USEFUL GRINDING INFORMATION

UNIVERSAL GRINDING MACHINE CO.

FITCHBURG, MASS., U. S. A.

471

Introductory

In preparing this booklet the aim has been three-fold: to show how certain operative features distinctive on our Universal Grinding Machine are used to advantage; to aid those confronted with grinding problems about which they are often unable to obtain all the necessary information, that they may use the Grinding Machine profitably and efficiently; and to assist those not familiar with grinding wheels to a right understanding of them, with the hope that it will prove of service to our many friends.

Special effort has been made to treat each subject in a clear and comprehensive manner, carefully avoiding all unnecessary matter.

We do not show in this booklet our complete line of Grinding Machines, which includes Duplex Internal, Surface, Disc, and Cylindrical Grinding Machines.

If the booklet does not contain certain explicit information you want, or if you have grinding problems of any kind causing difficulty, never hesitate to write us. We have specialists who are always ready to assist you in devising ways and means of economical grinding, and their suggestions may prove of value.

It is a pleasure to acknowledge the many courtesies received from Grinding Wheel Manufacturers, and the valuable information furnished by them on grinding wheels, in preparing this booklet.

Universal Grinding Machine Co.

Fitchburg, Mass.

THE TABLE is well proportioned, and like the cross slide thoroughly seasoned between operations. It is provided with a swivel plate for grinding tapered work and has a scale graduated in inches per foot and degrees.

THE GRINDING WHEEL HEAD is of the most rigid construction and has only a vertical movement. The wheel spindle is made of tool steel, hardened and ground, and runs in large adjustable phosphor-bronze bearings, thoroughly protected from grit. The screw which feeds the wheel head vertically is graduated to 1-16" and is provided with a micrometer reading to one-thousandth of an inch.

THE HEADSTOCK has a dust-proof swivel base, accurately graduated. The spindle is made of steel hardened and ground and runs in adjustable phosphor-bronze bearings. The spindle revolves for chuck and face-plate work, and is arranged to be locked when grinding on dead centers.

THE FOOTSTOCK SPINDLE is provided with a variable tension spring, controlled by a handwheel and quick acting lever. The spindle may be clamped rigidly for supporting the center to the work.

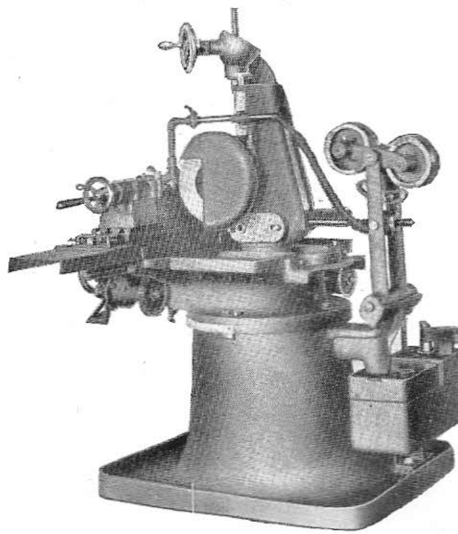
THE TABLE IS CONTROLLED by adjustable dogs, operating against the reversing lever, which actuates the clutch of the load and fire type, or by conveniently located hand reversing lever, which provides means for stopping the table at the end of its traverse automatically, by giving the lever a part of a turn at any time during the traverse of the table.

THE AUTOMATIC CROSS FEED FOR CYLINDRICAL GRINDING operates at each reversal of the work table, and can be set to reduce the diameter of the work from .00025" to .005". The feed is automatically thrown out when the work has been reduced to the required size.

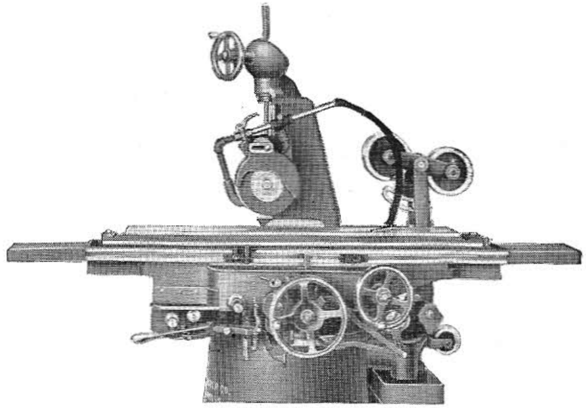
THE AUTOMATIC SURFACE CROSS FEED operates at either or both reversals of work table.

THE CROSS SCREW HANDWHEEL is provided with a stop for duplicating work.

WORK AND TRAVERSE SPEEDS are independent, and can be instantly changed while running.



Side and Rear View of Bath Universal Grinding Machine



The Bath Universal Grinding Machine Arranged for Surface Grinding

Surface Grinding

The cut at bottom of page shows our Surface Grinding Attachment, as furnished with the Bath Universal Grinding Machine, and is shown attached to machine in the above cut.

The attachment spindle is screwed onto the main wheel spindle through which it is driven. The arm which carries the outer bearing is clamped to the grinding wheel head, the alignment being insured by tongue and groove. The outer bearing is self-aligning, being carried by a swivel head.

Surface Grinding Attachment

Fig. 1 shows cross section of grinding wheel head on our No. 2 and 2½ Grinding Machine.

To adjust wheel spindle bearings: Remove dust screws AA and loosen tapered screws BB which

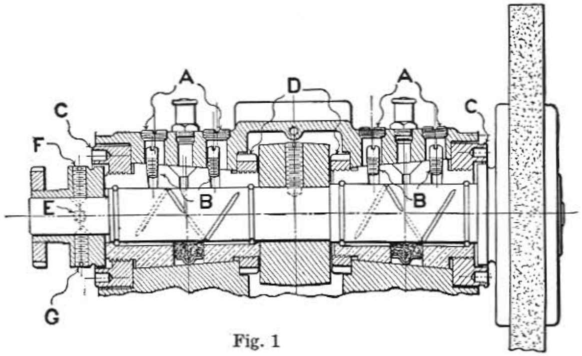


Fig. 1

take the place of liners, also loosen nuts CC. Then tighten nuts DD which draws tapered bearings in, when bearings are properly adjusted screws BB should be tightened, then nuts CC, and replace screws AA.

To take up end thrust of wheel spindle loosen screws E and F. Then tighten up screw G, also screw F, when the proper adjustment is made, clamp collet firmly in place by screw E.

Fig. 2 shows a section of cross screw adjustable nut on our No. 2 and 2½ Universal Grinding Machine.

To take up lost motion in nut, loosen lock nut A and draw nut B out until proper adjustment is made, when nut B should be locked in place by nut A.

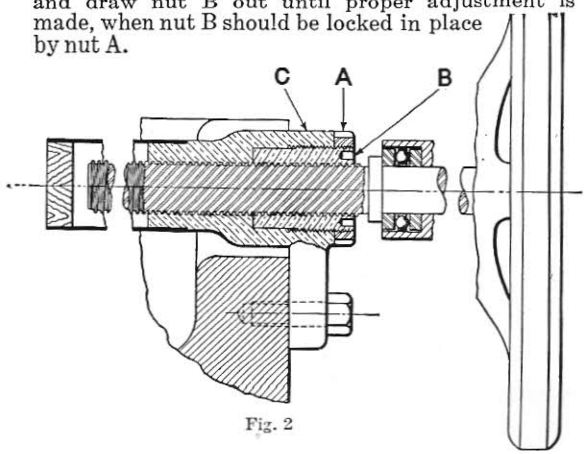
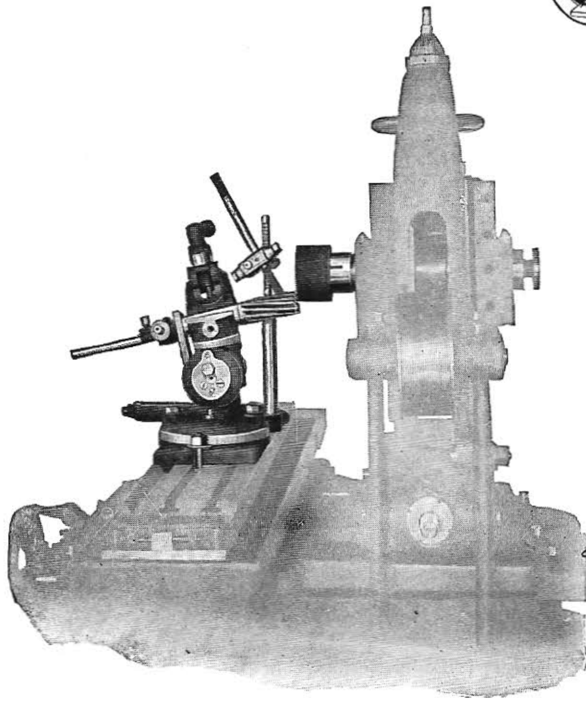


Fig. 2



Sharpening Large End Mill

Use cup grinding wheel.

Swing knee to 90 degrees, or right angles to wheel spindle.

Cutter is held by taper shank in Universal Work Holder. The Universal Holder is set so as to bring center of cutter in line with axis of wheel spindle, this being insured by dowel pins.

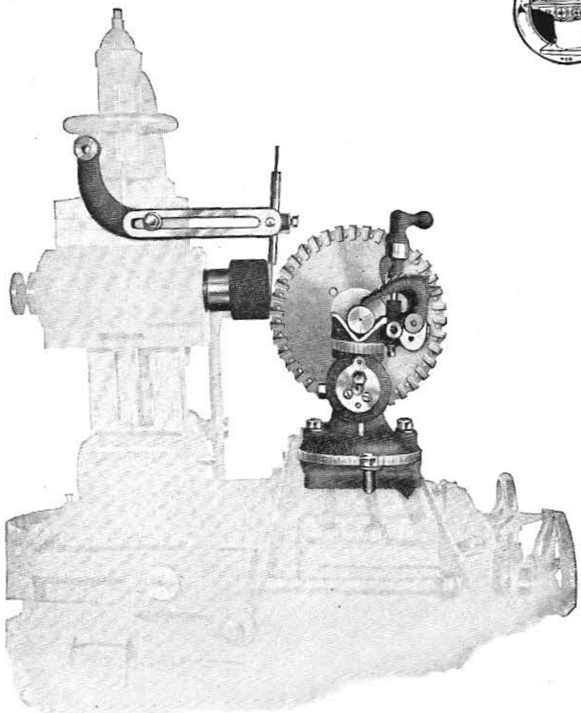
Set adjustable center and adjust jaw to mill shank so that mill revolves freely without shake.

