacing and of the so-called porous type have been found to be exceptionally fast and cool cutting, particularly when the grinding is done dry. These wheels are designated by the structure number 8 and the addition of the letter P (for porous) at the end of the marking; for example, 39C60-G+8VKP and 39C60-H8VKP.

This is a typical

NORTON GRINDING WHEEL MARKING

Note extra wide grain spacing of this 60 grit porous type Crystolon wheel

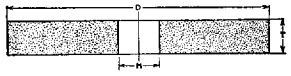
Standard Types of Grinding Wheels

On the next page is shown cross sections of six standard types of grinding wheels (exclusive of diamond wheels) which are representative of the shapes most commonly used for tool room grinding. The six types of wheels are numbered and each dimension designated by a letter. The key to the dimension letters is given at the top of the page.

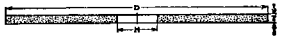
This classification of grinding wheels greatly simplifies the stocking of wheels wherever a quantity is kept on hand. It also enables the user to accurately order a grinding wheel by giving the type number and dimensions as designated by the cross section of that type.

Key to Letter Dimensions

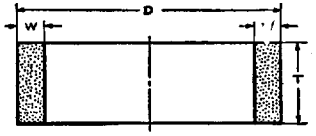
A = Flat Spot of Beveled Wall.
D = Diameter (Over All).
E = Center or Back Thickness.
F = Depth of Recess. (See Type 5.)
G = Depth of Recess.
H = Arbor Hole.
J = Diameter of Flat or Small Diameter.
K = Diameter of Flat Inside.
M = Large Diameter of Bevel.
P = Diameter of Recess.
R = Radius.
T = Thickness (Over All).
U = Width of Face.
V = Angle of Bevel.
W = Thickness of Wall.



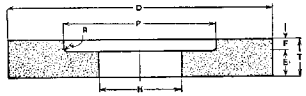
Type No. 1 *Straight*



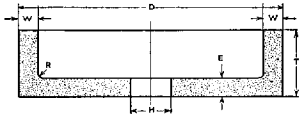
Type No. 1 *Cut-off*



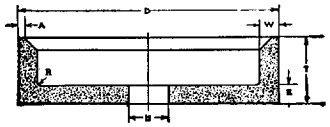
Type No. 2 *Cylinder*



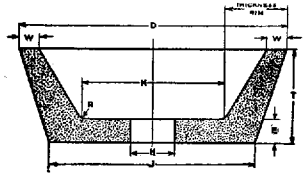
Type No. 5 *Recessed One Side*



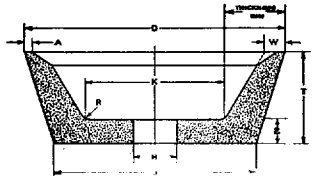
Type No. 6 *Straight Cup*



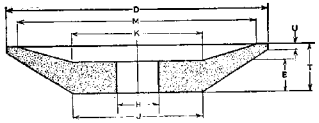
Type No. 6 *Beveled Face*



Type No. 11 *Flaring Cup*



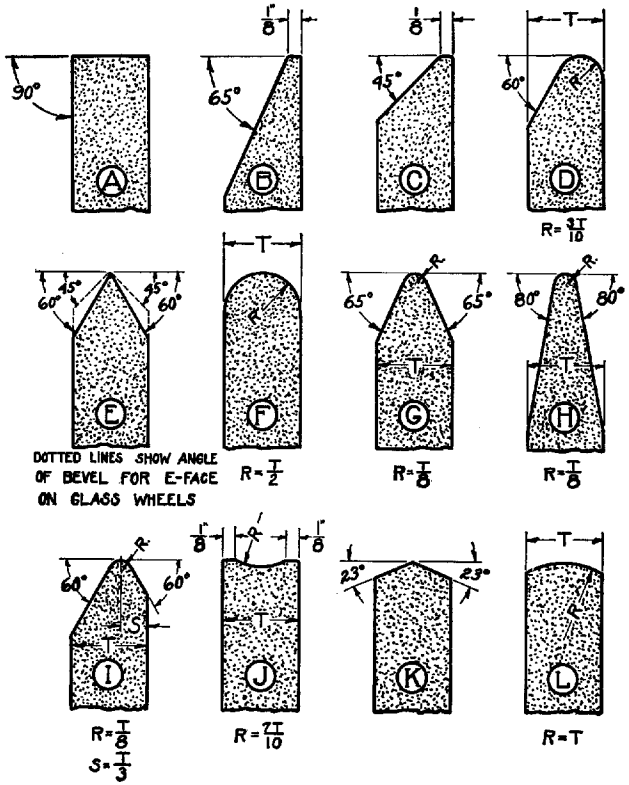
Type No. 11 *Beveled Face*



Type No. 12 *Dish*

Standard Shapes of Grinding Wheel Faces

When no face is specified a straight "A" face wheel is furnished. The different faces which are regularly supplied are designated by letters as shown below:



For dressing large tool sharpening wheels, the Huntington or other revolving cutter type of dresser, rigidly supported on the work rest, is recommended.

