* *Making the most of our...*

CLARKSON
CUTTER GRINDER

CLARKSON (ENGINEERS) LTD

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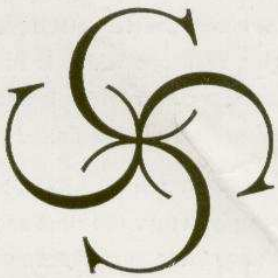
QUALITY MILLING CHUCKS, CUTTERS AND REAMERS

AVAILABLE THROUGH SELECTED DISTRIBUTORS

CLARKSON
CUTTER GRINDER



OPERATORS HANDBOOK

CLARKSON (ENGINEERS) LIMITED
NUNEATON, WARWICKSHIRE
GT. BRITAIN

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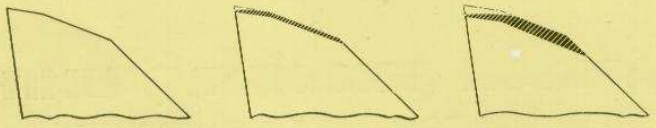
NOTES ON CUTTER GRINDING

Keeping cutters sharp by regular regrinding pays a valuable dividend. Although it may appear most economical to postpone regrinding until it becomes absolutely essential to "grind away some more of the cutter," it has been established by research and experiment as well as by close observation of cutter performance under everyday conditions, that the rate of wear increases sharply as the cutter loses its edge. Thus, a dull cutter which has remained too long without regrinding will require much heavier metal removal to restore the original clearance angles, than one which is subject to a regular light treatment. Furthermore, a cutter which is not in good condition uses more power, and produces an inferior finish.

Treating a cutter on the CLARKSON machine is a simple, speedy matter which amply repays the time and effort spent, in terms of higher efficiency and greater cutter economy as well as superior standards of accuracy and finish.

The pictures and suggestions which appear on the following pages are to help you get the most from your CLARKSON machine, and although space limitations prevent the inclusion of solutions to all problems which could possibly arise, each *type* of application has been dealt with so that you may gain an understanding of the principles involved and apply this knowledge to any other applications.

AMOUNT OF METAL REMOVAL TO RESTORE ORIGINAL FORM



KEEN CUTTER | DULL CUTTER | NEGLECTED CUTTER

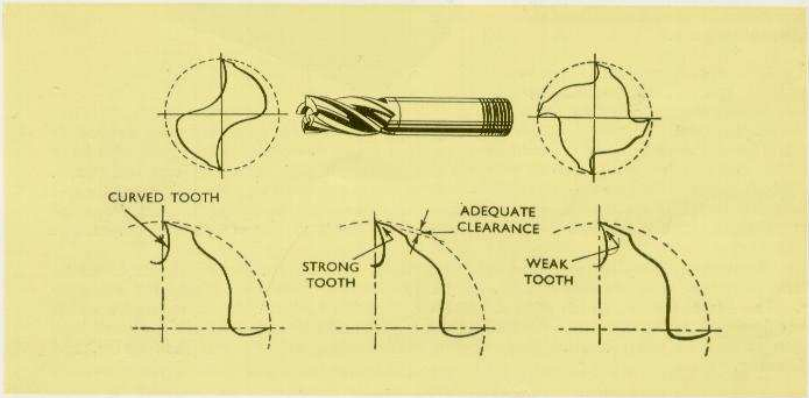
NOTES ON MILLING CUTTERS

Some brief notes on the elements of milling cutter design may help to explain the importance of maintaining accurately the correct cutting angles, and the benefits to be derived from regular grinding. Efficiency and economy in milling depend primarily upon the use of first-class cutters, made from high-grade materials and manufactured to a sound design. For the examples we have taken our own CLARKSON AUTOLOCK cutters, the design being the product of long experience and sustained research devoted entirely to specialist milling cutter manufacture.

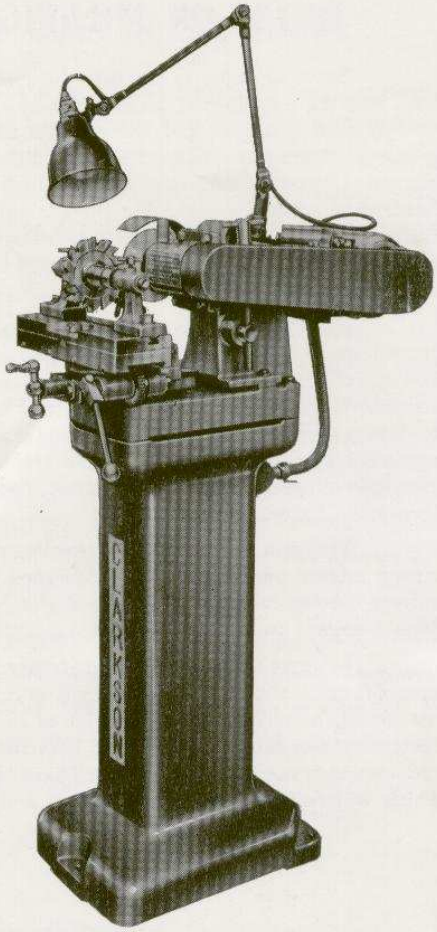
CLARKSON cutters are produced to the form which has proved to be most efficient for rapid metal removal and high finish. The spiral teeth perform a shearing action which minimizes chatter and intermittent cutting since it maintains at least one cutting edge in continuous contact with the workpiece and eliminates the impact produced by a straight tooth at the moment of engagement. The practical results of this are freer cutting, finer finish and a lower power absorption factor.

The form of tooth profile must be a combination of a sufficiently strong section and ample swarf clearance which, together with the correct cutting rake and clearance angles, will achieve a high rate of metal removal and a good finish.

A factor which contributes largely to this successful combination of forms is the one with which we, as cutter grinders, are primarily concerned, namely the critical angles of the double back-off. As the sketches show, the double back-off is of the greatest importance as it provides each cutting edge with sufficient clearance and also a section which will resist chatter and chipping and effectively disperse heat.



NOTES ON THE MACHINE



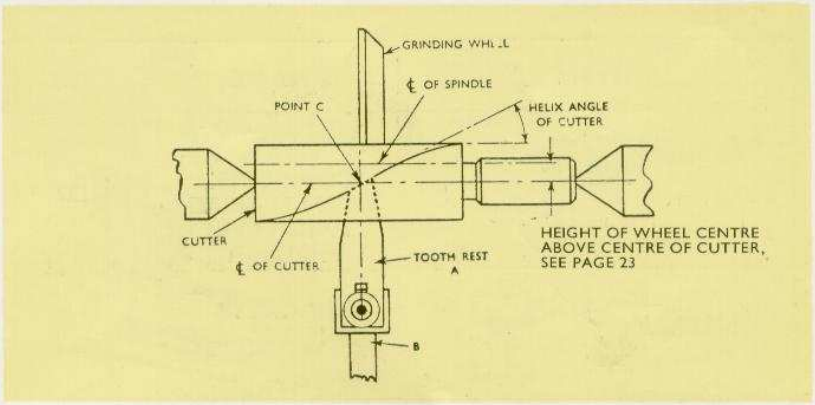
As manufacturers of Milling Cutters we have many thousands to sharpen every week, and the experience gained over many years has taught us a great deal about the various features which, together, comprise the most useful cutter grinding machine. Before the advent of the CLARKSON Cutter Grinder, we employed many different machines each of which possessed its own peculiar virtues, but none of which offered all the characteristics to make it ideal for our purpose.

We had to have a machine which would be simple and straightforward in design; one which, whilst performing every function required of it, conceded no efficiency to complications which would render it adaptable to purposes outside the specific demands of cutter grinding. It must be easy and comfortable to operate and rapid in use, should the quantity be a thousand off or merely the odd cutter. It must be possible to perform all operations from the front of the machine so that both work and wheel are fully visible and under complete control at all stages, with a universal work lamp to give the correct degree of illumination in exactly the required position. Toothrests as well as all fixtures and adapters have to be of good design and quickly interchangeable. Strength and rigidity should be such as to withstand continuous use under arduous conditions, space requirements modest, and the cost kept to a reasonable figure.

Designs were formulated, prototypes built and improvements embodied until there emerged the CLARKSON Cutter Grinder which is the subject of these notes. Because they proved so successful in our own factory at Nuneaton we have made them available to all who have cutters to sharpen and who wish to perform the operation with accuracy, ease and speed. Remember, you will find no other machine, whatever its price, so economical, versatile and efficient as your CLARKSON machine for regrinding end mills, slot drills, reamers, woodruff cutters, tee slot cutters, side and face cutters, cylindrical cutters, face mills, angle cutters, etc.

Equipment is available to enable both straight and Morse taper shank cutters to be held and sharpened, and any side and face cutter up to 6" diameter with 1" and 1¼" diameter holes. The ½ H.P. motor, which runs at 2800 R.P.M., has an adjustable mounting by which belt tensioning is easily effected. Wheel height is regulated by releasing the two half-inch hexagon screws on the left-hand side of the head turning the vertical jack screw, and retightening.

NOTES ON SETTING UP

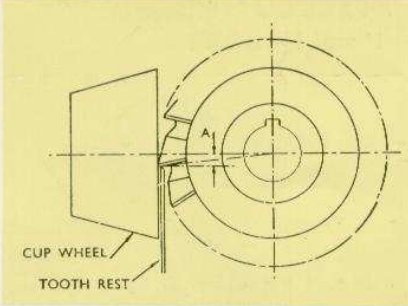


SPIRAL FLUTES—USING A DISC WHEEL

After placing the cutter between centres, tilt the toothrest (A) until its top edge assumes the helix angle of the flute, then adjust bracket (B) laterally until the toothrest is just clear of the cutting edge of the wheel. Move the toothrest vertically until the point on the toothrest edge, in line with the cutting edge of the wheel (C), reaches the centre line of the cutter.