The proper clearance is obtained by tilting V block the required number of degrees which is read direct from dial.

Clamp High Tooth Rest on swivel plate and adjust finger so as to bring cutting face of tooth on the same height as center of mill.

Hold cutter against tooth rest finger when grinding.

Use tooth rest finger for indexing also



Sharpening Periphery of Inserted Milling Cutter

Use cup grinding wheel.

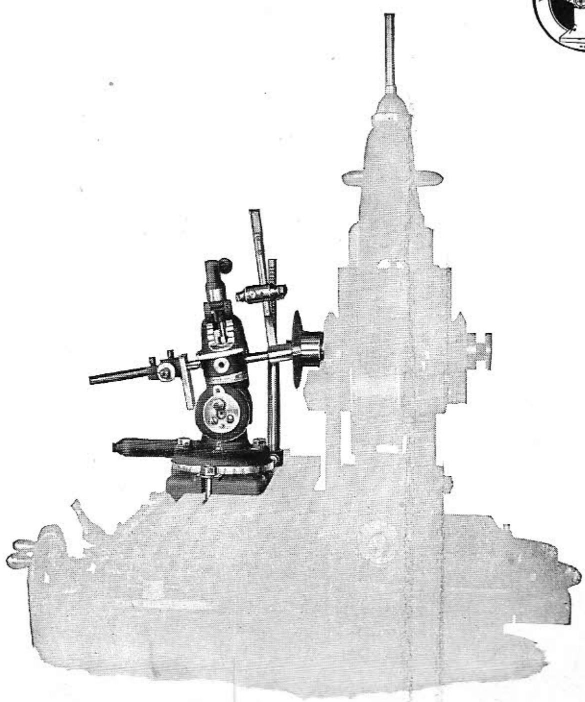
Swing knee around to 89 degrees, thus allowing clearance on the "upside" of grinding wheel.

Cutter is mounted on an arbor and held in Universal Work Holder. The horizontal Swivel and V block being doweled on zero insures the face of cutter being ground absolutely straight and at right angles to side of cutter.

The tooth rest is mounted on wheel head, finger being set over cutting point of wheel and on center of cutter.

The tooth clearance can then be obtained either by raising wheel head the desired amount, which can be read from elevating screw dial, or by tilting the V block the desired number of degrees which can be read direct from vertical dial. See table on page 34 for clearance.

When grinding, hold cutter against tooth rest finger, and be careful not to run cutter off of finger.



Sharpening a Counterbore

Use dish-shaped grinding wheel.

Swing knee around to 90 degrees.

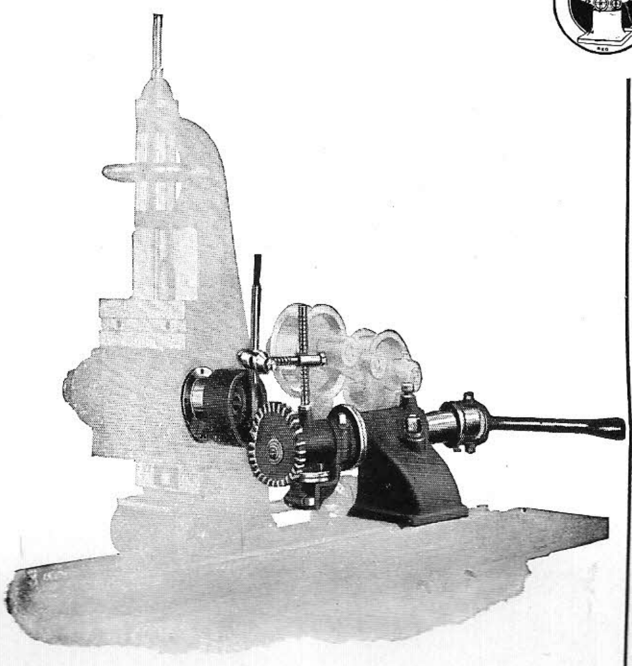
Counterbore is held by shank in Universal Work Holder. The Universal Holder is set so as to bring center of cutter in line with axis of wheel spindle, this being insured by dowel pins.

Set adjustable center and adjust jaw so counterbore revolves freely without shake.

The proper clearance is obtained by tilting V block the required number of degrees which is read direct from dial.

Clamp high tooth rest on swivel plate and adjust finger so as to bring cutting face of tooth the same height as center of cutter

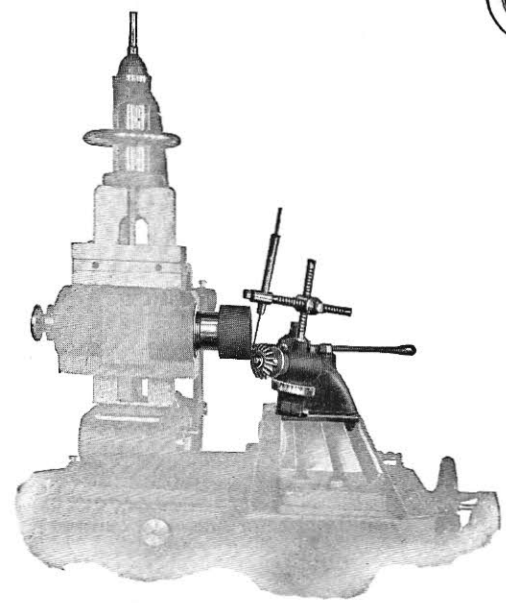
Hold cutter against tooth rest finger, when grinding.



Sharpening Periphery Teeth of a Side Milling Cutter

Use cup grinding wheel.

side teeth the cutter can be left in place and swivel head swung around 90 degrees. The swivel head is provided with a dowel pin, thus insuring the periphery and side of teeth being ground absolutely at right angles.



Sharpening an Angular Cutter

Use cup grinding wheel.

Swing knee to 89 degrees which allows clearance on the "upside" of wheel.

Mount cutter on arbor and hold in Cutter Bar attachment, which provides a very sensitive movement.

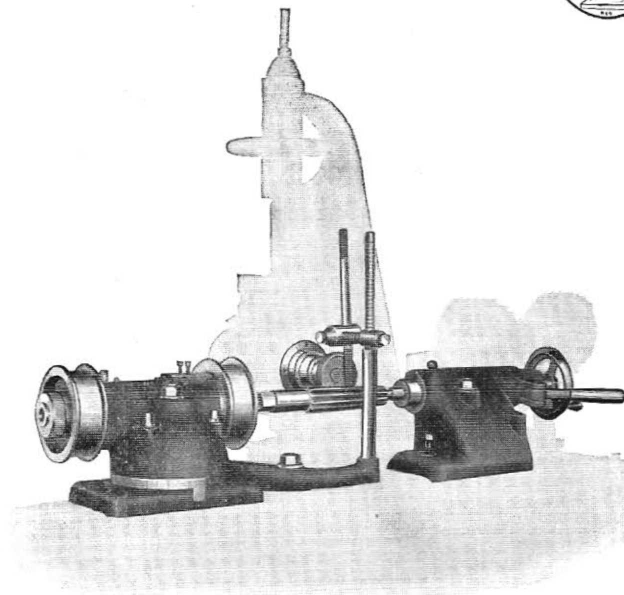
Swivel head to required angle for cutter.

The proper clearance on tooth is obtained by tilting swivel head the required number of degrees which is read direct from dial.

Adjust tooth rest finger to bring face of tooth being ground the same height as center of work.

Hold cutter against tooth rest finger, when grinding.

Use lever feed.



Sharpening a Taper Reamer

Use cup grinding wheel.

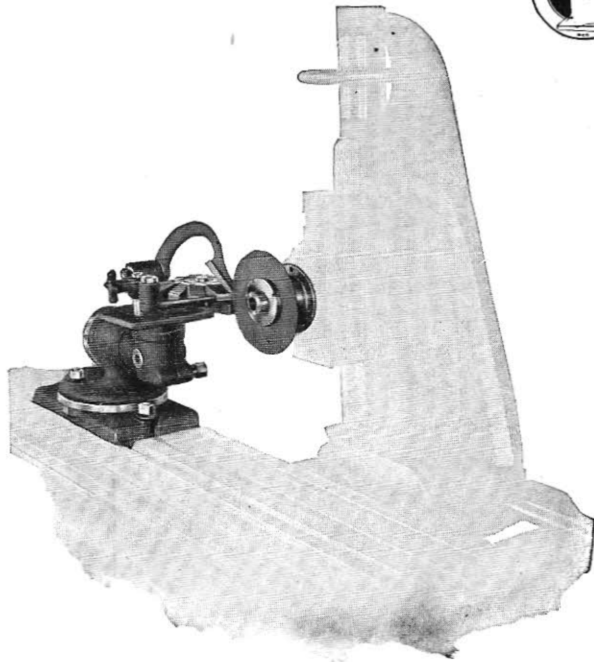
Swing knee around to 89 degrees, which allows clearance on "upside" of grinding wheel.

The reamer is held between head and footstock centers.

Swivel Plate is set to the proper angle. This cannot be accurately obtained by reading scale alone, but must be determined by repeatedly trying the reamer in a standard taper hole.

Clamp high tooth rest on swivel plate and adjust finger above the center of work the desired amount to give proper clearance on tooth. See table on page 34 for clearance.

When grinding, hold reamer against tooth rest finger, and use finger to index by.



Sharpening a Gear Cutter

(Using Special Gear Cutter Attachment)

Use dish-shaped grinding wheel.

The knee is swung around to 90 degrees.

The gear cutter attachment is held in Universal Work Holder.

The cutter is mounted on stud of attachment.