Typical vitrified bonded diamond wheels and hand hone

Diamond Wheels

Diamond wheels have become the accepted type of abrasive wheel for offhand *finish* grinding carbide single-point tools and for all fixed feed or precision grinding operations on cemented carbides, including the grinding of chip breakers, multi-tooth cutters such as face mills, reamers, etc. Their advantages of exceptionally fast and cool cutting action and extremely low rate of wear as compared to silicon carbide wheels—resulting in low grinding costs—are well known to every tool grinder hand who has used diamond wheels.

They are available with either mined or man-made diamond which was introduced to American industry in 1958. Both resinoid and vitrified bonded wheels containing this man-made diamond, in the 100 grit and finer range, have proved to be very satisfactory for the grinding of cemented tungsten carbides.

Bond Types

Norton Company pioneered in the development of diamond wheels in this country, bringing out the first resinoid bonded diamond wheel about 25 years ago. This was followed six years later by the durable metal bonded diamond wheel and soon afterwards by still a third type, the vitrified bonded diamond wheel, a patented development of the Norton Research Laboratories. Each of these three types of Norton diamond wheels fits into certain fields of application in the grinding of carbide-cutting tools, dies and wear-resistant parts.

Resinoid bonded diamond wheels have an exceptionally fast and cool cutting action. For this reason they are particularly suited to sharpening multi-tooth cutters, reamers, etc., for grinding chip breakers and for all precision grinding operations, including cylindrical, surface and internal grinding of carbide dies, gages, rolls, etc.

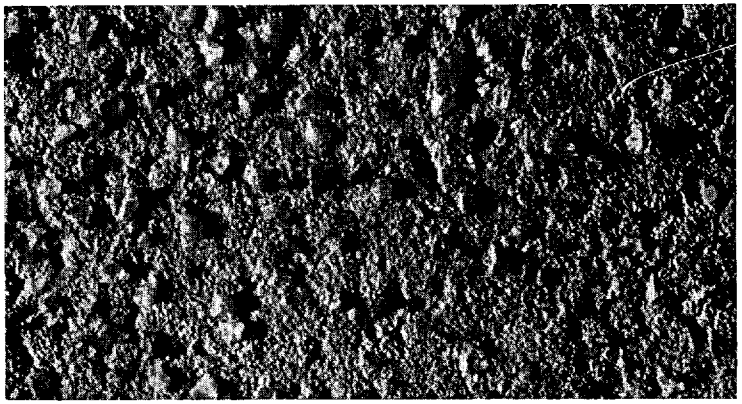
Where diamond wheels must be used dry, as in cutter sharpening, Norton Company has developed a special heat-resistant type of resinoid bond designated as B6.

Norton **metal bonded** diamond wheels are used for offhand grinding single-point tools, particularly where durability, long life and resistance to grooving rather than a very fast rate of cut, are primary considerations. In the popular 6″ cup wheel, a D120-N50M$\frac{1}{16}$ has proved to be a very satisfactory specification for general resharpening.

The Norton vitrified bonded diamond wheel combines the fast cutting quality of resinoid bonded diamond wheels with a resistance to wear and grooving approaching that of metal bonded diamond wheels. The vitrified bond "wets" the diamond particles and adheres tightly to them. This means that the diamond grains can achieve their maximum useful life before they dull, eventually, and are fractured or released by normal grinding pressure.

In common with other vitrified wheels, the Norton vitrified bonded diamond wheel has (1) rigidity that gives dimensional accuracy to the work being ground, (2) a porous structure to promote faster and cooler cutting and (3) positive adhesion between the vitrified bond and the abrasive cutting grains (diamond) which insures a long, useful wheel life.

These desirable qualities serve to make the vitrified bonded diamond wheel particularly suitable both for reconditioning excessively dull single-point tools, using a 100 grit roughing wheel, and for ordinary resharpening or finish grinding, using cup wheels around 220 grit. Inasmuch as the diamond points protrude higher above the face of the bond than in the case of the resinoid or metal bonded types of diamond wheels, the wheel has a noticeably sharper cutting action.