STRAIGHT FLUTES—USING A CUP WHEEL

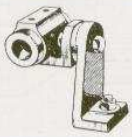
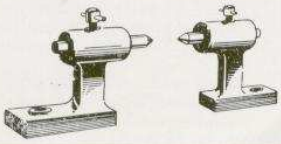
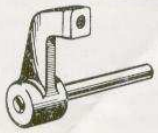
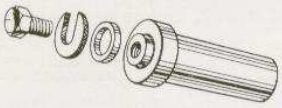
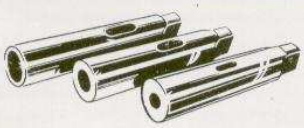
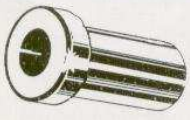
The cutter is placed between centres. As opposed to the procedure previously described where the toothrest remains coincident with the cutter centre, and the centre of the disc wheel raised above this level, the height of a cup wheel is not critical and the correct clearance is obtained by setting the toothrest below cutter centre. This distance (A) will, of course, vary with the clearance angle and the table on this page indicates values for 'A' assuming a clearance of either 5° or 7°. 'A' may be calculated by using the formula : 'A' = D/2 x sin, α where 'D' = diameter of cutter, and α = clearance angle required.



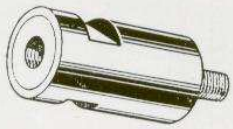
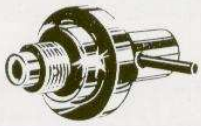
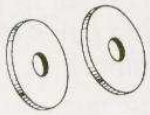
Dia. of Cutter	A 5° Clear	A 7° Clear	Dia. of Cutter	A 5° Clear	A 7° Clear
in.	in.	in.	in.	in.	in.
2½	·110	·150	5	·220	·300
3	·132	·180	6	·264	·360
3½	·154	·210	7	·308	·420
4	·176	·240	8	·352	·480
4½	·198	·270	10	·440	·600

Although method 1 illustrates a spiral fluted cutter, and method 2 straight fluted, both types may be relieved by either method. However, it is recommended that the disc wheel method be used, as, in general, it is much easier to adjust the clearance angle by altering the height of the wheel, than the height of the toothrest.

EQUIPMENT AND ACCESSORIES

ITEM	NAME	No.
	UNIVERSAL HEAD COMPLETE WITH 1″ BORE PARALLEL HOLDER	91127
	BRACKETS WITH CENTRES	91104
	TOOTHREST BRACKET FOR SPIRAL CUTTERS	91103
	TOOTHREST BRACKET FOR GENERAL WORK	91102
	ADAPTER & BUSH FOR SIDE & FACE CUTTERS 1″ and 1¼″ BORE	91120
	MORSE SOCKETS	92603/5
	No. 4 MORSE TAPER HOLDER	93548

EQUIPMENT AND ACCESSORIES

ITEM	NAME	No.
	ADAPTER BUSHES $\frac{1}{4}$"—$\frac{3}{4}$"	92607/11
	EXTENSION SPINDLE	92614
	DEDLOCK GRINDING MANDREL	47073
	CENTRE FOR LONG REACH DEDLOCK CUTTERS	47074
	SUPPORT WASHERS FOR ELASTIC GRINDING WHEELS	93575
	DISC WHEEL	92612
	CUP WHEEL	92613

DO'S AND DON'T'S

always..

ALWAYS *dress your wheel frequently and keep it to a keen edge.*

ALWAYS *feed the cutter smoothly across the wheel.*

ALWAYS *locate the tooth-rest in the tooth to be ground.*

ALWAYS *keep a good variety of toothrests in both shapes and sizes.*

never...

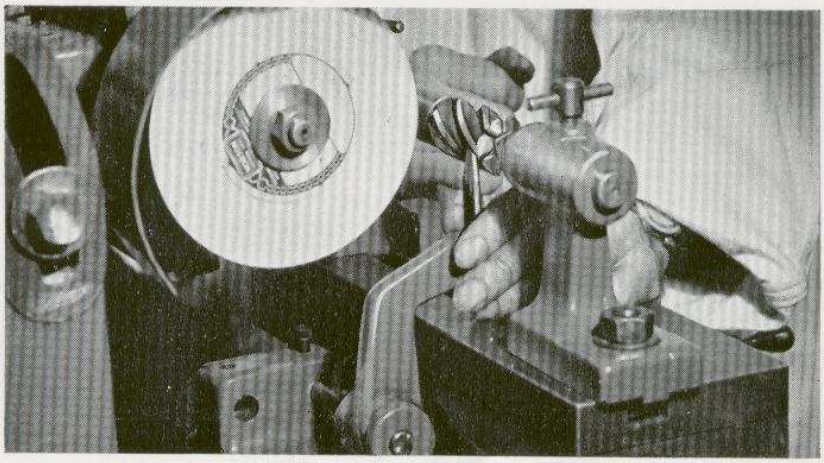
NEVER *remove too much metal at one pass.*

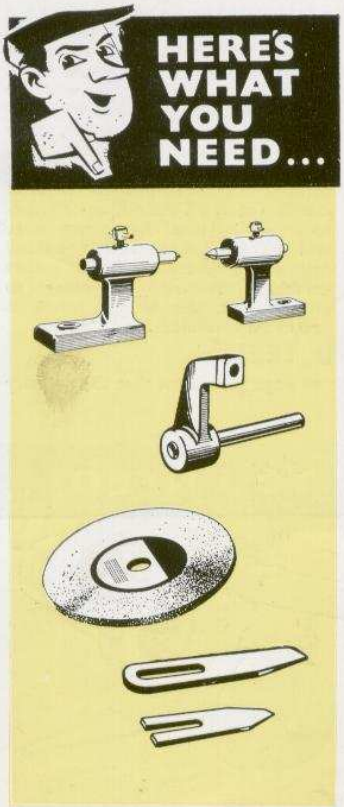
NEVER *let grinding dust accumulate in the moving parts of the machine.*

NEVER *use the cross slide screw to feed the cutter across the wheel.*

NEVER *use the centre points in a damaged condition.*

RELIEVING FLUTES — END MILL

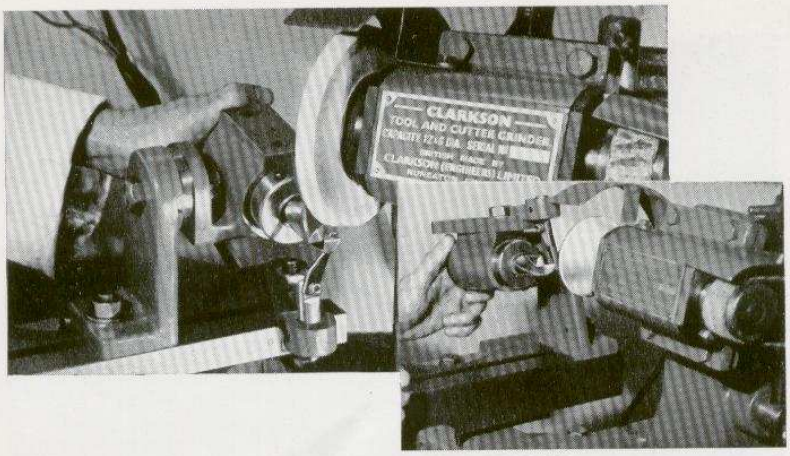




This operation requires the brackets, with centres, a disc type grinding wheel, the cranked toothrest bracket, and a type 'B' or 'C' toothrest, according to depth of flute (see page 25).

1. Dress the wheel to leave a clean cutting edge on the left-hand side.
2. Set top swivel plate into line with the table slide at zero position and lock.
3. Adjust grinding spindle to the height recommended for primary clearance in the chart on page 23.
4. Secure brackets to top swivel plate and mount cutter between centres.
5. Fit toothrest bracket and type 'B' or 'C' toothrest.
6. Wind the cutter forward until the cutter is close to the grinding wheel.
7. Make final adjustments to toothrest, taking care to match top edge of blade with helix angle of cutter, and making certain that cutting edge of wheel, top edge of toothrest, and centre line of cutter, all intersect (see diagram on page 5).
8. Start wheel and wind table until a light cut is obtained.
9. Now regrind each tooth in turn, keeping the inside of the flute in contact with the toothrest as the cutting edge passes the wheel.
10. The number of passes will vary according to the amount of wear on the cutter.
11. Feed the cutter past the wheel smoothly and slowly enough to produce a good finish.
12. Readjust wheel height for grinding secondary clearance and proceed as before.
13. For the greatest accuracy measure the flute diameter at either end and slightly adjust swivel plate as necessary.
14. The clearance angles obtained can be checked by the relief measuring equipment described on page 22.