Set cutting face of grinding wheel against gauge, this insures the teeth being ground radially.

Set cutting face of cutter by the gauge equal to the amount of stock desired to be removed, then adjust tooth rest against heel of tooth and clamp in place.

Feed grinding wheel into cutter by traverse handwheel.

When grinding, hold cutter against tooth rest.

Corundum wheels have been very successful in all classes of grinding and especially tempered steel.

Emery is a natural abrasive, obtained from mines in India, Brazil and Massachusetts, and contains a large percentage of non-cutting elements composed of amorphous alumina, silica and iron oxide, which gives emery grains their dark color, crystalline alumina being the only element in emery hard enough to have any appreciable cutting action on metals. The grains are tough and have a rough surface which provides excellent hold for the bond, allowing wheels of great durability to be made. However, few grinding operations require such durability. Wheels made of emery are used mostly for the grinding of steel balls and on work where a very high finish is desired.

Aloxite is an artificial corundum manufactured by the Carborundum Company, and in its crude form is taken from electric furnace in the form of large compact ingot or pig weighing several tons. This pig consisting of crystalline alumina is crushed to grain form by means of special machinery, then refined, dried and graded, when the grains are then ready to be made into grinding wheels.

The characteristics of Aloxite are its purity, hardness, sharpness, toughness, absolute uniformity in quality, and it has in addition a temper which makes it ideal for grinding steel. It not only cuts fast, cool and clean, but it shows wonderful durability, and has been extensively successful in all classes of steel grinding.

Alundum is an artificial abrasive, manufactured by the Norton Company, and is made by fusing in the intense heat of the electric arc furnace, Beauxite, a soft clay-like susbtance. Beauxite is the purest form of aluminum oxide.

In chemical composition Alundum is similar to the ruby and sapphire, and the physical formation is such that when it is broken it leaves sharp cutting corners or edges.

Alundum characteristics are hardness, sharpness, and temper or character of fracture, which make it a highly efficient cutting material for the grinding of steel.

Carbolite is an artificial abrasive manufactured by the American Emery Wheel Works. It is extraordinarily hard and sharp, and while not tough, as compared with other abrasives, its very brittleness makes it most efficient for certain grinding operations.

Carbolite wheels are used for the grinding materials of low tensile strength, especially cast iron, brass, rubber and leather.

Carborundum is an artificial abrasive, manufactured by the Carborundum Company, and is distinct from anything found in nature. The principal with certain other materials, the Silicate of Soda is added and the whole mass thoroughly mixed together in special machines. This forms a pasty mixture, which is then rammed into moulds. Only experienced men are allowed to do this work, as the uniformity and balance of wheels depend largely upon the skill of the moulder. After the wheels are dried they are baked in special ovens at a moderate heat. Silicate wheels are light gray in color.

The advantages of Silicate wheels are: Wheels can be made in a week. As no excessive heat is used, the abrasive grains possess all their original strength. Wheels of any size can be made up to five feet in diameter and over. Wheels may be moulded on iron centers, which cannot be done with Vitrified wheels. For wet grinding the soda in the bond has a favorable action, as it causes the wheel to cut smoothly and with little heat.

The disadvantage of the Silicate wheel is: In the harder grades silicate wheels are generally not as free cutting as Vitrified wheels because they are denser.

Silicate wheels are especially adapted for wet grinding on hardened steel. For wet tool grinding and wet surface grinding (particularly when cup wheels are used), they are unequaled. They are also good for wet cutter grinding and some kinds of cylindrical and internal grinding.

Elastic Process: Elastic wheels are made from a mixture of abrasive grains and shellac. For making very thin wheels this mixture is rolled into moulds. Thicker wheels are either moulded under hydraulic pressure or rammed into moulds the same as silicate wheels. They are baked at a temperature to set the shellac. Elastic wheels are nearly black in color.

Advantages of Elastic Process: Wheels as thin as 1-32 may be made and used with safety. Their elastic quality makes them very smooth cutting, so that if properly graded for the work they give a fine finish, whether used wet or dry. They can be made quickly, and can be moulded on iron centers.

The disadvantages are: Elastic wheels will not stand much heat. They are less open and porous than Vitrified wheels, and they cost a little more than Vitrified or Silicate wheels.

Elastic wheels are used chiefly for fine grinding where no great amount of stock is to be removed, or where a very thin wheel is necessary. They are well adapted for dry cutter and reamer grinding, wet tool grinding, saw gumming and cutting of small stock.

From the foregoing it is evident that wheels of any abrasive material may be made by any one of the above described processes for binding the grains required, because the grains will break away more readily, thus presenting sharp points more often.

Use a wheel one grade softer for cast iron than for soft steel.

Coarse Wheels: Use a coarse wheel for reducing the stock rapidly, where finish is not important. The larger the grains the deeper the cut that may be taken and the less liable the wheel is to clog and glaze.

A coarse wheel properly dressed will produce a good finish.

Complaints are not uncommon that grinding wheels appear to be softer towards the center. Usually this is because the same surface rate of speed is not maintained as the wheel is reduced in diameter. This causes the wheel to wear away faster and appear softer. To obtain the best results the revolutions per minute of grinding wheel must be increased as the wheel wears down, so as to keep approximately the same surface speed of grinding wheel per minute.

For Surface Grinding a softer bonded wheel is required than for external Cylindrical grinding.

The larger the surface of contact between the wheel and the work the softer should be the wheel. Thus, a softer wheel is required for surface grinding than for cylindrical grinding. Conversely, a harder wheel should be used for work of very small diameter than for larger work, and a thin wheel should be harder than a thick one.

A loaded wheel is one whose face has particles of the metal being ground adhering to it, which is caused by the wheel running too slow or being too hard.

A glazed wheel is one whose cutting particles have become dull or worn down even with the bond, and is caused by the wheel running too fast or being too hard.

TRUING OF GRINDING WHEELS

Good results cannot be obtained with wheels which are even slightly out of true. In cylindrical grinding the work shows chatter marks and a wavy appearance, and in all cases of grinding the finish is poor if the wheel is out of true.

In truing and dressing the grinding wheel the diamond should be firmly clamped to the table, and the diamond traversed rapidly by the face of grinding wheel until it is true, this will leave the face of the wheel rough and in proper condition for rough grinding. For a smooth finish the final pass of the diamond across the face of the wheel should be very slow, and for extra fine finish the cutting face of the wheel may be slightly glazed by holding an oil stone against the face of wheel for a moment.

It is important that the diamond point presented to the wheel should be sharp, this is accomplished by

Work and Traverse Speeds

If the best results are to be obtained, careful attention must be given the selection of work and traverse speeds. Often when failure to produce good results is attributed to the grinding wheel, it may be remedied by changing the work and traverse speed of work; as, for instance, if the wheel speed is correct and work is running too fast the wheel will glaze and give the effect of a harder grade wheel. Then too the work and traverse speeds govern, to a certain extent, the kind of finish obtained.

No fixed set of rules can be laid down for the proper selection of work and traverse speeds. Different conditions, as kind of material, amount of stock to be removed, desired finish, grade, grain, material, and speed of wheel, etc., all vary the requirements; hence, we give no absolute instructions.

The Work Speed recommended for steel is 15 to 25 surface feet per minute for ordinary work, although on a very hard and tough steel better results will be obtained with slower speed for roughing. For finish grinding the speed should be increased. The work speed can be somewhat increased for cast iron; 25 to 35 surface feet per minute giving good results in the most of cases. Use a higher work speed for finishing than for roughing.

The Traverse Speed of the work for roughing steel should be about two-thirds the width of grinding wheel per revolution of work, and for cast iron should be slightly less. For finishing, a very narrow traverse per revolution is required.

Broadly speaking, for removing stock use a slow work speed and fast traverse; vice versa for finishing.

When finishing cast iron pass the work over the wheel as few times as possible, as the wheel will be less liable to glaze..

The depth of cut to be taken depends upon the wheel, material to be ground, and amount of stock to be removed. Where the part to be ground is rigid enough to stand a heavy cut, the cut should be of sufficient depth to allow the wheel to do its utmost.

Grinding to Shoulder: The best method of grinding work with a shoulder is to feed the wheel in to the work at shoulder to within .0005″ above size, then grind the balance of work. This will leave edge of wheel next to shoulder sharp.

Water upon most work is absolutely indispensable, and should be used wherever possible, except when grinding bronze, and some classes of Internal grinding. Water keeps the wheel clean and free cutting, and prevents the generation of heat, which causes the work to get out of true.

Dont's

Don't try to grind all materials with the same wheel. It is economy to get the right grain and grade for the work.

Don't mount wheels without soft washers between the wheel and the flanges.

Don't force wheels onto the collet. It is liable to cause breakage. Enlarge the hole so the wheel will slip on easily.

Don't use a wheel which is not sound. This can be ascertained by tapping lightly and listen for a clean ring.

Don't start work on a new wheel until you are sure it runs true and is in balance.

Don't attempt to true wheel without first seeing that diamond is held rigid.

Don't start to grind until you know the speed is right.

Don't crowd a wheel on the work. It will not cut any faster, but will simply heat the work and wear out sooner.

Don't destroy the tags on the wheels, keep them for reference and re-ordering.

Don't try to grind with a wheel that is loaded or glazed, pass the diamond over wheel a few times.

Don't use a belt of uneven thickness to drive the wheel.

Don't hesitate to ask us any questions pertaining to grinding machines and wheels. There will be no charge.

Don't forget to change speed of wheel Spindle as wheel wears down.

Don't run a grinding wheel at a greater number of revolutions per minute than the manufacturer recommends.

Don't move head and footstock before thoroughly cleaning swivel table.

Don't allow dust or grit to enter oil holes.

Don't forget that soda water keeps the work and the machine from rusting.

Don't put work in machine until centers and center holes in work have been carefully clamped.

Don't forget that we invite correspondence relating to grinding propositions and difficulties.

