

# A Clarkson Tool and Cutter Grinder 1

Mike Houghton describes buying, renovating and learning to use a Clarkson Mk2 tool and cutter grinder

## Background

There is a case for the use of small industrial machines in the home workshop. Owners or prospective owners of any make of "universal" tool and cutter grinder should find interest in this short series of articles.

Of course we all do things differently. It's a part of the independence that a home 'shop can give you. "I did it my way"; "Your mileage may vary" etc. Here are the reasons that took me into this tool and cutter grinder project.

I built a Dore-Westbury vertical mill and later replaced it with a Chester UK 626 vertical mill. I couldn't sharpen end mills and slot mills on the offhand grinder in the way that I had learnt to sharpen lathe tools and drills. Clearly I needed something a bit more sophisticated or was I destined to spend a lot more money on end mills etc.?

I purchased the Quorn book by Professor Dennis Chaddock Ref. 1 and subsequently purchased a set of castings from Model Engineering Services Ref. 2. The book is a reprint of 17 articles in ME volume 140, 1974. Unfortunately the greyscale photographs in this book are just as bad as they were in the original ME articles. Fortunately, the Quorn drawings supplied by MES are excellently drafted, clear, and accurate and had been updated.

The Quorn is now so well known worldwide that there are suppliers of castings in the USA, Ref. 3 and Australia, Ref. 4 and maybe other countries. Versions of the Quorn have appeared regularly on the front cover of this magazine (e.g. 131, 96, 83 and 62) and can be seen at most ME shows in competition and on display. As one cynical friend commented as we stood admiring an exhibition Quorn, complete with fitted mahogany box and many accessories, "I wonder if the maker has ever actually used that in anger." It didn't look like it had ever struck a bat and we noticed that it was back in the show the following year! Is that the fate of many (most) completed Quorn's?

MEW 62 contains a useful compendium of Quorn modifications and additional accessories; there have been many over the years. The requirement to add more accessories to extend the capabilities of the Quorn and many of the home workshop machines referenced later in this article is a common and recurrent theme that has occupied many minds and created many column feet of articles in this and other magazines.

My cynical friend went away from that ME show and subsequently bought, in a private sale, a used Clarkson Mk1 with some accessories for less than I paid for the un-machined Quorn castings, materials and drawings! Am I doing something wrong?

There is a fairly active Yahoo Group on the Internet devoted to Quorn Owners Ref. 5 and they have an extensive and useful picture gallery and files sections covering the Quorn and similar machines e.g. The Bonnelle and related topics. I would recommend any prospective Quorn buyer or builder join this Group. There is also a Yahoo tool grinding group, also Ref. 5 that contains a wealth of files and photographs for anybody with wider interests in tool grinding; it is highly recommended in my opinion.

It saddens me to report that my Quorn project remains in an incomplete state! (It has got past the maturing the castings under the bench stage.) I think it's safe to say that making a Quorn exercises just about every model engineering skill except boiler making and sheet metal work; and it's very time consuming. I have read estimates that to complete a Quorn requires at least 1700 workshop hours. Apparently that's about half a modest steam loco construction time with no short cuts. (I.e. without laser cut frames and purchased boiler.) You just have to be single minded and dedicated to complete a Quorn. Some Home Workshops must be more productive than mine!

## A bit more Quorn

The Quorn was, or has evolved into, a truly "universal" tool and cutter grinder of some complexity. Several UK home workshop machines have been developed to provide some or most of the Quorn's functionality but at supposed reduced construction time and complexity, but not necessarily reduced materials cost. In the UK we have the Stent, Ref. 6, the Worden, Ref. 7, the Kennet, Ref. 8, and there may be more. There is a very brief review of some of these machines in a recent book by Harold Hall, Ref. 9. In addition there is the Tinker modification to a standard bench grinder. The Stent was apparently developed to provide affordable Clarkson capabilities to the Home Workshop.

In the 1970's when the Quorn was designed by Prof. Chaddock, Clarkson were manufacturing all 3 versions of their Tool and Cutter Grinder. At that time, the new cost of even the cheapest Clarkson Mk1 would have been completely outside what any home workshop owner could afford, probably 20 times the Quorn castings cost at the time. So I can easily appreciate the good Professors' motives for designing the Quorn. He must have had access to professional tool and cutter grinding machines at the Loughborough University Workshops where he was Prof. of Engineering Design at the time. In the 1960's I used to sneak into the some of the engineering workshops at Loughborough; they seemed pretty well equipped to me, but I was only an undergraduate at the time.



Photo 1. Clarkson MK2 installed.

Quorn is of course the name of a small town close to Loughborough where Chaddock lived, not something a vegetarian might eat.