END TEETH — SLOT DRILLS

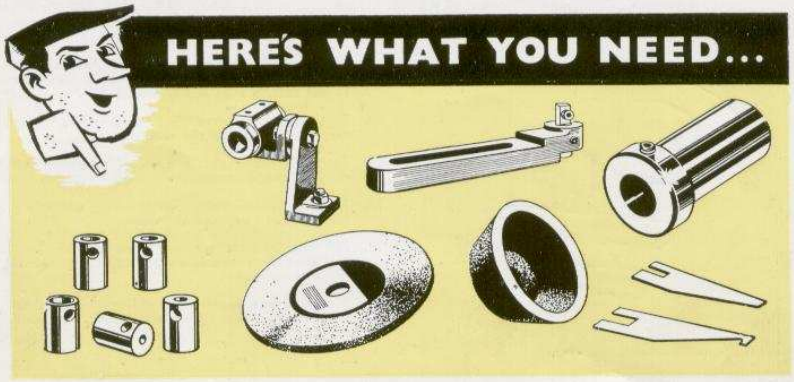


FORMING THE END TEETH

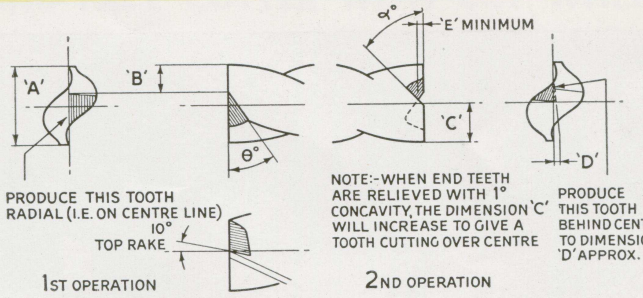
1. Set the table at right angles to the grinding spindle and lock.
2. Mount universal head and bracket, also swan-necked tooth rest bracket and type ' H ' tooth rest.
3. Depress front end of universal head to 10° and lock on bracket.
4. Set top swivel plate to produce angle $\theta°$, specified in the table opposite.
5. Mount holder, bush and cutter in universal head.
6. Set hooked tooth rest ' H ' to locate in the flute of the tooth to be ground, so that the tips of the two teeth are level.
7. With a series of light cuts, using the wheel height movement to adjust the cut and the cross slide movement to produce dimension ' B,' form the cutting edge of the longer end tooth so that it is radial (i.e. in line with the tips of the teeth). Check with diagram opposite, and if possible, study a new cutter as an example.
8. Next form the shorter tooth. Adjust top swivel plate to produce angle $\alpha°$ if different to $\theta°$, and adjust height of toothrest so that the cutting edge will be produced slightly behind centre (see sketch). Grind as before using the cross-slide movement to ensure that the longer tooth is produced to dimension ' C.'

RELIEVING THE END TEETH

This operation is similar to that described for end mills on page 16, except that the primary clearance angle should be 8° and the secondary 15°.

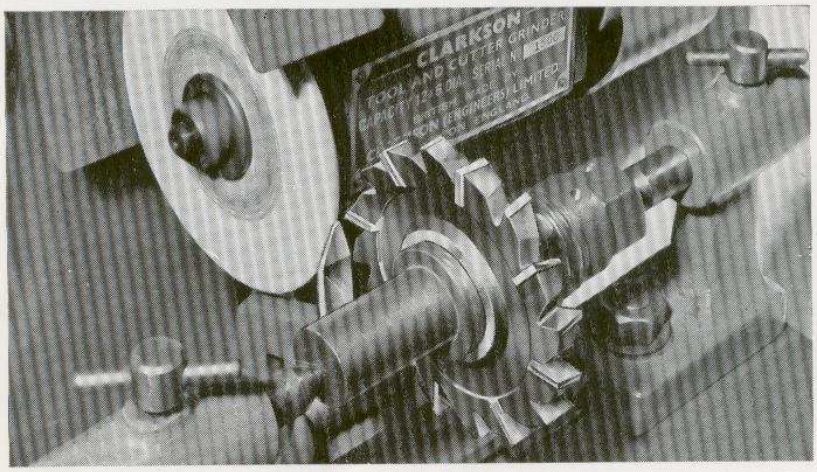


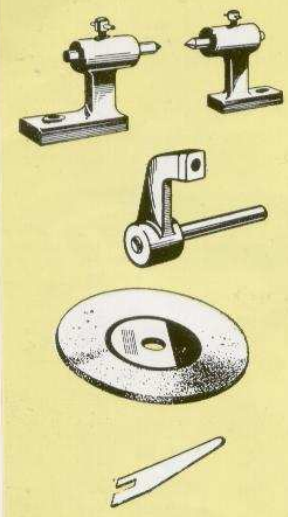
END TEETH — SLOT DRILLS



A Dia.	B ins.	θ°	C ins.	D ins.	E ins.	α°
Below $\frac{3}{16}$" diameter produce two equal end teeth meeting at the centre of the cutter						
$\frac{3}{16}$	$\frac{1}{16} \pm \frac{.000}{.010}$	42°	$\frac{3}{32} \pm \frac{.005}{.000}$	.010	.020	45°
$\frac{7}{32}$	$\frac{1}{16}$	42°	$\frac{7}{64} \pm \frac{.005}{.000}$	$\frac{1}{64}$	.025	45°
$\frac{1}{4}$	$\frac{1}{16}$	35°	$\frac{1}{8} \pm \frac{.005}{.000}$	$\frac{1}{64}$	.025	45°
$\frac{9}{32}$	$\frac{5}{64}$	35°	$\frac{9}{64} \pm \frac{.005}{.000}$	$\frac{1}{64}$	.025	45°
$\frac{5}{16}$	$\frac{3}{32}$	35°	$\frac{5}{32} \pm \frac{.010}{.000}$	.020	.025	45°
$\frac{11}{32}$	$\frac{7}{64}$	35°	$\frac{11}{64} \pm \frac{.010}{000}$	.020	.025	45°
$\frac{3}{8}$	$\frac{1}{8}$—$\frac{7}{64}$	35°	$\frac{3}{16} \pm \frac{.010}{.000}$	.025	$\frac{1}{32}$	45°
$\frac{13}{32}$	$\frac{1}{8}$—$\frac{7}{64}$	35°	$\frac{13}{64} \pm \frac{.010}{.000}$	.025	$\frac{1}{32}$	45°
$\frac{7}{16}$	$\frac{9}{64}$—$\frac{1}{8}$	35°	$\frac{7}{32} \pm .005$	.025	.040	45°
$\frac{15}{32}$	$\frac{9}{64}$—$\frac{1}{8}$	35°	$\frac{15}{64} \pm .005$	.025	.040	45°
$\frac{1}{2}$	$\frac{5}{32}$—$\frac{9}{64}$	35°	$\frac{1}{4} \pm .005$	$\frac{1}{32}$	.040	45°
$\frac{17}{32}$	$\frac{11}{64}$—$\frac{5}{32}$	35°	$\frac{17}{64} \pm .005$	$\frac{1}{32}$	.040	45°
$\frac{9}{16}$	$\frac{11}{64}$—$\frac{3}{16}$	35°	$\frac{9}{32} \pm .005$	$\frac{1}{32}$	.040	45°
$\frac{19}{32}$	$\frac{11}{64}$—$\frac{3}{16}$	35°	$\frac{19}{64} \pm .005$	$\frac{1}{32}$	.040	45°
$\frac{5}{8}$	$\frac{3}{16}$—$\frac{13}{64}$	35°	$\frac{5}{16} \pm .005$	$\frac{1}{32}$	.045	45°
$\frac{11}{16}$	$\frac{7}{32}$—$\frac{15}{64}$	35°	$\frac{11}{32} \pm .005$	$\frac{1}{32}$	.045	45°
$\frac{3}{4}$	$\frac{1}{4}$—$\frac{17}{64}$	35°	$\frac{3}{8} \pm .005$	$\frac{3}{64}$	.045	45°
$\frac{13}{16}$	$\frac{17}{64}$—$\frac{9}{32}$	35°	$\frac{13}{32} \pm .005$	$\frac{3}{64}$	$\frac{3}{64}$	40°
$\frac{7}{8}$	$\frac{9}{32}$—$\frac{19}{64}$	35°	$\frac{7}{16} \pm .005$	$\frac{3}{64}$	$\frac{3}{64}$	40°
$\frac{15}{16}$	$\frac{19}{64}$—$\frac{5}{16}$	35°	$\frac{15}{32} \pm .005$	$\frac{3}{64}$	.055	40°
1	$\frac{21}{64}$—$\frac{11}{32}$	35°	$\frac{1}{2} \pm .005$	$\frac{3}{64}$	.055	40°
$1\frac{1}{16}$	$\frac{21}{64}$—$\frac{11}{32}$	35°	$\frac{17}{32} \pm \frac{.000}{.010}$	$\frac{3}{64}$	$\frac{1}{16}$	35°
$1\frac{1}{8}$	$\frac{11}{32}$	35°	$\frac{9}{16} \pm \frac{.000}{.010}$	$\frac{3}{64}$	$\frac{5}{64}$	35°
$1\frac{3}{16}$	$\frac{3}{8}$	35°	$\frac{19}{32} \pm \frac{.000}{.010}$	$\frac{3}{64}$	$\frac{5}{64}$	35°
$1\frac{1}{4}$	$\frac{3}{8}$	35°	$\frac{5}{8} \pm \frac{.000}{.010}$	$\frac{3}{64}$	$\frac{3}{32}$	35°
$1\frac{5}{16}$	$\frac{13}{32}$	35°	$\frac{21}{32} \pm \frac{.000}{.010}$	$\frac{3}{64}$	$\frac{3}{32}$	35°
$1\frac{3}{8}$	$\frac{7}{16}$	35°	$\frac{11}{16} \pm \frac{.000}{.010}$	$\frac{3}{64}$	$\frac{3}{32}$	35°
$1\frac{7}{16}$	$\frac{15}{32}$	35°	$\frac{23}{32} \pm \frac{.000}{.010}$	$\frac{1}{16}$	$\frac{3}{32}$	35°
$1\frac{1}{2}$	$\frac{1}{2}$	35°	$\frac{3}{4} \pm \frac{.000}{.010}$	$\frac{1}{16}$	$\frac{3}{32}$	35°
$1\frac{9}{16}$	$\frac{17}{32}$	35°	$\frac{25}{32} \pm \frac{.000}{.010}$	$\frac{1}{16}$	$\frac{3}{32}$	35°
$1\frac{5}{8}$	$\frac{17}{32}$	35°	$\frac{13}{16} \pm \frac{.000}{.010}$	$\frac{1}{16}$	$\frac{7}{64}$	35°
$1\frac{11}{16}$	$\frac{9}{16}$	35°	$\frac{27}{32} \pm \frac{.000}{.010}$	$\frac{5}{64}$	$\frac{7}{64}$	35°
$1\frac{3}{4}$	$\frac{9}{16}$	35°	$\frac{7}{8}$ — $\frac{.005}{.015}$	$\frac{5}{64}$	$\frac{7}{64}$	35°
$1\frac{13}{16}$	$\frac{19}{32}$	35°	$\frac{29}{32}$ — $\frac{.005}{.015}$	$\frac{5}{64}$	$\frac{7}{64}$	35°
$1\frac{7}{8}$	$\frac{5}{8}$	35°	$\frac{15}{16}$ — $\frac{.005}{.015}$	$\frac{3}{32}$	$\frac{7}{64}$	35°
$1\frac{15}{16}$	$\frac{21}{32}$	35°	$\frac{31}{32}$ — $\frac{.005}{.015}$	$\frac{3}{32}$	$\frac{7}{64}$	35°
2	$\frac{21}{32}$	35°	1 — $\frac{.005}{.015}$	$\frac{3}{32}$	$\frac{1}{8}$	35°