Magnified (20x) view of freshly lapped vitrified bonded diamond wheel. The diamonds appear to be merely sitting on the surface but are actually tightly held by the vitrified bond

Besides the plain cup wheels used for offhand grinding, Norton vitrified bonded diamond wheels are available in straight wheels, flaring cup, dish and mounted wheels for various precision and tool and cutter grinding operations. (See page 185 in appendix.)

Standard Grit Sizes

Norton diamond wheels (of any bond type) are supplied in the following standard grit sizes for grinding carbide tools. While still coarser sizes, such as 36, 46 and 60 are available, these do not appear to have application in the carbide grinding field:

80	Sometimes used for rapid rough grinding, offhand.
100	For rapid removal of stock, either offhand or machine grinding; also for cutting off. It is the most common roughing grit size in all diamond wheel shapes.
100S	(This size may be considered intermediate between 100 and 120.) For rough grinding, where 100 grit may be too coarse. For cutting off.
120 } **150**	For resharpening, offhand, steel-cutting grades of single-point roughing tools. For combination roughing and finishing wheel on offhand grinding single-point tools. For cutting off and grooving. For chip breaker grinding.
220 } **240**	For finish grinding all types of tools, either offhand or machine grinding. For cylindrical, surface and internal grinding to a fine finish.
320 } **400**	For very fine finishing, especially boring tools. For hand hones.

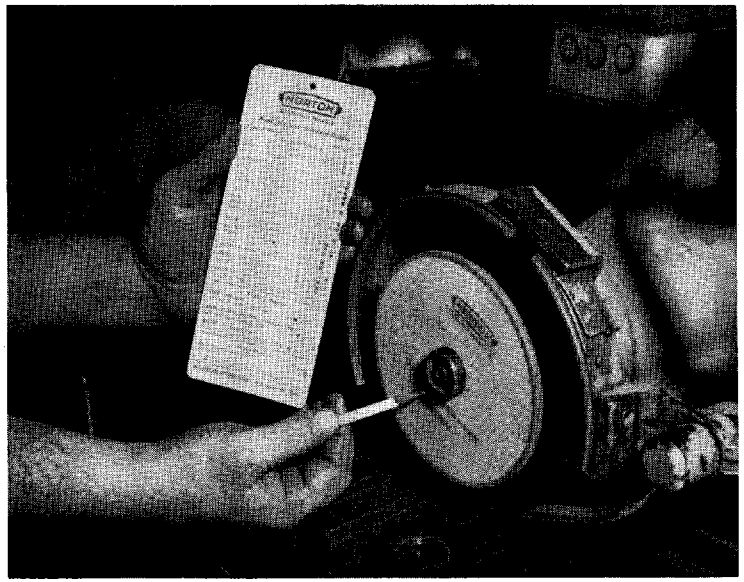
(cont.)

500 For lapping extremely keen edges with resinoid bonded wheels, as sometimes required for certain boring tools.

600, 800, 1200, 1500 For mirror finish on carbide gages, rolls, etc.

Standard Grades

Like other types of wheels, Norton diamond wheels can be made in a range of grades of hardness. This means that diamond wheels can be fitted closely to the conditions and



Checking the grade of a diamond wheel against a list of available and standard grades. See pages 195 and 196 in appendix for same information

requirements of a specific operation, the same as ordinary grinding wheels.

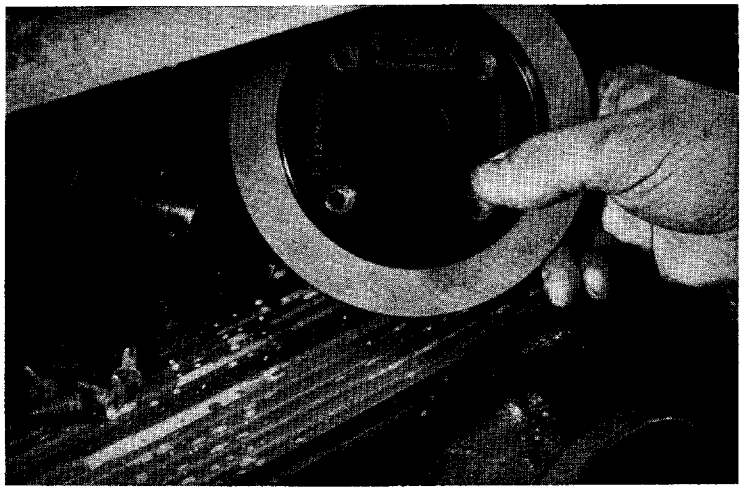
For example, resinoid bonded wheels are available in any one of five grades, namely H, J, L, N and R. There is a so-called standard grade for each type (shape) of wheel and this standard grade should always be considered first when selecting a wheel inasmuch as it represents an all-around average grade and one that is probably carried in the Norton factory and warehouse stocks. However, the user should not hesitate to specify either a softer or a harder grade, as the case may be, to meet the requirements of a particular job.