## Small Industrial tool and cutter grinders (and drill sharpeners)

There are a remarkable number of these machines and they vary a lot in their design objectives. Many are not common in home workshops and many are worth serious consideration should you come across a used one. These tend to be single purpose machines rather than the one machine does everything approach. Unfortunately the usual reference, the Lathes website, Ref. 10 is somewhat lacking when it comes to these machines. If you Google for names like Brierley (Cuttermaster, now owned by Chester UK), Boremasters (Tiplap), Deckel, Alexander, Drill Doctor, Dorex and Gorton. The Alexander/Deckel SO and SOE style of engraving and milling cutter grinders have been extensively "copied" by a number of Asian manufacturers and imports are

available under the Vertex and other brand names in the UK. I have heard slightly variable reports but don't have any first hand experience, but the £600 or so fully equipped model from RDGtools sets the price standard at the time of writing.

### Other Factors

So with a Quorn more than half built and a list of modifications for it already in mind, why did I change horses and look for a Clarkson Tool and Cutter Grinder? I'm sure some, if not all of these factors will resonate with most of our readers.

A retired engineer gave me a large part of the tools collected over a working lifetime by his brother and himself. This was a substantial collection of taps, drills, reamers, and mills and slot drills, slitting saws and milling cutters. All this tooling was High Speed Steel by respected Sheffield makers with lesser quantities of German and Australian manufacture. I think one of the brothers worked in Adelaide at one point. Most of the hoard of tooling was in need of re-sharpening and some de-rusting. See MEW 127 for my article on electrolytic de-rusting of tools. Some of this tooling had already been badly re-sharpened and was in need of reworking. Some of the larger tooling in this hoard was ideal to practice tool sharpening on.

Used tooling in a very similar condition to the above often appears at car boot sales at very attractive prices, and provided you can re-sharpen them, they are often worth purchasing. Even though the supply of tooling from local engineering closures is drying up, there is still a steady trickle of stuff from private workshops and house clearances. FleaBay is another source, but I prefer to see the stuff in the flesh before purchasing.

A local factory, with extensive modern CNC milling and turning facilities has decided not to re-sharpen any tooling below 13mm dia. They use it until the performance falls then they scrap it. I have been lucky; some of it comes my way. This factory makes medical equipment components and machines a lot of stainless steel and tough steels. The tooling, mostly drills and end mills in HSS and carbide comes from very reputable manufacturers, though most is, sadly, no longer made in Sheffield.

You can learn a lot from studying the cutting edges applied to this quality



Photo 2. Clarkson MK2 table and tooling.

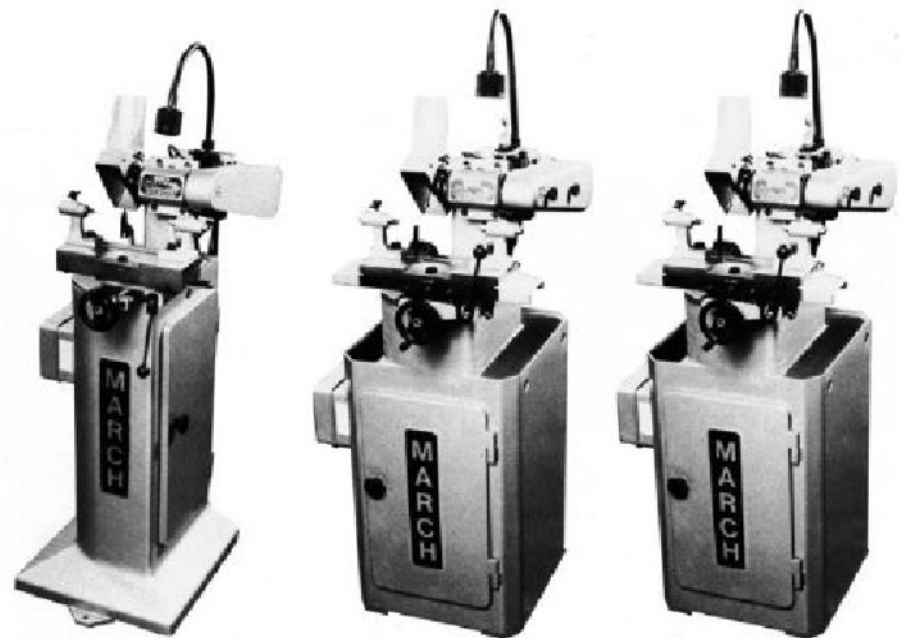


Photo 3. Clarkson March MK1, 2 and 3.

tooling, especially when you compare it to some of the cheap Asian stuff. You can also learn a lot from the tool wear produced by repetitive high speed and high feed rate machining on modern rigid machines.