RELIEVING PERIPHERAL TEETH OF SIDE AND FACE CUTTER WITH DISC WHEEL

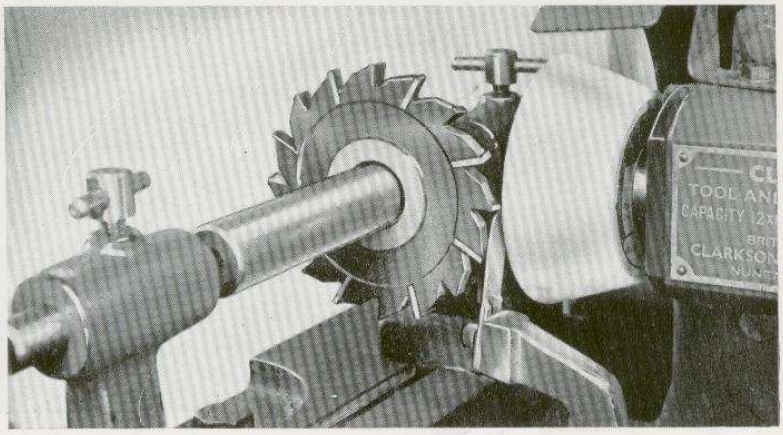


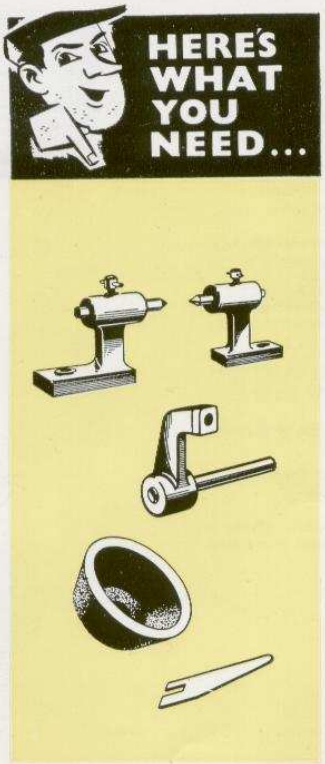


This operation will require—brackets, with centres, a mandrel to suit the bore of the cutter to be ground; cranked type toothrest bracket and type 'A' toothrest (see page 25).

1. Dress the wheel to leave a clean cutting edge on the left-hand side.
2. Swing table and top swivel plate parallel with grinding spindle, and secure.
3. Adjust spindle height to value specified on page 23.
4. Place cutter on taper mandrel and mount between centres.
5. Fit cranked toothrest bracket and type 'A' toothrest, leaving set screws slack for subsequent adjustment.
6. Wind table forward until cutter meets grinding wheel.
7. Make final adjustments to toothrest, taking care to see that centre of tooth blade radius, cutting line of wheel and centre line of cutter mandrel intersect (see diagram, page 5).
8. Withdraw table to separate wheel and cutter, start wheel and return table, so as to obtain a light cut.
9. Take a trial cut and inspect for parallel, adjusting the top swivel plate as necessary.
10. Lock top swivel plate.
11. Now grind each tooth in turn : the alternate spiral angles will slide easily over the ball end of the finger.
12. After removal of the worn edges, repeat a light cut all round to ensure concentricity and a good finish.
13. Adjust wheel height for secondary clearance, and repeat.

RELIEVING PERIPHERAL TEETH OF SIDE AND FACE CUTTER WITH CUP WHEEL



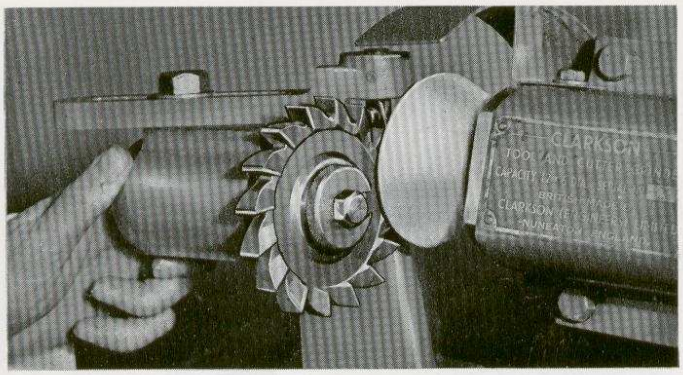


The question of whether cutters are best reground by a disc or cup type wheel, though the subject of wide discussion and experiment, remains substantially a matter of opinion. The argument appears to hinge on the alleged superiority of a flat backing off (cup wheel) or one of concave form (disc wheel) which produces hollow grinding. Clearly the cup wheel, grinding its straight edge will, in theory, produce a stronger tooth, but arguments supporting the disc wheel maintain that the chordal difference between straight and concave forms, over a distance as small as the primary clearance angle is so slight as to constitute no material difference in strength or proneness to chipping. However, to produce a similar effect to that obtained in the previous operation, but using a cup type wheel, there are certain fundamental differences to be observed. The first of these is that the wheel spindle height is not vital and that any convenient position may be used, consistent with the wheel not fouling other parts of the cutter. The second applies to the position of the toothrest. It will be remembered that in the last case great importance was attached to the accurate setting of the toothrest at the centre height of the cutter mandrel, whereas in this instance the required clearance is obtained by setting the rest below centre. (See note and formula on page 5).

The equipment required will be brackets, with centres, tapered mandrel, cranked type toothrest bracket and type 'A' toothrest (see page 25).

1. Fit and dress cup wheel.
2. Swing the table at right angles to the grinding spindle.
3. Place cutter on taper mandrel and mount between centres.
4. Fit cranked toothrest bracket and type 'A' toothrest (see page 25), setting highest point of toothrest radius below the centre line of the cutter to give the required clearance (see page 5).
5. Take a trial cut and inspect for parallel, adjusting the top swivel plate as necessary.
6. Lock top swivel plate.
7. Now grind each tooth in turn : the alternate spiral angles will slide easily over the ball end of the finger.
8. After removal of the worn edges, repeat a light cut all round to ensure concentricity and a good finish.
9. Lower toothrest height for secondary clearance, and repeat.

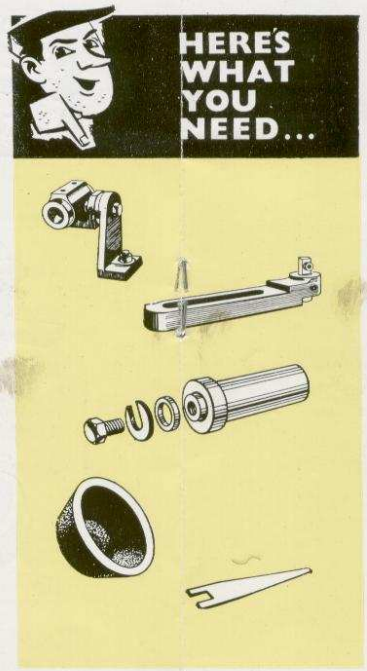
RELIEVING SIDE TEETH OF SIDE AND FACE CUTTERS



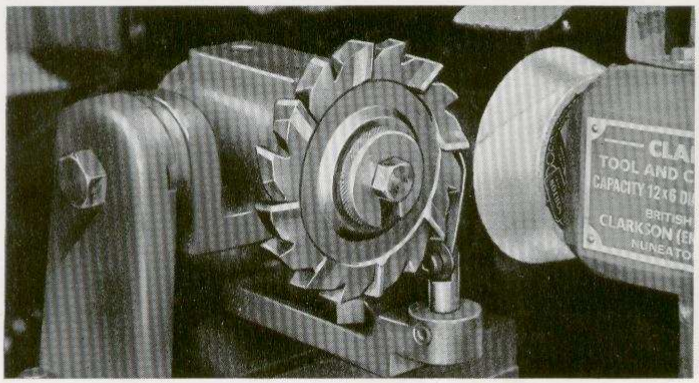
FIRST SIDE

This operation uses a cup wheel, universal head and bracket, swan-necked toothrest bracket with type 'E' blade, and the mandrel which secures side and face cutters by means of a screw and washer.