For example, in a 1/8" thick straight wheel for chip breaker grinding, while the standard grade for this type of resinoid bonded diamond wheel is N, a wheel one grade harder, namely R, very often can be used with the advantage of a lower rate of wear, and particularly, improved corner strength. On the other hand, when grinding one of the extremely hard and abrasion-resistant grades of carbide, a diamond wheel softer than the standard grade may be required in order to grind it satisfactorily without danger of overheating and cracking the carbide.

Norton vitrified and metal bonded diamond wheels, likewise, can be made in several grades of hardness. The available and standard grades for each of the three bond types of Norton diamond wheels are listed on pages 195 and 196 and should be referred to when selecting and ordering diamond wheels.

Diamond Concentration

Each Norton 100 concentration diamond wheel contains an amount of diamond in carats calculated to a formula of 72 carats per cubic inch. Wheels of 75, 50 and 25 concentration



A popular shape and size of metal bonded diamond wheel for sharpening carbide single-point tools

of diamond contain 75%, 50% and 25% of this 100 concentration standard respectively.

The finished wheel actually contains the calculated number of carats of diamond except for the slight loss resulting from truing the diamond section to place the wheel in proper truth and condition for grinding.

Norton Company guarantees that every Norton diamond wheel is made in accordance with this standard.

When to Use "100" Concentration

Wheels of "100" concentration are recommended for machine grinding operations on cemented carbides, such as chip breaker grinding, cutter grinding, cylindrical, surface and internal grinding, particularly in grit sizes up to about 220. Most peripheral type wheels, flaring cups and dish wheels come under this classification. No. 100 diamond concentration is also best suited for thin cut-off wheels, mounted wheels and hand hones.

In the peripheral type wheel, commonly used for fixed feed precision grinding, the reduced concentrations, particularly in the coarser grit sizes such as 100, 120 and 150, generally cause the wheel to wear too fast to be economical and "100" concentration, therefore, should normally be used. The relatively greater number of cutting particles provided by grit sizes 220 and finer frequently permit the use of "50" concentration wheels for this same class of grinding.

When to Use "75" Concentration

Wheels of "75" concentration are recommended, in grit sizes 220 to 600, for the same class of precision grinding operations as "100" concentration wheels; also "75" for cutter sharpening in such shapes as D11V9 (D11B), D12A2 (D12W) and D15V9 (D15B) used *dry*, in combination with type B6 resinoid bond. The advantages usually associated with "100" concentration in precision grinding are not as great in *dry* grinding and "75" concentration wheels are generally more economical to use.

When to Use "50" Concentration

Wheels of "50" concentration are recommended for both vitrified and metal bonded cup wheels when used for offhand grinding. In the case of vitrified bonded wheels, the "50" concentration should be combined with a hard grade such as P or R, to obtain lowest grinding cost.

Wheels of "50" concentration are recommended for resinoid bonded cup wheels in the finer grit sizes, 220, 240, 320, 400 and 500, when used for offhand or constant pressure grinding. The term "constant pressure" is meant to include pressure between the wheel and the work supplied either by hand or by springs. The popular type D6A2C (D6WHC) and D6A2H (D6WH) cup wheels are in this classification.

When to Use "25" Concentration

Diamond wheels of "25" concentration and metal bonded are used primarily in the cutting of soft stone. They are not considered economical for grinding cemented carbide.

Depth of Diamond

Depending upon the bond type and wheel size, straight wheels for peripheral grinding are made with either $\frac{1}{16}$", $\frac{1}{8}$" or $\frac{1}{4}$" depth of diamond, measured radially. Cup or recessed wheels for grinding on the side or rim are available with a layer of diamond either $\frac{1}{16}$" or $\frac{1}{8}$" deep in the case of resinoid or vitrified bonded wheels and also $\frac{1}{32}$" deep for metal bonded wheels.

From the standpoint of wheel cost per tool ground, wheels with a relatively large depth of diamond are more economical. Very small sizes of wheels such as types D1A8 (D1S) and DWS are made with the diamond particles throughout the entire wheel.