TABLE OF GRINDING WHEEL SPEEDS

Diameter Wheel	Rev. Per Minute for Surface Speed of 4,000 Feet	Rev. Per Minute for Surface Speed of 5,000 Feet	Rev. Per Minute for Surface Speed of 5,500 Feet	Rev. Per Minute for Surface Speed of 6,000 Feet
1 inch	15,279	19,099	21,000	22,918
2 "	7,639	9,549	10,500	11,459
3 "	5,093	6,366	7,350	7,639
4 "	3,820	4,775	5,250	5,730
5 "	3,056	3,820	4,200	4,584
6 "	2,546	3,183	3,500	3,820
7 "	2,183	2,728	3,000	3,274
8 "	1,910	2,387	2,600	2,865
10 "	1,528	1,910	2,100	2,292
12 "	1,273	1,592	1,750	1,910
14 "	1,091	1,364	1,500	1,637
16 "	955	1,194	1,300	1,432
18 "	849	1,061	1,150	1,273
20 "	764	955	1,050	1,146
22 "	694	868	950	1,042
24 "	637	796	875	955
26 "	586	733	800	879
28 "	546	683	750	819
30 "	509	637	700	764

TABLE OF WHEEL GRADES

ABRASIVE Wheel Co.

Degree of Hardness	PROCESS: Vitrified and Silicate	PROCESS: Elastic
Very Soft	H	1
	I	1½
	J	2
Soft	K	2½
	L	3
Medium	M	3½
	N	4
Medium Hard	O	5
	P	6
Hard	Q	7
	R	
	S	
Very Hard	T	
	U	
	V	
	W	
	X	
	Y	
Extremely Hard	Z	

AMERICAN E. Wheel Co.

Degree of Hardness	PROCESS: Vitrified	PROCESS: Silicate	PROCESS: Elastic
Very Soft	G	½	½ E
	H	¾	¾ E
	I	1	1 E
Soft	J	1½	1½ E
	K	2	2 E
	L	2½	2½ E
Medium	M	3	3 E
	N	3½	3½ E
	O	4	4 E
Medium Hard	P	4½	4½ E
	Q	5	5 E
	R	5½	5½ E
Very Hard	S	6	6 E
	T	7	7 E
	U		
	W		
Extremely Hard	Y		
	Z		

CARBORUNDUM Co.

Degree of Hardness	PROCESS: Vitrified and Silicate	PROCESS: Elastic
Very Very Soft	Z	
	Y	13
	X	12
Very Soft	W	11
	V	10
	U	9
Soft	T	8
	S	7
	R	6
Medium Soft	P	
	O	5
	N	
Medium	M	4
	L	
	K	3
	J	
Medium Hard	I	2
	Ix	
	H	1
	Hx	
Hard	G	½
	Gx	
	F	
	E	
Very Hard	D	

TABLE OF WHEEL GRADES

SAFTY Emery Wheel Co.

Degree of Hardness	PROCESS Vitrified	PROCESS Silicate
Extra Soft	C	6
	C½	5½
Very Soft	H	5
	H½	
Soft	A	4½
	A¼	
	A½	
	A¾	
Medium Soft	M	4
	M¼	
	M½	
	M¾	
Medium	P	3½
	P¼	
	P½	
	P¾	
Medium Hard	I	3
	I¼	
	I½	
	I¾	
Hard	O	2½
	O¼	
	O½	2
	O¾	
Very Hard	N	1½

STERLING Emery Wheel Co.

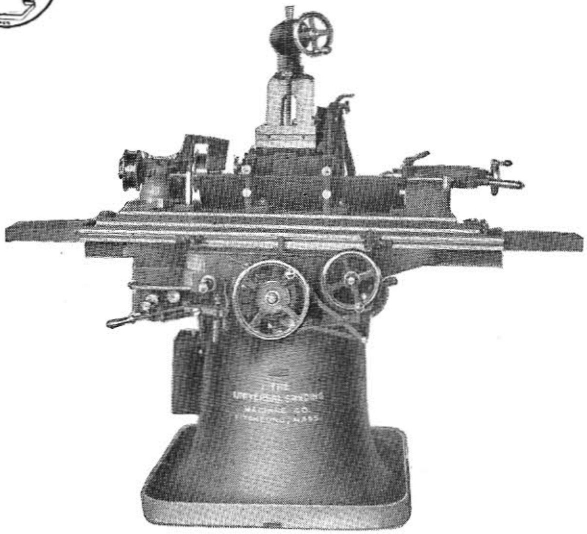
Degree of Hardness	PROCESS Vitrified and Silicate	PROCESS Elastic
Very Soft	1¼	1
	1½	2
	1¾	
Soft	2	3
	2¼	
Medium Soft	2½	3½
Medium	3	4
	3¼	
Medium Hard		4½
	3½	
	3¾	5
Hard		
	4	6
	5	
Very Hard		
	6	

VITRIFIED Wheel Co.

Degree of Hardness	PROCESS Vitrified and Silicate	PROCESS Elastic
Soft	C	½ E
	C^1	1 E
	C^2	1½ E
	C^3	2 E
Medium Soft	D	2½ E
	D^1	3 E
	D^2	3½ E
	D^3	4 E
Medium	E	4½ E
	E^1	5 E
	E^2	5½ E
	E^3	6 E
Hard	F	6½ E
	F^1	7 E
	F^2	
	F^3	
Extremely Hard	G	

TABLE FOR SELECTION OF GRADES AND GRAINS

Kind of Material To Be Ground.	ABRASIVE MATERIAL CO.		MONARCH GRINDING CO.		NORTON CO. ALUNDUM		NORTON CO. CRYSTOLOIN	
	Grain	Grade	Grain	Grade	Grain	Grade	Grain	Grade
ALUMINUM *Cylindrical Grinding*	24–36	4E–5E	7/9	D	⊕ 3830	1½–2	3036	1½–2
ALUMINUM *Internal Grinding*	30–46	2½E–3½E	9/11	D–O	⊕ 3836	1½	30	1½
ALUMINUM *Surface Grinding*	24–46	2E–3E	8–9/11	R	⊕ 3830	1½	30	1½
BRONZE ~ BRASS *Cylindrical Grinding*	46–100	K–M	7/9–8	U–D	⊕ 3830	1½–2	3036	1½–2
BRONZE ~ BRASS *Internal Grinding*	46–100	J–L	9/11	U	⊕ 3836	1½	30	1½
BRONZE ~ BRASS *Surface Grinding*	46–100	J–L	8–6/8	R	⊕ 3830	1½	30	1½
CAST IRON, *Small. Cylindrical Grinding*	30–60	K–M	9/11–12	2½	* 3846	J	36	K
CAST IRON PULLY. *Cylindrical Grinding*	24 36	L–N	8	3½	* 3836	K	36	K
CAST IRON CHILLED ROLLS. *Roughing.*			9/11–12	N–E	* 3846	J	36	J
CAST IRON CHILLED ROLLS. *Finishing*					* 3860	J	60	J
CAST IRON *Surface Grinding*	36–60	K–M	8	2	* 3836	J	36	J
CAST IRON *Internal Grinding*	36 60	J–K	9/11–10	2¼–2½	* 3846	J	36	J
CAST IRON *Disc Grinding*					* 3836	J	36	J
CUTTERS, *Gear and Formed. Saucer Wheel*	46–70	J–M	9/11	R	* 3860	J		
CUTTERS, *T-Slot and Milling. Cup Wheel*	46–60	L–N	8/11	D	* 3850	K		
KNIVES-HARD *Cup Wheel*	46–60	K–M	9/8	2–1¾	* 46	J–K		
MILLS, *Face, End and Side. Cup Wheel*	60	L–N	9	R	* 3850	J–K		
REAMERS *Cup Wheel*	46–60	L–N	11/12	2¾				
RUBBER *Cylindrical Grinding*	36–46	K–L			* 3846	J	46	J
STEEL CASTING *Cylindrical Grinding*	36–60	L–M	7/9	3¼	* 50	K		
STEEL CASTING *Surface Grinding*	36–60	K–L	8–9	2 1¾	* 3846	J		
STEEL-HARD *Cylindrical Grinding*	36–60	K–L	9–9/11	2½–2¼	* 3850	J		
STEEL-HARD, *Small. Internal Grinding*	46–60	J–L	9–11	2¾–2½	* 3846	J		
STEEL-HARD, *Large. Internall Grinding*	36–60	J–L	9/11–9	2½–3	* 3846	J		
STEEL-HARD *Surface Grinding*	36–46	K–L	8–8/9	1¾	* 3846	H		
STEEL-HARD *Disc Grinding*	36–60	K–M	7/11	C	* 3846	J		
STEEL-SOFT *Cylindrical Grinding*	46–60	M–N	9/11–11	2½–2¼	* 50	L		
STEEL-SOFT, *Small. Internal Grinding*	46–60	K–M	9–11	2½	* 3846	K		
STEEL-SOFT, *Large. Internal Grinding*	46–60	K–M	9/11–9/12	2½–2¾	* 3846	K		
STEEL-SOFT *Surface Grinding*	36–60	L–M	8–9	2–2¼	* 3836	J		
STEEL-SOFT *Disc Grinding*	46–60	L–M	9/11–11	U	* 3846	J		
SAWS *Metal Sliting*	46–60	M	9–9/11	3½–3¼	* 3846	J		
TAPS-HOBS *Saucer Wheel*	46–60	L–N	2–9/11	U–O	* 3850	K		
TWIST DRILLS *Cylindrical Grinding*	46–60	L–M	9–11	2½	* 46	K		



Front View of Bath Universal Grinding Machine

A Brief Description of

Bath Universal Grinding Machine

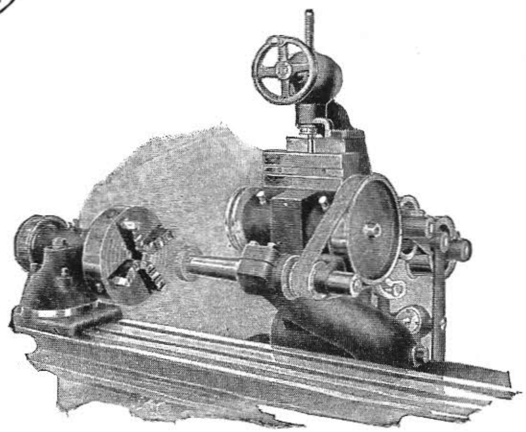
THE BATH UNIVERSAL GRINDING MACHINE has been designed for the purpose of combining in a single machine efficient means for the grinding of Cylindrical, Internal, Surface, Disc, Cutter and Reamer work of all descriptions.