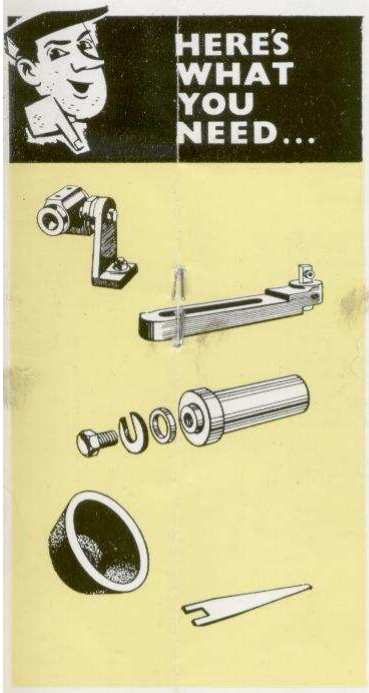
1. Fit and dress cup wheel.
2. Swing table at right angles to grinding spindle.
3. Fit universal head and bracket, as shown above.
4. Mount cutter in position, using mandrel, screw and washer, adjusting to a running fit in the universal head by means of the collar, and ensuring that the cutting edges are anti-clockwise.
5. Secure toothrest bracket obliquely across the universal head and adjust toothrest to the first cutter tooth so that it lies horizontal.
6. Slacken off universal head bracket screw and tilt top of cutter away from grinding wheel, to give side clearance of 3°, then lock universal head.
7. Adjust spindle height so that wheel clears all but the tooth being treated.
8. Set over the top swivel plate to produce a slight concavity.
9. Take a light cut checking concavity.
10. Index cutter, continuing with subsequent teeth and giving a light final grind to all teeth so as to spread wheel wear and ensure tooth concentricity.



RELIEVING SIDE TEETH OF SIDE AND FACE CUTTERS



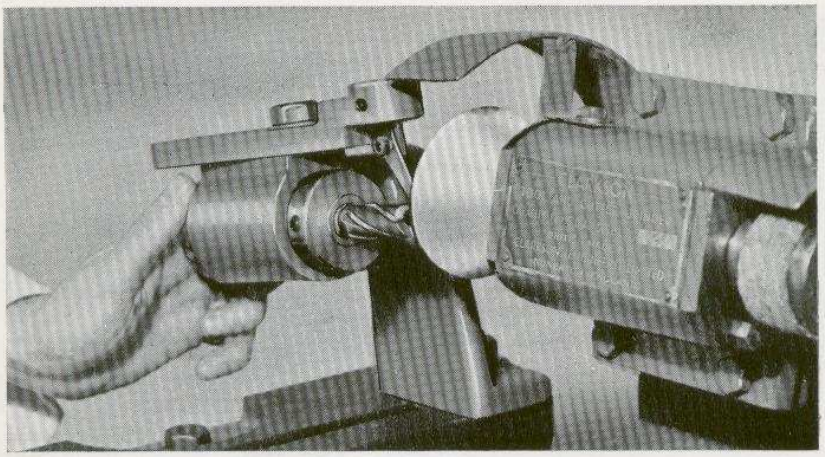
SECOND SIDE

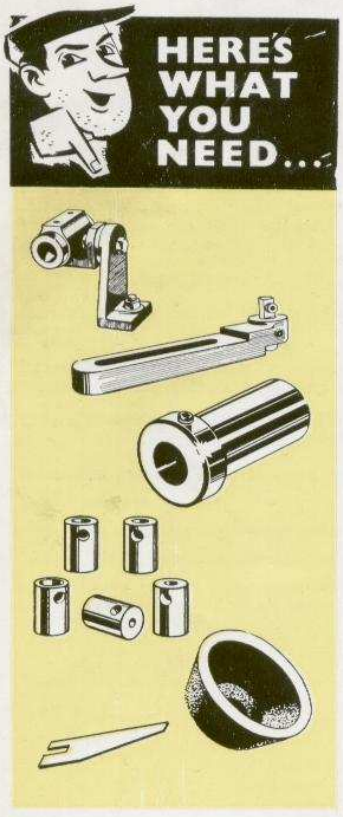


No additional equipment is required for regrinding the second side, but certain minor adjustments must be made to the set up. First, the cutter must be reversed on its mandrel, i.e., the teeth clockwise. Secondly, the universal head must be set over to 3° as before, but in the opposite direction (i.e., top of the cutter towards the grinding wheel) to give side clearance. The setting of the top swivel plate for concavity is constant for both sides of the cutter and can be left undisturbed.

1. Remove toothrest bracket from universal head.
2. Reverse cutter on its mandrel and adjust as in previous operation.
3. Slacken off universal head bracket screw and tilt universal head so that top of cutter inclines toward grinding wheel.
4. Mount toothrest bracket on top swivel plate and adjust to bring one tooth parallel with table, as shown above.
5. Readjust spindle height and proceed with grinding as before.

RELIEVING END TEETH — END MILL

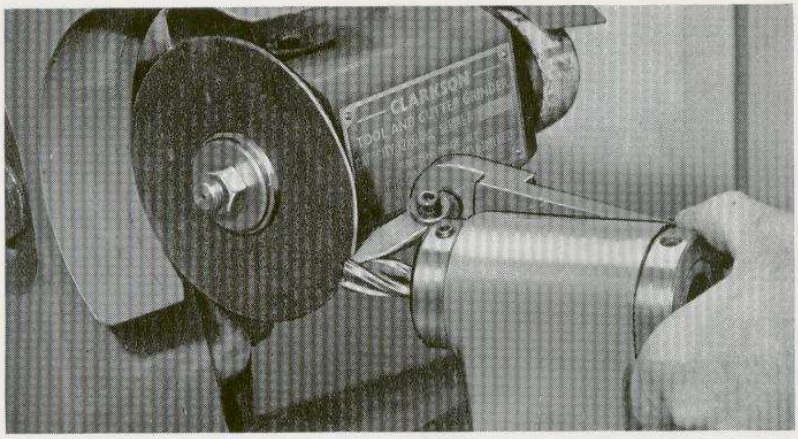


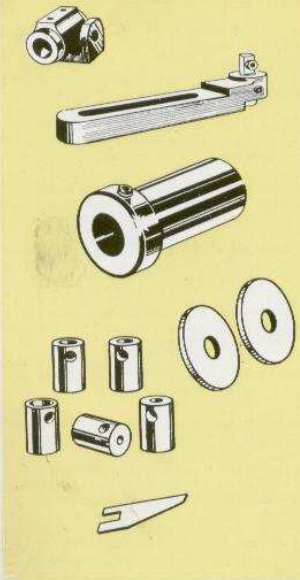


The following accessories are required—universal head and bracket, cup type grinding wheel, straight shank cutter holder, adapter bush to suit cutter shank, swan-necked toothrest bracket and type 'F' toothrest.

1. Fit and dress cup wheel.
2. Swing table into position square to grinding wheel and lock.
3. Mount universal head and bracket at far end of table, in the manner illustrated above.
4. Assemble cutter in adapter and holder.
5. Insert holder, etc., into universal head, adjusting collar to give free running fit.
6. Secure toothrest bracket above universal head and adjust type 'F' toothrest so that the end tooth to be ground is approximately parallel to the table.
7. Slacken universal head bracket screw and, tilting the end of the cutter upwards, lock the head at 8° for cutters below $\frac{13}{16}$" diameter, 6° for larger cutters.
8. Adjust spindle height so that grinding wheel clears the lower tooth while covering the tooth to be treated.
9. Set over the top swivel plate slightly, moving the cutter away from the wheel head, to obtain concavity.
10. Take light cuts, indexing from tooth to tooth until all wear is removed, finally taking a light cut all round.
11. On cutters $\frac{13}{16}$" diameter and larger, reset universal head to 15° and repeat the operation grinding a secondary clearance angle.

RECUTTING END TEETH — END MILL

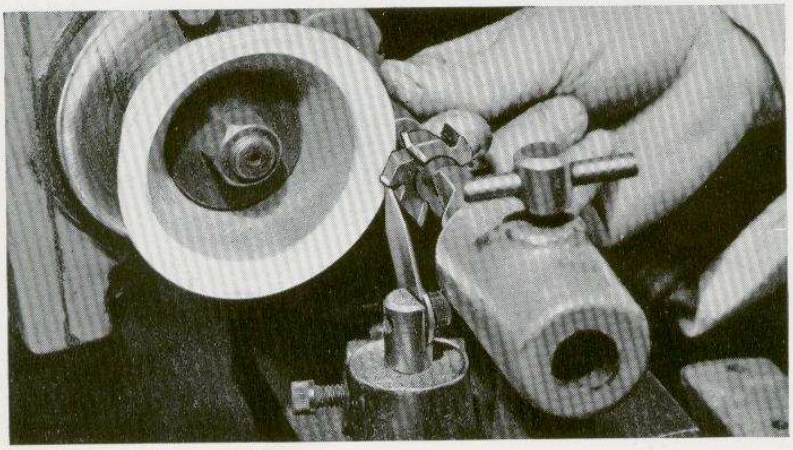


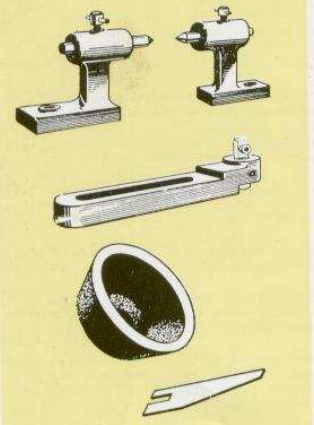


With the continuous regrinding, the end teeth of end mills will reach a stage where there remains insufficient depth to allow adequate backing off, and when this happens the teeth can be recut as follows :—take universal head (detached from its bracket) straight shank cutter holder, adapter bush to suit cutter shank, swan-necked toothrest bracket with type 'G' toothrest and suitable abrasive wheel.

1. Mount suitable grinding disc, using support washers.
2. Set table at right angles to grinding spindle.
3. Swing top swivel plate through 90° so as to bring it parallel to grinding spindle.
4. Mount universal head direct on top swivel plate, as shown above.
5. Assemble holder, adapter, bushes and cutter.
6. Insert assembly in universal head and adjust collar to give free-running fit.
7. Secure toothrest bracket to universal head with swan-neck offset to right.
8. Adjust blade to rest just inside cutter flute and far enough back to clear grinding wheel at full depth of cut.
9. To give a positive rake set universal head or swivel table to 10°.
10. Find most suitable wheel height by trial with a stationary wheel and make final adjustments to toothrest position.
11. Depth of gash is not critical, and whilst personal judgment will become more accurate with experience, some guidance may be gained from examination of a new cutter.