In this machine is incorporated all the essential features necessary for performing the various grinding operations with as much rapidity and accuracy as could be accomplished on a single purpose machine. It is so designed that the changing of machine from one operation to another is reduced to a minimum.

THE BASE of the machine is a single massive casting, on top of which is permanently bolted a vertical column of liberal dimensions; internally ribbed, and having a circular flange base as large as the top of machine base. To this Vertical Column is gibbed the grinding wheel head, thus supporting the grinding wheel head by a heavy wall of metal direct to the floor, and having only one movable joint between the wheel head and base of machine.

THE CROSS SLIDE KNEE, which carries the cross and longitudinal slides, has a very large circular base that fits over the circular base of the vertical column which provides a bearing of liberal dimensions for the knee to swivel on, the knee being swung around the column to bring the work table in proper relation to the wheel for the various operations this machine is adapted for. The knee is graduated in degrees and can be readily clamped at any angle from 0 to 90 degrees.

THE CROSS SLIDE which provides means for feeding the work into grinding wheel, and carries work table and operating mechanism, is substantially ribbed internally and of liberal dimensions throughout. It is thoroughly seasoned between machining operations to insure alignment.



The Bath Universal Grinding Machine Arranged for Internal Grinding

Internal Grinding

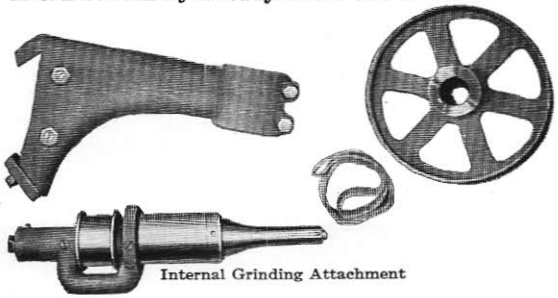
The cut at bottom of page shows our Internal Grinding Attachment, in detail, as furnished with our Universal Grinding Machine, and is shown attached to machine in above cut.

The design of this attachment secures the utmost rigidity in operation. The arm is a parabola form of massive proportion, is bolted firmly to the side of the column near its base, and is self-aligning.

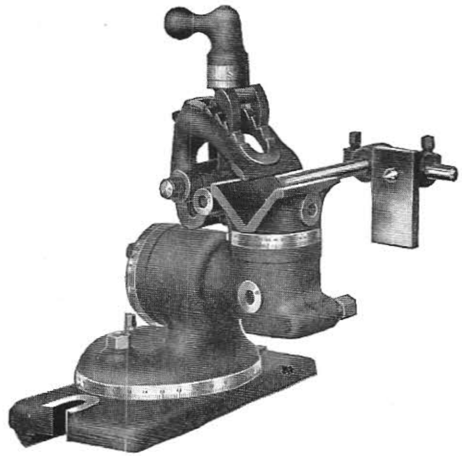
The internal spindle is driven from a pulley which is clamped on the nose of the main wheel spindle.

The internal wheel spindle is made of tool steel, hardened and ground, and runs in adjustable phosphor-bronze bearings, thoroughly protected from water and grit.

This attachment is readily attached to machine, as can be seen by a study of the two views.



Internal Grinding Attachment



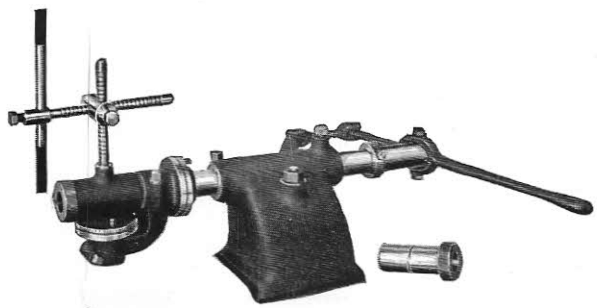
Universal Work Holder

The Universal Work Holder adds greatly to the variety of work possible to be ground on our Universal Grinding Machine. It is of special value for holding inserted tooth mills, counterbores, large end mills, reamers, etc., with straight or taper shank.

By using Flange Plate, which is furnished with this attachment, gear cutters, flat form cutters, saws, etc., can be readily held.

The Flat Vise also can be clamped to this Flange Plate, which provides means for holding a .arge variety of work to be surface ground.

The Cutter Bar Attachment is especially adapted for holding small end mills, angular and straight cutters, etc., when a very sensitive movement is necessary.



Cutter Bar Attachment

CUTTER GRINDING

On the following pages we show how certain operative features, distinctive on the Bath Universal Grinding Machines, are used to advantage in sharpening cutters, reamers, etc.

We do not attempt to cover the entire range and capacity of the machine.

The illustrations shown will suggest a method of handling the great variety of other work that can be done on this machine.

The method of setting up, as shown by these illustrations, is not arbitrary, in most cases several other ways of grinding the same piece can be used.

For surface grinding small irregular pieces of work, clamp in flat vise and hold vise in Universal Work Holder, the V block being removed and flange plate inserted to receive flat vise.

Below we give a few general suggestions for grinding cutters, reamers, etc., in addition to the explanatory matter at the foot of illustrations on the following pages.

HINTS ON GRINDING CUTTERS AND REAMERS

Should the grinding wheel strike the tooth next to the one being ground, the wheel head should be raised until this tooth clears the bottom of grinding wheel.

When grinding clearance on the teeth of cutters, reamers, etc., always use a cup-shaped grinding wheel, as this gives a straight face to the land which supports the cutting edge of the tooth. If a disc wheel is used, the land will be concaved.

It is best to revolve the grinding wheel against the Cutting edge of tooth, as it prevents a burr being formed at the cutting point, and there is less danger of drawing the temper, thus enabling the grinding to be done faster.

Care must be taken to hold, by hand, the work against tooth rest, with sufficient pressure to prevent its being lifted by the grinding wheel.

Clearance on the "down" or "upside" of grinding wheel is obtained by setting the knee one degree off zero.

When the tooth rest is stationary and work is traversed, care should be taken not to run cutter off of tooth rest.

When grinding taper reamers, etc., always clamp tooth rest to swivel plate, as this gives the same clearance to the tooth throughout the length of the reamer.

In setting for tooth clearance on milling cutters, etc., instead of setting tooth rest above center, it will be found much quicker to tilt the V block on Universal Work Holder, and work carrier on Cutter Bar Attachment, the desired number of degrees.

The table on page 34 gives the amount to set tooth rest above center of work to obtain proper angle of clearance on milling cutters and reamers.

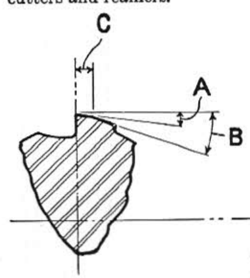


Fig. 1

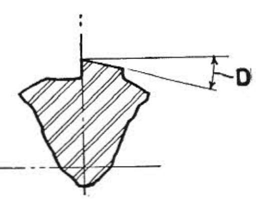
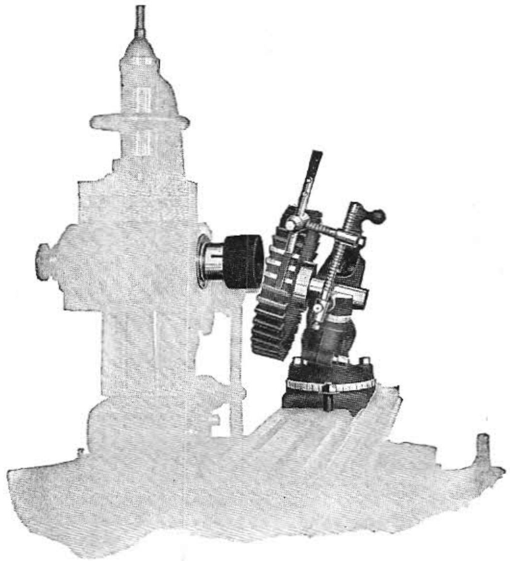


Fig. 2

Figs. 1 and 2 illustrate two methods of grinding reamers. Fig. 1 shows a very narrow land back of the cutting edge; C equals about .025″ for cast iron and .006″ for steel. B equals about 16 degrees for cast iron and 9 to 14 degrees for steel.

Fig. 2 shows the method generally used, the angle of clearance being from 3 to 9 degrees. Different manufacturers recommend various angles for cast iron, bronze and steel.



Sharpening Side Teeth of Inserted Tooth Milling Cutter

Use cup grinding wheel.

Swing knee to 89 degrees which allows clearance of "upside" of wheel.

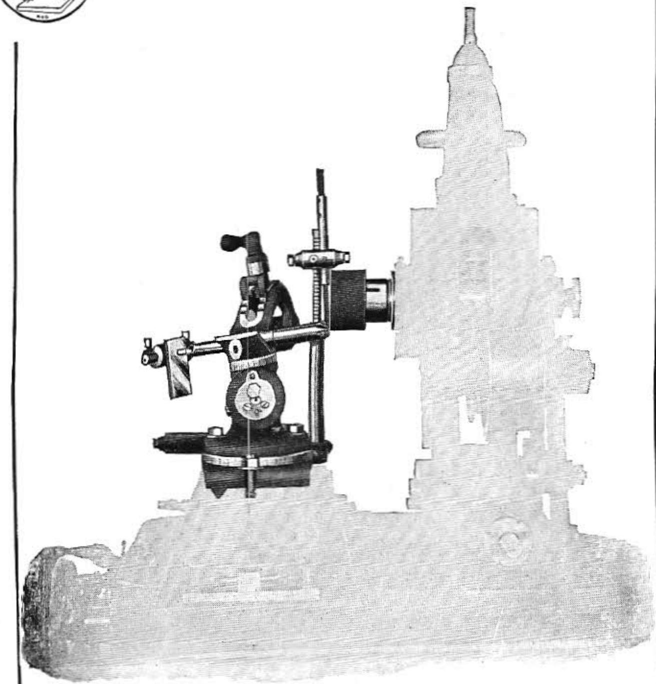
Cutter is mounted on arbor and held in Universal Work Holder.

The Swivel Base is doweled on zero to insure the side being ground absolutely at right angles to periphery of cutter.

Tooth Rest is adjusted so as to bring cutting face of tooth on same height as center of cutter.

The tooth clearance is obtained by tilting the V block the required number of degrees to give proper clearance, the degrees can be read direct from vertical dial.

When grinding, hold cutter against tooth rest finger, and use finger to index by.



Sharpening End of Chucking or Rose Reamer

Use cup grinding wheel.

Swing knee around to 89 degrees which allows clearance on "upside" of wheel.

Reamer is held by taper shank in Universal Work Holder.

Set adjustable center and adjust jaw to shank so that reamer revolves freely without shake.

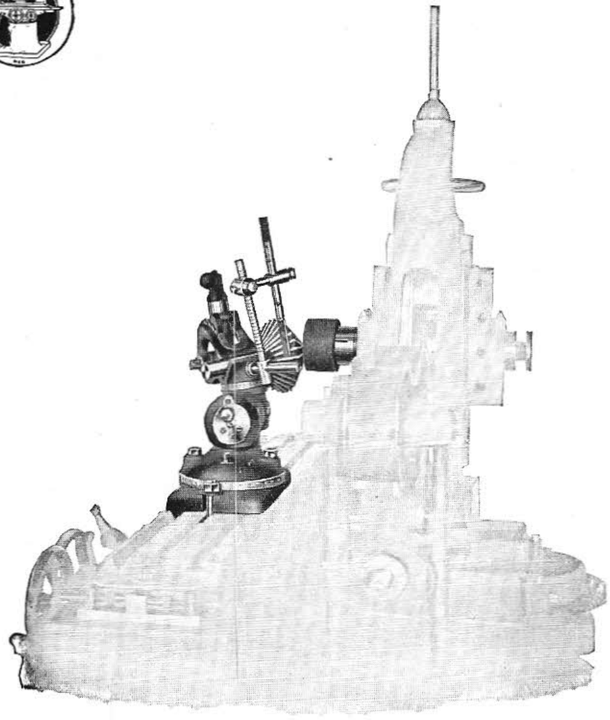
Set Universal Work Holder swivel base to give proper angle.

Clamp high tooth rest stand on swivel plate and set finger on center of work.

The proper tooth clearance is obtained by tilting the V block the required number of degrees.

When grinding, hold reamer against tooth rest finger.

Use tooth rest finger for indexing.



Sharpening a Special V Cutter

Use cup grinding wheel.

Swing knee around to 89 degrees which allows clearance on "upside" of grinding wheel.

Mount cutter on arbor and hold in Universal Work Holder.

Set Universal Work Holder to proper angle which can be read from Swivel Base.

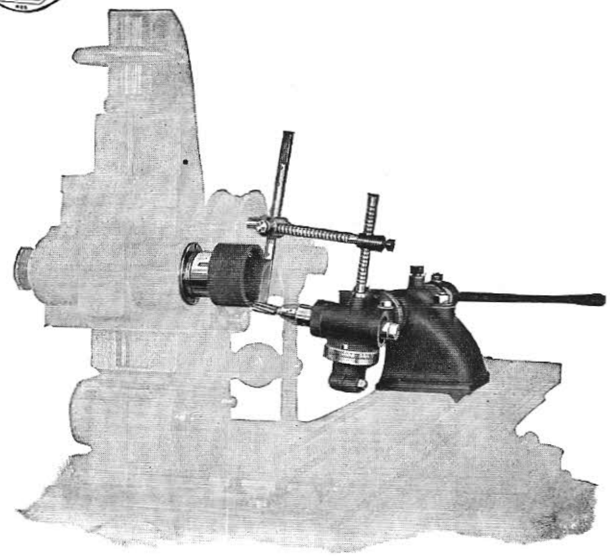
Set tooth rest finger on center of work, and tilt V block the required number of degrees to give proper clearance.

When one side of cutter is sharpened swivel Universal Work Holder around to opposite angle.

Set tooth rest on other side of cutter.

When grinding, hold cutter against tooth rest finger, and use finger to index.

The cutter may be also held between head and footstock centers for sharpening. In that case the knee is set to give the desired angle and tooth rest finger set above center to give the proper tooth clearance. See table on page 34 for clearance.



Sharpening Small End Mill

Use cup grinding wheel.

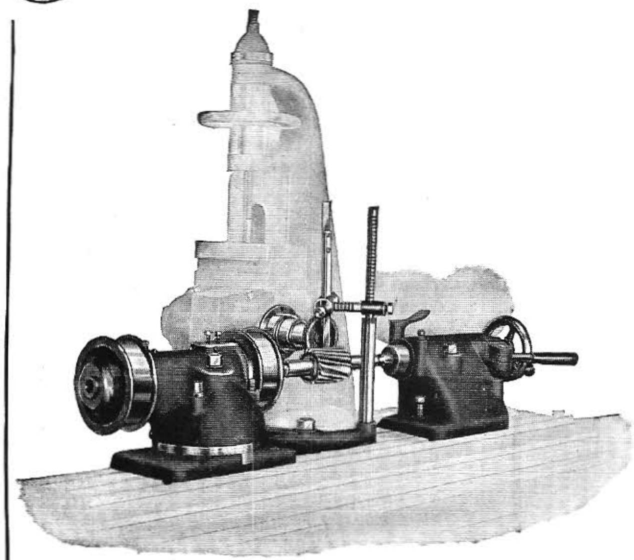
Swing knee at right angles to wheel spindle.

Cutter is held in Cutter Bar attachment, which provides a very sensitive movement.

The Cutter Bar swivel head carrier is set so as to bring center of cutter in line with axis of wheel spindle, this being insured by dowel pin, also tilt swivel head to required number degrees to give proper clearance on tooth, the degrees being read direct from vertical dial.

Adjust tooth rest finger so to bring cutting face of tooth the same height as center of cutter.

Use the lever feed, and hold cutter by hand against tooth rest finger. To index, revolve bushing.



Sharpening a Spiral Milling Cutter

Use cup grinding wheel.

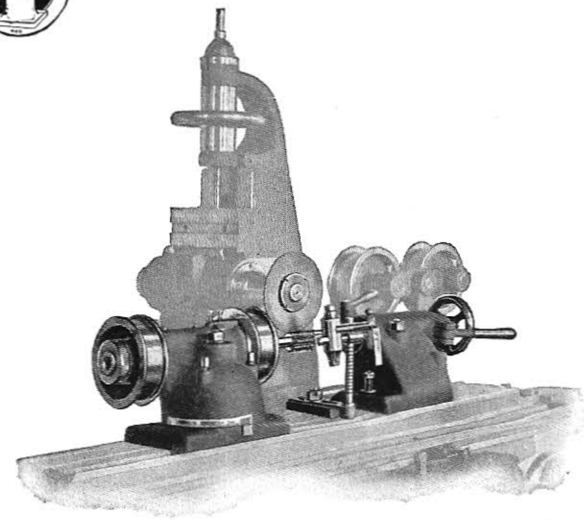
Swing knee around to 89 degrees, thus allowing clearance on the "upside" of grinding wheel.

Cutter is held on an arbor between head and footstock centers. It is preferable to have the cutter revolve and slide on arbor as this method insures the cutter being ground absolutely straight and true with the hole.

Use high tooth rest stand and set center of tooth rest finger above center of work to give the desired clearance. See table on page 34 for clearance.

When grinding, hold cutter against tooth rest finger, and slide on arbor, being careful not to let cutter run off tooth rest finger.

If cutter is pressed on arbor, the tooth rest stand must be clamped on grinding wheel head.



Sharpening a Hob

Use a dish-shaped grinding wheel.

Swing table around to 90 degrees or table at right angles to wheel spindle.

Hob is held on arbor between head and footstock centers.

The table is adjusted towards wheel head until face of grinding wheel is in line with work center, as face of tooth must be kept radial.

The Low tooth rest is clamped on swivel plate and tooth rest finger adjusted so as to bring face of tooth by the face of wheel, a distance equal to amount of stock desired to be removed.

The Table should be traversed by power and the grinding wheel fed into work by the wheel head elevating handwheel.

When grinding, hold bob against tooth rest finger.

Use tooth rest finger for indexing.

Note—The set-up is the same for Large Formed Milling Cutters.

Grinding Wheels

The operation of grinding as we know it today, is nothing more or less than a cutting process. The cutting tools are the sharp particles of abrasive extending from the face of the grinding wheel. When these small sharp tools are brought in contact, at high speed, with iron, steel, etc., each sharp abrasive grain cuts its own minute chip from the work. These chips resemble those removed by a lathe tool. As these abrasive grains wear or become dulled, they should loosen from the bond which binds them, allowing the sharp points that are below to be brought into action, in order that the grinding wheel may do efficient work. If the points are retained after they become dulled, they prevent other sharp points from coming in contact with work, and the cutting action of the grains changes to a rubbing action, causing undue generation of heat that distorts the work, and prevents accurate work being obtained. While on the other hand, if the abrasive grains break away before they become dulled, the wheel is unnecessarily wasted.

From the foregoing it will be seen that the successful operation of any grinding machine depends in a large measure upon the proper selection and use of grinding wheels. Frequently a change of grinding wheel or method of using it will result in greatly increasing the quantity and quality of the output. It is, therefore, important that all operators of grinding machines be informed on this subject.

The inexperienced operators of grinding machines have come to regard the selection of wheels as a mysterious process dependent upon long experience and good judgment. To a certain extent this is true, but in the main, the general principles involved are not difficult to grasp, and the time required is not excessive.

A grinding wheel is made up of two distinct kinds of material, namely: the "abrasive" or cutting material, and the "bond," which holds together the abrasive grains.