RELIEVING BACK TEETH — TEE SLOT CUTTER



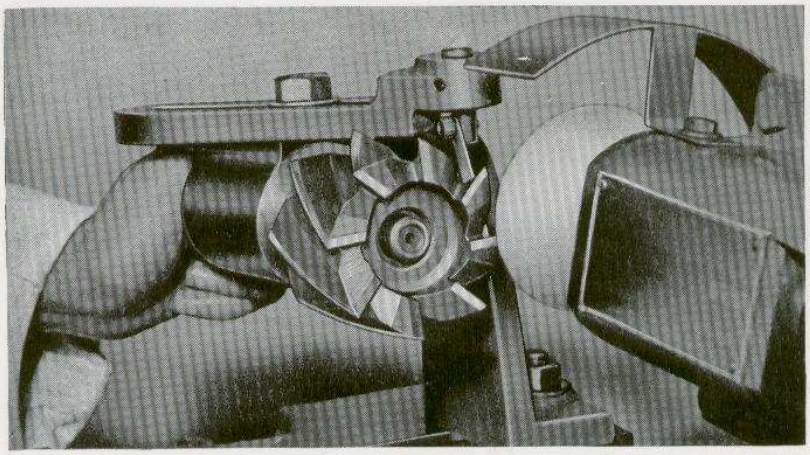


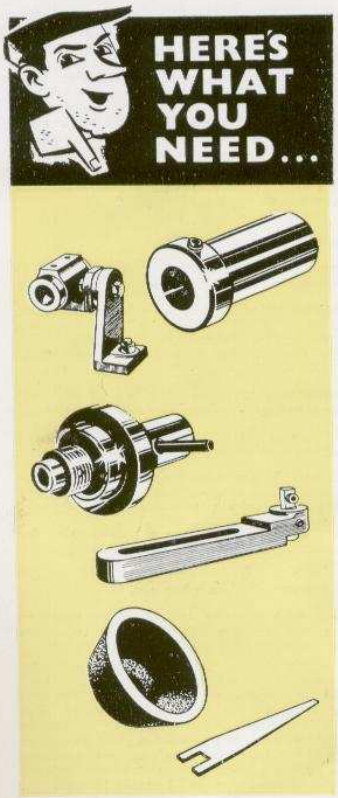
This operation differs from others described in this booklet in that the relief angle is obtained by raising the level of one centre bracket so as to tilt the axis of the cutter. A cup type wheel is needed, as well as the centre brackets, with centres, swan-necked toothrest bracket with type 'F' toothrest, and two packing pieces.

1. Fit and dress cup type wheel.
2. Swing table to a position at right angles to grinding spindle, and lock.
3. Set top swivel plate at 90° to table (parallel with grinding spindle).
4. Place the packing pieces under the left-hand centre bracket and lock the bracket.
5. Fix right-hand centre bracket and mount cutters between centres with cutting head toward left-hand bracket.
6. Secure toothrest bracket to top swivel plate, setting type 'F' toothrest so that the tooth to be ground is approximately horizontal.
7. Adjust table slide and rack feed so as to bring together wheel and back teeth of cutter, as shown in illustration.
8. Swing top swivel plate about one degree in anti-clockwise direction, so as to produce slight concavity when grinding.
9. Set spindle height so that wheel clears the tooth above the one being ground.
10. Proceed with grinding, indexing cutter and taking a light final cut on each tooth.
11. Do not forget to remove packing on completion of the operation as, if overlooked, this will upset subsequent settings.

Note: Height of Packing is found by the formula :—
Height=Length of Cutter × Tangent of Clearance Angle
Clearance Angles=3° primary, 7° secondary

RELIEVING END TEETH — DEDLOCK CUTTER

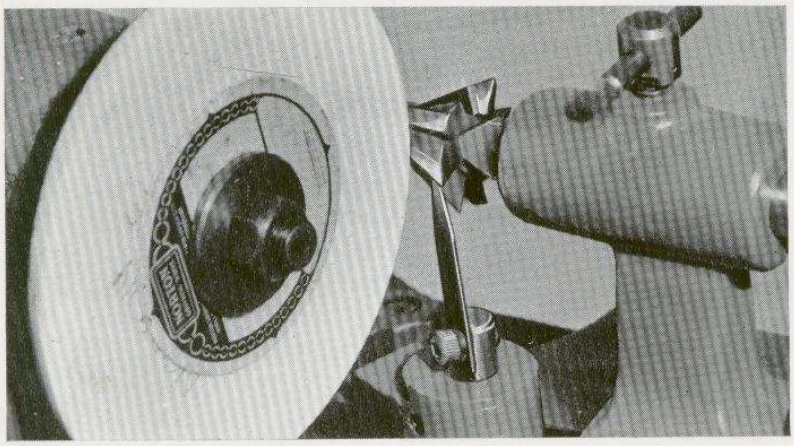


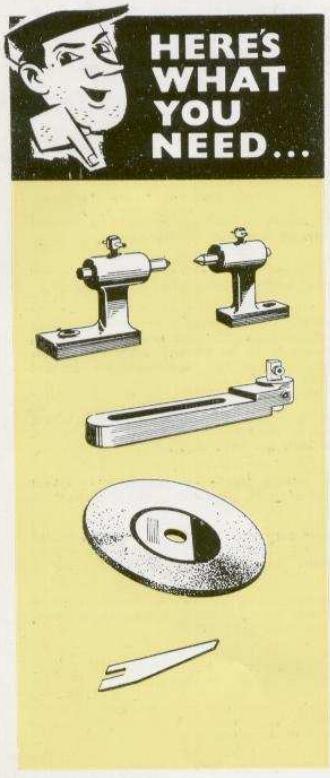


This operation is much the same as described for end mills on page 16. The equipment for this operation comprises universal head, and bracket, cup type grinding wheel, Dedlock grinding mandrel, straight shank cutter holder, swan-necked toothrest bracket and type 'E' blade.

1. Fit and dress cup type wheel.
2. Swing table into position at right angles to grinding spindle and lightly lock.
3. Mount universal head and bracket at far end of table, as shown in illustration.
4. Fit cutter to mandrel and assemble in universal head, adjusting collar to give free running fit.
5. Secure toothrest bracket above universal head and adjust type 'E' toothrest so that the cutter tooth to be treated nearest the rear of the machine lays approximately parallel with the table.
6. Slacken universal head bracket screw and, tilting the upper half of the cutter away from the wheel, lock the head at 6°.
7. Adjust spindle height so that grinding wheel is clear of tooth below that being ground.
8. Set over top swivel plate, moving the cutter away from the wheel head, so as to obtain concavity.
9. Take a number of light cuts all round, indexing from tooth to tooth until all wear is removed, and then a light, final cut.
10. Reset the universal head to 15° and repeat to produce secondary clearance.

RELIEVING ANGLE — DOVETAIL CUTTER





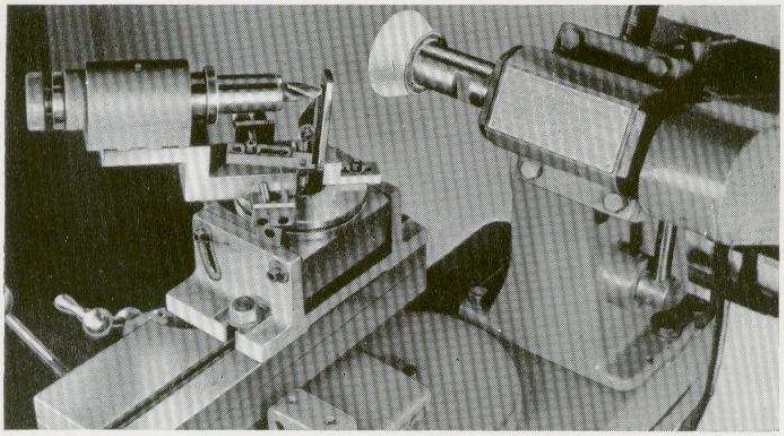
This form of cutter has to be approached a little differently from the parallel type cutters, and a careful study of the picture is recommended. The taper in its cutting length means that we must effect a compromise when considering its diameter. For most purposes the average of the largest and smallest diameters is a good guide, e.g., a 1" dia. reducing to ½" dia. could be considered ¾" when consulting the wheel height chart on page 23.

The operation requires a swan-necked toothrest bracket with a type 'F' toothrest, the centre brackets and a disc type wheel.

1. Fit and dress disc type wheel.
2. Mount toothrest bracket, centres and cutter as illustrated with the cutter head to the left.
3. When dealing with a cutter with radial flutes, i.e., no front rake set the 'F' type toothrest on the centre line and just inside the cutting edge. (For cutters with positive rake flutes see 3A).
4. Set swivel table to required angle, e.g., 45° using the degree calibrations and lightly lock.
5. Apply set-up to the wheel and adjust the complete slide assembly unit for the best access.
6. Set wheel height according to the diameter decided upon, as mentioned in paragraph 1 (For positive rake cutters see 6A).
7. Start wheel and take trial cut, inspecting for accuracy of angle, and adjusting top plate if necessary.
8. Lock top swivel plate when set.
9. Proceed with grinding, indexing from tooth to tooth and taking a light final cut, to ensure true concentricity

3A and 6A For the dovetail cutters with positive rake the toothrest must be set to bring the tooth edge horizontal. It is not possible to refer to the wheel chart ; for ordinary purposes it will be good enough to estimate the wheel height and to pick up on the original grinding. For accurate backoff control the relief measuring attachment described on page 22 should be used.