Abrasive materials are of two kinds, natural and artificial. The natural abrasives are Emery and Corundum. The artificial abrasives are known as Adamite, Aloxite, Alundum, Carbolite, Carbo-Alumina, Carborundum, Carbondite and Crystolon.

Corundum is a natural abrasive, found in Canada, India, Brazil and Georgia. The best corundum comes from the Canadian mines and contains 95% of crystalline alumina. Corundum grains are light in color, extremely hard, have a perfect fracture, the grains breaking, when dull, along planes, leaving new sharp cutting points.

The characteristics of corundum are durability, combined with fast and cool cutting, the grains being just brittle enough to break as soon as they become slightly dulled by use.

materials entering into the manufacture of carborundum are crushed coke mixed with sand. This raw material is placed in an electric furnace for thirty-six hours and raised to a heat between 7000 and 7500 degrees Fahrenheit. At this tremendous heat the elements of carbon and silicon form crystal masses. After these crystal masses cool, they are crushed, washed, dried and graded.

The characteristics of carborundum are hardness, sharpness, infusibility, insolubility, and just brittle enough to break slightly in use. The sharp edges of the crystals cut clean and fast, while its brittleness, by constantly presenting fresh cutting edges, prevents glazing. It has proven highly successful in grinding of cast iron.

Crystolon is an artificial abrasive manufactured by the Norton Company; is made from coke, sand, sawdust and salt, and heated in an electric furnace to between 1820 and 2250 degrees Centigrade, when the elements of carbon and silicon form a crystal mass.

The characteristic property of brittleness makes it highly efficient for grinding such metals as cast iron, chilled iron, brass and bronze.

The binding together of abrasive grains is now done by three common processes, namely: Vitrified, Silicate, and Elastic.

Vitrified Process—This, the most widely used process for making grinding wheels, consists in mixing abrasive grains with suitable clays and fluxes. The mixture is then moulded into wheels of the required sizes, which, when dry enough are shaped and then subjected to a high temperature in large ovens or kilns. This melts the clays, which, upon cooling, crystallize about the grains of abrasive and so bind them together. Vitrified wheels are reddish or reddish brown in color, and have a clear ring when they are tapped.

The advantages of the Vitrified wheel are: The bond itself is so hard that it acts as an abrasive. It is very porous, which makes it free cutting. They are perfectly uniform in quality and are not affected by water, acids, heat or cold.

The disadvantages of the Vitrified wheel are: It takes a month to make a wheel. The intense heat used in burning slightly weakens the abrasive grains. Thin wheels made in this way are not practical, as they will break under side pressure. Very large wheels are rarely made by this process on account of the danger of cracking in the kiln.

Vitrified wheels are generally the most efficient for rough snagging, general shop use, for dry tool grinding, for many kinds of cutter grinding, for cylindrical grinding, and for surface grinding when a disc wheel is used.

Silicate Process—The principal ingredient in the bond of silicate wheels is Silicate of Soda, or water glass. After the abrasive grains have been mixed together. Thus, we may have a Vitrified corundum wheel, a Silicate corundum wheel, or an Elastic corundum wheel.

Grade: The bond of a wheel, in addition to holding together the abrasive grains, also determines the grade or degree of hardness of the cutting wheel. A soft wheel is one where the cutting particles break away very rapidly under grinding pressure. A hard wheel will retain its cutting particles longer.

Different kinds of work have more or less tendency to wear away the wheel. Accordingly, wheels of different grades must be used for different operations. If the wheel is so soft that the grains are torn away before the points have become dulled, then the wheel is wasted. If the wheel is too hard the grains will remain in place too long, i. e., after their poirts are dulled, and the wheel will glaze over and cut slowly. The ideal wheel on any work is one that furnishes a new cutting face as fast as the particles in use become dull; in other words, the proper wheel will not glaze, but will remain sharp.

The degree of hardness or softness of bond is designated by letters of the alphabet and numerals. Each letter indicates a grade one degree harder than the preceding letter.

On pages 35, 36 and 37 are given tables of grades used by different manufacturers.

Grain and grade of grinding wheels should not be confused. By the grain of a wheel is meant the fineness of the grains of abrasive used in making it. If the grains will just pass through a sieve having sixty meshes to the inch, they are called number 60, and the grain of the wheel is said to be number 60. Numbers run from 10, which is very coarse, to 200 and flour.

Combination wheels: Grains of different numbers are often mixed in one wheel. Such wheels are called combination wheels. A combination wheel will hold its shape better and give a finer finish than would a wheel made entirely of coarser grains and will cut faster than one made altogether of the finer grains. These wheels are used quite extensively for the finishing of soft steel.

Hard wheels: Unsatisfactory work in the various grinding operations is very commonly the result of using wheels which are too hard. Such wheels are slow in action, and generally produce a poor finish. They are likely to burn the work or distort it and it is difficult to obtain accurate work with them. Chatter marks, scratches and flat spots are commonly due to this cause. Wheels which are too hard for the work require frequent dressing and are uneconomical to use in every way.

Soft Wheels: A wheel is most efficient when just soft enough not to wear away too rapidly. The harder the material to be ground, the softer the wheel revolving the diamond stud in its holders from time to time.

The number of times the face of a wheel has to be dressed depends entirely on the kind of wheel and work. Some wheels wear away fast enough that little dressing is necessary, on others, especially hard wheels, and on large work when considerable stock has to be removed it may be necessary, to true the wheel each time a piece receives its finish.

A new wheel that runs out considerably should be trued up at a slow speed and then increased to proper speed when it should be trued up again, as it may not run true at a high velocity, even if it does at a slower one.

SPEED OF WHEEL

Before starting to grind the operator should make sure his wheel is running at the proper speed. It is dangerous to run wheels too fast.

For Cylindrical and Internal grinding, the wheel should revolve at a surface speed of 5000 to 6000 feet per minute, and for surface grinding about 4000 to 5000 feet per minute. As wheels wear down the surface speed grows less, and the number of revolutions per minute of wheel spindle should be increased, so as to maintain the proper peripheral speed.

Increasing the speed of the wheel makes it act like one of a harder grade. Decreasing speed of the wheel gives the appearance of a softer grade.

To determine the peripheral speed of wheel in feet per minute, multiply the diameter of wheel in inches by 3.14 and the result by the number of revolutions per minute and divide by 12. For table of wheel speed see page 33.

ORDERING WHEELS

When ordering wheels, particular attention should be paid to the information necessary for the wheel manufacturer to fill your order intelligently.

Be sure to specify—Size of hole, Diameter of wheel, Width of face, Shape No. (if special shape send sketch), Make of Machine to be used on, Grade, Grain, whether Vitrified, Silicate or Elastic wheel, Kind of Abrasive.

If you cannot definitely specify the grade and grain and last wheel was satisfactory, send sample. If new work, state speed proposed to run wheel and work, whether to be ground wet or dry, send sample of work or give complete description as to kind of material, shape and size, machine wheel is to be used on, kind of finish desired, and how much stock to be removed. The tag which comes with the wheel should always be preserved and referred to when re-ordering.

When grinding bronze a thin oil or kerosene should be applied to work without water.

Internal grinding is done dry in some cases because the grindings which collect in the hole will form a paste if water is used, and this will become imbedded in the surface of the wheel and so impair its cutting action.

The waterspout, when grinding cylindrical work, should almost touch the work and stand away about ¼″ from wheel, except on work having a spline in it, when it will be necessary to move the spout further away from the wheel.

Sal-soda and lard oil or grinding compounds added to the water will prevent both the work and machine from rusting.

The tank and sediment pan must be cleaned occasionally, if the best results are to be obtained.

Setting Table to Grind Straight: The Swivel Plate should be set to the zero line and clamped, after which a light cut should be taken over entire length of work. Then the work should be measured at both ends, and if one end is larger than the other, loosen clamping bolt slightly and adjust Swivel Plate by the two adjusting screws at end of table, when another cut should be taken the entire length, and above operation repeated until the desired accuracy is obtained.

This method should also be employed for setting Swivel Plate for grinding tapers.

The Back Rests are placed against the part of work to be ground, and from six to ten inches apart. Work that is out of shape, due to its own internal strains, should be supported by the spring tension of rest which allows work to center itself and of balance.

Third: The grinding wheel is loaded or glazed by particles of material ground having become embedded in the wheel.

Fourth: Grinding wheel too hard.

Explanation of Tables for Selection of Grains and Grades of Wheels for Various Operations

The tables on pages 38, 39 and 40 give grades and grains of wheels, recommended by different wheel manufacturers, for a variety of the more common grinding operations.

These tables have been compiled more to give the operator a starting point for selecting wheels for various grinding operations, than to specify definitely grains and grades of wheels for certain operations. Individual conditions will often modify these; for example, the size and shape of work; size and speed of wheel; the use of water or grinding compound, or not; and the speed and traverse of work. Then, too, all metals vary in composition, as, for instance, the per cent. of carbon in steel, and this variation will often make necessary a harder or softer wheel than is generally used for similar work. Finally, there are the individual preferences and methods of the user to consider. In some shops work is ground from the rough, in others but little is left to grind. Some prefer rapid work and medium finish, others require high finish with necessarily slower production. Some demand very durable wheels, others look more for efficiency. Thus, it will be seen that no fixed rules can be laid down for the proper selection of wheels, but by carefully studying the characteristics of the wheels recommended in connection with the result to be obtained, the proper grain and grade of wheel can readily be ascertained.

By referring to the tables it will be seen that American Emery Wheel Co., Carborundum Co., and Norton Co., each offer two abrasive materials. For example: The American Emery Wheel Co. recommends wheels made of corundum for cylindrical grinding on Aluminum castings, and wheels made of Carbolite for surface grinding cast iron; the Carborundum Co. recommends Carborundum for grinding cast iron, bronze, etc., and Aloxite for steel.

There are two varieties of Alundum, one of which is known as No. 38, and to obtain it when ordering wheels, "No. 38" should be prefixed to the grain number required. Thus, referring to the table under Norton Co., for Surface Grinding Aluminum, Alundum, Grain ⊕ 3830, Grade 1½ is recommended; in detail would read Alundum No. 38 Grain 30, Grade 1½, ⊕ Elastic Wheel.