REGRINDING RADII — AUTOLOCK CUTTERS



THIS ATTACHMENT IS EXTRA EQUIPMENT

1. Having mounted the cutter in holder and sleeve and dressed the wheel, place a slip gauge of a thickness equal to the required radius between centre boss and setting bar slide, and lock the setting bar slide.
2. Slide the holder forward until the nose of the cutter touches the setting bar.
3. Lock, with the grubscrews—(a) the sleeve, and (b) both holder locating rings.
4. Bring the toothrest into position and lock the toothrest bracket. For ball nosing the toothrest being at centre height.
5. Swing the setting bar into the horizontal position, out of the way.
6. Set the clearance angle by tilting the fixture on its base, to the values indicated in the table below.
7. Advance the double slide of the machine until the end of the cutter touches the wheel.
8. Move the top slide of the machine so as to bring the cutter clear of the wheel.
9. Swing the head of the fixture through 90° so as to bring the side of the cutter parallel with the face of the wheel.
10. By means of the small traversing screw on the fixture, wind the swan-neck along its vee slide, bringing the cutter again into contact with the wheel.
11. Lock the swan-neck and withdraw the double slide of the machine until the fixture head can be swung through 90° without the cutter fouling the wheel.
12. The compound movement of swinging the fixture head and feeding forward the machine's double slide will produce the required radius.

A separate leaflet is available giving more detailed information on using the radius attachment.

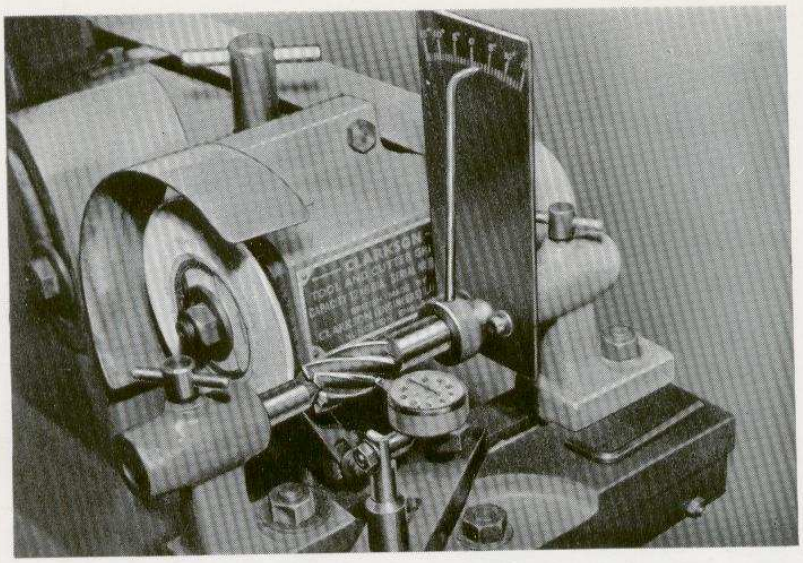
RECOMMENDED CLEARANCES

	Primary	*Secondary*
Up to $\frac{3}{16}$"	15°	30°
Over $\frac{3}{16}$" to $\frac{1}{2}$"	12°	25°
Over $\frac{1}{2}$" to $\frac{3}{4}$"	9°	18°
Over $\frac{3}{4}$" to 2"	7°	18°
Over 2"	6°	18°

When grinding radii larger than $\frac{1}{2}$" we recommend that the work be carried out at two operations, i.e., rough and finish in order that accuracy may be maintained.

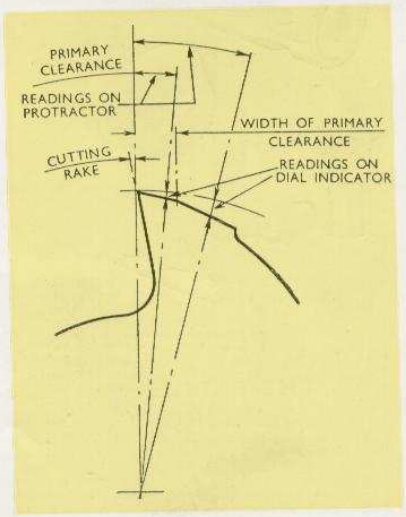
NOTE: Friction adjustment of the swivelling motion can be made by removing the bottom cover (3 screws) and tightening or loosening the adjusting screw which is thereby exposed.

RELIEF MEASURING ATTACHMENT



THIS ATTACHMENT IS ADDITIONAL EQUIPMENT

The notes on page 2 dealt at some length with the importance of restoring the correct clearances on the cutter teeth, and mentioned some of the advantages to be gained from following the makers' recommendations. Reference to the sketch below and the table opposite will enable you to establish accurate primary and secondary clearances on cutters of various diameters. You will find that the clearance angles are resolved in terms angular and linear movement which are easily measured by the special attachment shown above. A most valuable advantage to this attachment is that it can be used without having to remove the cutter from its grinding position, so that readings can be taken and adjustments made with the least trouble and greatest efficiency.



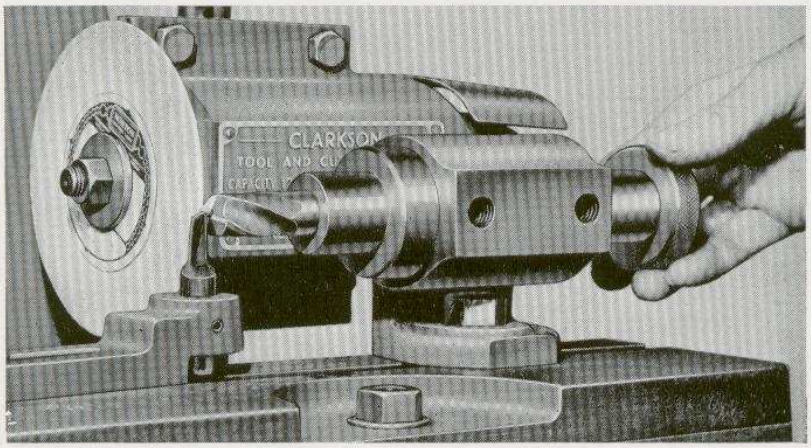
Basically the attachment consists of a clearly engraved protractor for measuring angular movement and a rigidly mounted dial indicator for reading the fall of the clearance. The collar which carries the protractor pointer fits over the cutter shank and is secured by a set screw. Thus, after relieving the flutes, the cutter is rotated through a given number of degrees, and the amount of clearance measured on the dial indicator.