KEY TO SIGNS USED IN TABLES

C = Combination wheel, grains of different numbers mixed in one wheel.

* = Vitrified Wheel.

⊕ = Elastic Wheel. — = to.

TABLE FOR GRINDING CLEARANCE USING CUP WHEEL

Diameter of Cutter or Reamer	Distance To Set Tooth Rest Above or Below Work Center				
	For 3° Clearance	For 5° Clearance	For 6° Clearance	For 7° Clearance	For 9° Clearance
1/4	.006	.011	.013	.015	.020
3/8	.010	.016	.020	.023	.029
1/2	.013	.022	.026	.030	.039
5/8	.016	.027	.033	.038	.049
3/4	.020	.033	.039	.046	.059
7/8	.023	.038	.046	.053	.069
1	.026	.044	.052	.061	.078
1 1/8	.029	.049	.059	.069	.088
1 1/4	.033	.055	.065	.076	.098
1 3/8	.036	.060	.072	.084	.108
1 1/2	.039	.065	.078	.092	.118
1 5/8	.043	.071	.085	.099	.127
1 3/4	.046	.076	.092	.107	.137
1 7/8	.049	.082	.098	.114	.147
2	.052	.087	.105	.122	.157
2 1/4	.059	.098	.118	.137	.177
2 1/2	.065	.109	.131	.153	.196
2 3/4	.072	.120	.144	.169	.216
3	.078	.131	.157	.183	.235
3 1/4	.085	.142	.170	.198	.255
3 1/2	.091	.153	.183	.214	.275
3 3/4	.098	.164	.196	.229	.294
4	.105	.174	.209	.244	.314
4 1/2	.118	.196	.235	.275	.353
5	.131	.218	.262	.305	.392
5 1/2	.144	.240	.288	.336	.431
6	.157	.262	.314	.366	.470
6 1/2	.170	.283	.340	.397	.510
7	.183	.304	.366	.427	.549
8	.210	.349	.419	.488	.628
9	.236	.392	.471	.549	.706
10	.262	.436	.523	.610	.784
11	.288	.480	.576	.671	.863
12	.314	.523	.628	.733	.941
13	.340	.567	.680	.794	1.020
14	.367	.610	.733	.855	1.098

TABLE OF WHEEL GRADES

DETROIT Emery Wheel Co

Degree of Hardness	PROCESS Vitrified and Silicate
Very Soft	D
	E
	F
Soft	G
	H
	I
Medium Soft	J
	K
	L
Medium	M
	N
	O
Medium Hard	P
	Q
	R
Hard	S
	T
	U
Very Hard	V

MONARCH Grinding Wheel Co.

Degree of Hardness	PROCESS Vitrified	Silicate	Elastic
Very Soft	1½		
	1¾	¾	A
	2	1	F
	2¼	1¼	I
	2½	1½	N
Soft	2¾	1¾	E
	3	2	P
	3¼	2¼	R
Medium	3½	2½	O
	3¾	3	D
	4	4	U
Hard	4½	5	C
	4¾	6	T
	5		
Very Hard	6		
	8		

NORTON Co.

Degree of Hardness	PROCESS Vitrified and Silicate	Elastic
Soft	E	1
	F	
	G	1½
	H	
Medium Soft	I	2
	J	
	K	2½
	L	
Medium	M	3
	N	
	O	4
	P	
Medium Hard	Q	
	R	
	S	5
	T	
Hard	U	6
	V	
	W	
	X	
Extremely Hard	Y	
	Z	

TABLE FOR SELECTION OF GRADES AND GRAINS

Kind of Material To Be Ground.	AMERICAN EMERY WHEEL CO				CARBORUNDUM CO.			
	CORUNDUM		CARBOLITE		ALOXITE		CARBO-RUNDUM	
	Grain	Grade	Grain	Grade	Grain	Grade	Grain	Grade
ALUMINUM *Cylindrical Grinding*	54	L					20	2
ALUMINUM *Internal Grinding*	46	2E	60	K			50	5
ALUMINUM *Surface Grinding*	80	2E	46	L			50	5
BRONZE ~ BRASS *Cylindrical Grinding*	54	M					36	M
BRONZE ~ BRASS *Internal Grinding*	60	K					60	M
BRONZE ~ BRASS *Surface Grinding*	80	2E	46	L			40	M
CAST IRON, *Small. Cylindrical Grinding*	46	K	36	M			36	P
CAST IRON PULLY. *Cylindrical Grinding*			36	L			303	M
CAST IRON CHILLED ROLLS. *Roughing.*	60	J	36	O			60	4
CAST IRON CHILLED ROLLS. *Finishing*	80	2½E					80	4
CAST IRON *Surface Grinding*			36	M			36	R
CAST IRON *Internal Grinding*			60	K			40	P
CAST IRON *Disc Grinding*	36	J	36	L			36	P
CUTTERS, *Gear and Formed. Saucer Wheel*	46	1½E			50	N		
CUTTERS, *T-Slot and Milling. Cup Wheel*	46	1½E			50	O		
KNIVES-HARD *Cup Wheel*	36	2E			365	M		
MILLS, *Face, End and Side. Cup Wheel*	46	1½E			50	N		
REAMERS *Cup Wheel*	60	K			40	O		
RUBBER *Cylindrical Grinding*			46	M			40	M
STEEL CASTING *Cylindrical Grinding*	36c	L			36	M		
STEEL CASTING *Surface Grinding*	46	J			36	O		
STEEL-HARD *Cylindrical Grinding*	60	K			40	O		
STEEL-HARD, *Small. Internal Grinding*	60	K			50	N		
STEEL-HARD, *Large. Internall Grinding*	60	J			50	O		
STEEL-HARD *Surface Grinding*	46	J			365	O		
STEEL-HARD *Disc Grinding*	46	J			50	N		
STEEL-SOFT *Cylindrical Grinding*	36c	L			24	K		
STEEL-SOFT, *Small. Internal Grinding*	46	K			80	O		
STEEL-SOFT, *Large. Internal Grinding*	46	J			60	O		
STEEL-SOFT *Surface Grinding*	36	J			30	P		
STEEL-SOFT *Disc Grinding*	46	J			40	L		
SAWS *Metal Sliting*	60	K			60	H		
TAPS - HOBS *Saucer Wheel*	46	1½E			50	N		
TWIST DRILLS *Cylindrical Grinding*	54	M			50	N		

TABLE FOR SELECTION OF GRADES AND GRAINS

Kind of Material To Be Ground.	DETROIT WHEEL CO.		SAFETY WHEEL CO.		STERLING WHEEL CO.		VITRIFIED WHEEL CO.	
	Grain	Grade	Grain	Grade	Grain	Grade	Grain	Grade
ALUMINUM *Cylindrical Grinding*							36	4E
ALUMINUM *Internal Grinding*							46	3E
ALUMINUM. *Surface Grinding*	16	D					36	3E
BRONZE~BRASS *Cylindrical Grinding*	46	M	30 – 60	M¼ – M	30	3	36	E2
BRONZE~BRASS *Internal Grinding*	46	P	36 – 70	A¾ – A½	36	2	46	E1
BRONZE~BRASS *Surface Grinding*	46	J	46	M½	30	2½	24	E1
CAST IRON, *Small. Cylindrical Grinding*	46	K	36 – 60	M½	36	2	36	D3
CAST IRON PULLY. *Cylindrical Grinding*	36	L	24 – 36	M½ – P	30	2½	36	E1
CAST IRON CHILLED ROLLS. *Roughing.*	36	K	36 – 46	M½	70	2	46	2E
CAST IRON CHILLED ROLLS. *Finishing*								
CAST IRON *Surface Grinding*	46	H	36 – 60	M – M¼	20	2	30	D1
CAST IRON *Internal Grinding*	46	K	36 – 60	A½ – M	46	1½	36	D2
CAST IRON *Disc Grinding*							46	D3
CUTTERS, *Gear and Formed. Saucer Wheel*	46	K	16 – 60	M – M½	60	2½	60	D3
CUTTERS, *T-Slot and Milling. Cup Wheel*	46	L	36 – 60	A¾ – M¼	46	2½	46	D2
KNIVES-HARD *Cup Wheel*	46 – 54	L – K	46	M½	30	2	36	D2
MILLS, *Face, End and Side. Cup Wheel*	60c	N	46	M	60	2½	60	E
REAMERS *Cup Wheel*	60	O-P	60	M¼	60	2½	54	D2
RUBBER *Cylindrical Grinding*	36	H			30	2	46	D2
STEEL CASTING *Cylindrical Grinding*	14c	S	30	M½	36	3	36	E
STEEL CASTING *Surface Grinding*	36	G	36	M½	30	2	46	D3
STEEL-HARD *Cylindrical Grinding*	46	K	46 – 60	M – M¼	36	2½	60	E
STEEL-HARD, *Small. Internal Grinding*	30	M	46	A½	60	1½	46	E
STEEL-HARD, *Large. Internall Grinding*	36	M	36	A¾	46	2	36	E1
STEEL-HARD *Surface Grinding*	36	F	46	M	36	1½	46	D2
STEEL-HARD *Disc Grinding*	36	G	46	M	46	2	24	E
STEEL-SOFT *Cylindrical Grinding*	46	L	46	M½	36	2½	46	D3
STEEL-SOFT, *Small. Internal Grinding*	46	M	46	A¾	60	2½	36	D2
STEEL-SOFT, *Large. Internal Grinding*	36	M	36	A¾	60	2½	60	D3
STEEL-SOFT *Surface Grinding*	46	H	36	M½	30	2½	46	E
STEEL-SOFT *Disc Grinding*	46	K	46	M½	36	2	46	E
SAWS *Metal Sliting*	36 – 46	N	46 – 60	M	46	2½	46	E1
TAPS-HOBS *Saucer Wheel*	60	O	46	M¼	60	2½	60	E
TWIST DRILLS *Cylindrical Grinding*	36	N	46	M½	46	2	46	E1