RELIEFS AND CLEARANCES

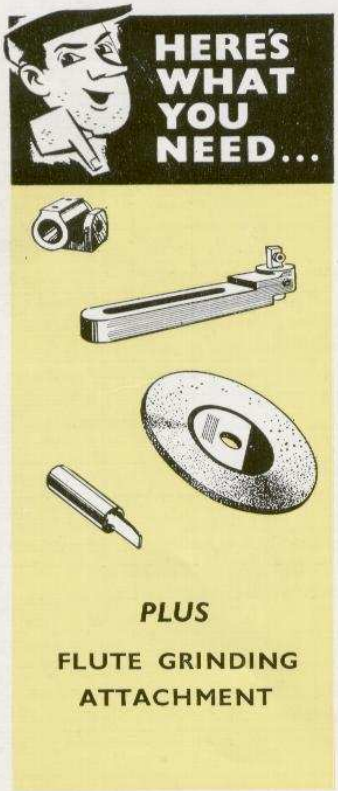
SPIRAL FLUTED CUTTERS

PRIMARY CLEARANCE								DIA. OF CUTTER	SECONDARY CLEARANCE						
HEIGHT OF WHEEL CENTRE ABOVE CENTRE OF CUTTER					Width of Primary Clearance	Relief Measuring Attachment			HEIGHT OF WHEEL CENTRE ABOVE CENTRE OF CUTTER					Relief Measuring Attachment	
DIAMETER OF WHEEL									DIAMETER OF WHEEL						
6″	5½″	5″	4½″	4″					6″	5½″	5″	4½″	4″		
13/16″	3/4″	11/16″	5/8″	—	1/64″	6°	·00125″	1/8″	1 5/8″	1 1/2″	1 3/8″	1 1/4″	—	25°	·0055″
13/16″	3/4″	11/16″	5/8″	—	1/64″	6°	·002″	5/32″	1 5/8″	1 1/2″	1 3/8″	1 1/4″	—	25°	·008″
13/16″	3/4″	11/16″	5/8″	—	1/64″	6°	·00225″	3/16″	1 5/8″	1 1/2″	1 3/8″	1 1/4″	—	15°	·0065″
13/16″	3/4″	11/16″	5/8″	—	1/64″	6°	·0025″	7/32″	1 5/8″	1 1/2″	1 3/8″	1 1/4″	—	15°	·0085″
5/8″	9/16″	1/2″	15/32″	11/32″	1/64″	6°	·002″	1/4″	1 3/8″	1 1/4″	1 1/8″	1 1/32″	15/16″	15°	·0065″
5/8″	9/16″	1/2″	15/32″	11/32″	1/64″	4°	·002″	5/16″	1 3/8″	1 1/4″	1 1/8″	1 1/32″	15/16″	9°	·0055″
5/8″	9/16″	1/2″	15/32″	11/32″	·020″	4°	·002″	3/8″	1 3/16″	1 3/32″	1″	29/32″	13/16″	9°	·006″
5/8″	9/16″	1/2″	15/32″	11/32″	·020″	4°	·002″	7/16″	1 3/16″	1 3/32″	1″	29/32″	13/16″	9°	·0075″
5/8″	9/16″	1/2″	15/32″	11/32″	·020″	4°	·0025″	1/2″	1 3/16″	1 3/32″	1″	29/32″	13/16″	9°	·009″
1/2″	15/32″	7/16″	13/32″	3/8″	·020″	4°	·0025″	9/16″	1 1/16″	31/32″	7/8″	13/16″	23/32″	9°	·009″
1/2″	15/32″	7/16″	13/32″	3/8″	·020″	4°	·003″	5/8″	1 1/16″	31/32″	7/8″	13/16″	23/32″	9°	·010″
7/16″	13/32″	3/8″	11/32″	5/16″	·025″	3°	·00175″	11/16″	15/16″	27/32″	3/4″	11/16″	5/8″	9°	·010″
7/16″	13/32″	3/8″	11/32″	5/16″	·025″	3°	·002″	3/4″	15/16″	27/32″	3/4″	11/16″	5/8″	9°	·010″
3/8″	11/32″	5/16″	9/32″	1/4″	·025″	3°	·002″	13/16″	15/16″	27/32″	3/4″	11/16″	5/8″	7°	·0075″
3/8″	11/32″	5/16″	9/32″	1/4″	·025″	3°	·002″	7/8″	15/16″	27/32″	3/4″	11/16″	5/8″	7°	·0085″
3/8″	11/32″	5/16″	9/32″	1/4″	·025″	3°	·00225″	15/16″	15/16″	27/32″	3/4″	11/16″	5/8″	7°	·0095″
3/8″	11/32″	5/16″	9/32″	1/4″	·025″	3°	·00225″	1″	15/16″	27/32″	3/4″	11/16″	5/8″	7°	·0105″
5/16″	9/32″	1/4″	7/32″	3/16″	·030″	2°	·00175″	1 1/16″	3/4″	11/16″	5/8″	9/16″	1/2″	7°	·0075″
5/16″	9/32″	1/4″	7/32″	3/16″	·030″	2°	·002″	1 1/8″	3/4″	11/16″	5/8″	9/16″	1/2″	7°	·0085″
5/16″	9/32″	1/4″	7/32″	3/16″	·030″	2°	·002″	1 3/16″	3/4″	11/16″	5/8″	9/16″	1/2″	7°	·009″
5/16″	9/32″	1/4″	7/32″	3/16″	·030″	2°	·002″	1 1/4″	3/4″	11/16″	5/8″	9/16″	1/2″	7°	·010″
5/16″	9/32″	1/4″	7/32″	3/16″	·030″	2°	·00225″	1 5/16″	3/4″	11/16″	5/8″	9/16″	1/2″	7°	·011″
5/16″	9/32″	1/4″	7/32″	3/16″	·030″	2°	·00225″	1 3/8″	3/4″	11/16″	5/8″	9/16″	1/2″	7°	·012″
5/16″	9/32″	1/4″	7/32″	3/16″	·030″	2°	·0025″	1 7/16″	3/4″	11/16″	5/8″	9/16″	1/2″	7°	·012″
5/16″	9/32″	1/4″	7/32″	3/16″	·030″	2°	·0025″	1 1/2″	3/4″	11/16″	5/8″	9/16″	1/2″	7°	·013″
5/16″	9/32″	1/4″	7/32″	3/16″	·030″	2°	·0025″	1 5/8″	3/4″	11/16″	5/8″	9/16″	1/2″	5°	·010″
5/16″	9/32″	1/4″	7/32″	3/16″	·030″	2°	·0025″	1 3/4″	3/4″	11/16″	5/8″	9/16″	1/2″	5°	·011″
5/16″	9/32″	1/4″	7/32″	3/16″	·030″	2°	·003″	1 7/8″	3/4″	11/16″	5/8″	9/16″	1/2″	5°	·012″
5/16″	9/32″	1/4″	7/32″	3/16″	·035″	2°	·0032″	2″	15/16″	7/8″	13/16″	3/4″	11/16″	4°	·0135″
5/16″	9/32″	1/4″	7/32″	3/16″	·035″	2°	·005″	3″	15/16″	7/8″	13/16″	3/4″	11/16″	3°	·016″
5/16″	9/32″	1/4″	7/32″	3/16″	·040″	1°	·004″	4″	15/16″	7/8″	13/16″	3/4″	11/16″	2°	·014″
5/16″	9/32″	1/4″	7/32″	3/16″	·040″	1°	·005″	5″	7/8″	13/16″	3/4″	21/32″	19/32″	2°	·017″
5/16″	9/32″	1/4″	7/32″	3/16″	·040″	1°	·0055″	6″	7/8″	13/16″	3/4″	21/32″	19/32″	1½°	·015″

RELIEVING FLUTES OF CUTTER HAVING NO CENTRE HOLE



THIS ATTACHMENT IS EXTRA EQUIPMENT



This operation utilises the universal head which must be removed from its bracket and bolted firmly to the right-hand side of the top swivel plate. In addition to the universal head you will need the swan-necked toothrest bracket, a bush to carry the cutter shank sliding in an outer bush fitted in the universal head. Also required will be a rigid toothrest—type 'D' (see opposite).

1. Swing table slide parallel with spindle and lock.
2. Lock top swivel plate.
3. Mount appropriate bush in universal head and fix head directly to top swivel plate.
4. Dress wheel as directed on page 5 and 9, bring toothrest into position close to the wheel.
5. Mount cutter in regrind holder and pass through bush in universal head.
6. Set grinding spindle to height recommended in the chart on page 23.
7. Lock or secure table slide traverse.
8. Make final adjustments to tooth rest setting, as on pages 5 and 9.
9. Slide the holder through the bush, keeping the edge of the cutter flute in contact with the tooth rest as it passes the wheel.
10. Practise to ensure ease of movement. It must be friction free.
11. Proceed to grind primary clearance.
12. Repeat for secondary clearance.

RECOMMENDED SHAPES FOR TOOTH RESTS

REST	TYPE	APPLICATION
	**A** CODE 93601	Radiused toothrest used for relieving staggered tooth cutters.
	**B** CODE 93514	For use in relieving spiral fluted cutters. The locating edge of 'C' has been thinned down to suit small diameter, shallow fluted, cutters.
	**C**	
	**D**	Ground from solid material to provide extra rigidity necessary when relieving flutes of cutters without centre holes.
	**E**	Toothrests of varying length to suit individual set-up requirements.
	**F** CODE 93547	
	**G**	
	**H**	Toothrest with end hooked over to form locating edge.

Note: C,D,E,G,H are not available from Clarkson (Engineers) Ltd., but E.G.H. may be made from discarded hacksaw blade.

RECOMMENDED GRINDING WHEELS

SLOT DRILLS

Diameter of Slot Drill	Type of Wheel for backing off end teeth	Backing off flutes	Reangling slot drills
3/16" to 1/4"	See End Mills	See End Mills	Norton 5" x 1/4" x 1/2" 38A120L9VG
9/32" to 15/32"	See End Mills	See End Mills	Norton 5" x 1/4" x 1/2" 38A120K5VBE
1/2" to 9/16"	See End Mills	See End Mills	Norton 5" x 1/2" x 1/2" 38A60K5VBE
11/16" to 3/4"	See End Mills	See End Mills	Norton 5" x 1/2" x 1/2" 38A60KVBE
13/16" to 1 1/2"	See End Mills	See End Mills	ditto

END MILLS

Diameter of End Mill	For regashing end teeth	For backing off end teeth	For backing off flutes
Dia. of End Mill 1/8"	4" x ·020" x 1/2" Universal A150RR	Norton cup wheel 3 1/4" x 2 1/8" x 1 1/2" x 1/2" 38A150L8VBE	Norton 5" x 1/4" x 1/2" 38A60K5VBE
5/32" to 9/32"	5" x 1/32" x 1/2" Norton A120P8B2	ditto	ditto
5/16" to 3/8"	6" x 3/64" x 1/2" Norton A60P6E3	Norton cup wheel 3 1/4" x 2 1/8" x 1 1/2" x 1/2" 38120K5VBE	ditto
7/16" to 9/16"	6" x 1/16" x 1/2" Norton A60P6E3	Norton cup wheel 3 1/4" x 2 1/8" x 1 1/2" x 1/2" 38A60K5VBE	ditto
5/8" to 15/16" 1"	6" x 5/64" x 1/2" Norton A60P6E3	ditto	ditto
1 1/16" to 1 3/16"	6" x 3/32" x 1/2" Norton A60P6E3	ditto	ditto
1 5/16" to 1 1/2"	6" x 7/64" x 1/2" Norton A60P6E3	ditto	ditto
1 9/16" to 2" Inc.	6" x 3/32" x 1/2" Norton A60P6E3	ditto	ditto

BRITISH STANDARD WHEEL SYMBOLS

ABRASIVE		Grain Size	Grain Combination	Grade	Structure	Bond
Aluminium Oxide						
Aloxite ...	A	Coarse 8, 10, 12, 14, 16, 20, 24; Medium 30, 36, 46, 54, 60; Fine 80, 100, 120, 150, 180; very Fine 220, 240, 280, 320, 400, 500, 600	Coarse 1, 3; Fine 5, 7, 9	Soft F, G, H, I, J, K; Medium L, M, N, O, P, Q; Hard R, S, T	Dense 0, 1, 2; Normal 3, 4, 5, 6, 7, 8; Open 9, 10, 11, 12	V=Vitrified; B=Resinoid; R=Rubber; E=Shellac; S=Silicate
Alundum ...	A					
Bauxilite ...	A					
Blue Aloxite ...	BA					
White Aloxite ...	AA					
Alundum No. 38 ...	38A					
White Bauxilite ...	WA					
Silicon Carbide						
Carborundum ...	C					
Crystolon No. 37 ...	37C					
Unirundum ...	C					
Green Carborundum	GC					
Green Crystolon No. 39	39C					
			Some Makers use two Grain Size Numbers e.g., 46/60			
			Omitted when one Grain Size only is used			

INDEX

Designed and Produced by "Machinery," Brighton

CLARKSON

cutter grinder