A friend visiting from South Africa with origins in the Sheffield Tool industry pushed me to consider a Clarkson Tool and Cutter Grinder as an alternative to the Quorn. His company still uses 40 or so Clarkson Mk1's for low volume and specials production for the local SA and export markets. (Some to the USA). I have some of their tools and they are good quality. Their high volume precision stuff in carbide and HSS is increasingly produced on 5 axis CNC grinding machines with auto size adjustment to allow for wheel wear, but the Clarkson's never the less remain in use.

Clearly these Clarkson's can have a very long life, even under very heavy industrial use. No spares are available in SA, so they make their own. I was even offered a spindle should a purchased used machine require one. Whilst my friend was staying, we took a look at Clarkson's advertised on UK Ebay and a few dealers stocks on the internet. Evidently there are a lot of them about still. Apparently there were quite a lot of Indian produced Clarkson clones being traded at one time. These may not have made it into the UK, but buyers beware.

### Purchase

I placed a free advert on the excellent Home Workshop website, Ref. 11. I also decided to ask at my local club to see if anybody had a suitable machine. Returning from a weekend away, I found 10 machines offered from the internet advert plus an additional 2 from club members.

Most of the Tool and Cutter grinders offered were Clarkson Mk1 and 2, but there were a couple of Boxford G200's. Prices varied from £100 to completely silly money, more akin to Dealers prices. Look in this and other magazines adverts to see what I mean. One of the most important price determining factors seems to be the number and type of accessories offered with the machines. However if you can't afford

specialised accessories such as radius grinding, 3 axis vices, drill point and tap lead grinding, air bearing and controlled spiral attachments don't despair; there may be cheaper alternatives once you have learnt the basics of tool and cutter grinding.

I bought a Clarkson Mk2, a 3 phase machine, serial number MT1058, photo 1 plus some of the basic accessories and grinding wheels from a local private seller. I saw the machine operate before purchase. To keep costs down I declined the radius attachment and this sold quickly on Ebay a few days later for almost as much as I paid for the Mk2.

Although Clarkson produced several hard to get i.e. expensive attachments there are alternatives available as I shall detail later.

Photo 2 shows the top half of the machine with some basic attachments and sleeves on the table. The Clarkson is small enough to fit into most home workshops, and is considerably smaller than say the Cincinnati No2 or the Jones and Shipman 310T. I have seen Clarkson Mk1's converted to bench mounting, but I wouldn't recommend it.

### About Clarkson and the spare parts situation

Tony Griffiths has some information about the company and its three Tool and Cutter Grinder products on his website. Most of this material has been re-published in ME. Ref. 12.

I have been unable to find anything about the origins of the Clarkson Company; maybe a reader with inside knowledge of the Sheffield Tool Industry could enlighten us all? I'm sure it would be an interesting story.

Clarkson were certainly very innovative and famous for their development of screwed shank milling cutters and milling cutter holders. (Trade names Autolock, Dedlock etc) Of course the Clarkson name lives on as manufacturer of cutters. (Now as Clarkson Osborn International.)

Clarkson appear to have to started manufacture of the MK1 at their factory in Nuneaton to support their own cutter manufacture in Sheffield and other



Photo 4. March Mk3.

locations. The Company seems to have eventually become a part of the ill-fated Thorn EMI group, the Nuneaton Plant and all its work in progress, spares and drawings, but not the Clarkson name, were transferred to March Engineering Ltd who had become a big sub contractor to the Clarkson Operations at Nuneaton. March continued the manufacture of all three versions of the Clarkson with very small changes. March Engineering finally went into liquidation in 2004 and the assets were bought by Machine Spares, Ref. 13, who can supply manuals and spare parts for March and Clarkson badged machines. I have visited Machine Spares in Brierley Hill and was very impressed by their stock of complete machines (even a rare Mk3) also spares, drawings, belts, casting patterns, un-machined and machined castings. They are definitely worth a try should you require spares, advice etc.

March machines are very like their Clarkson cousins, many of the spares and parts sharing the same part numbers. March moved to fabricating their machine bases whilst Clarkson used cast iron construction, although it's hard to tell from the external appearance.

March reconditioned Clarkson's do occasionally appear second-hand and it seems that March did quite a bit of rebuilding of older Clarkson Machines.

The following illustrations of the three machines are taken from fairly late March Sales Literature, courtesy of Machine Spares, and show the later fabricated bases, photo 3.

The Mk3 machine is very rare, few were sold and they were very expensive. The Mk3 is bigger in capacity than the earlier models and has a rotating and elevating column. Machine Spares have the demonstration/ sales room Mk3, photo 4.

### Refurbishment of my Mk2

Although the Mk2 machine weighs in at about 500lb (225Kg) it was very easily broken down into four major man-sized chunks for transport. I needed 2 helpers to unload the heavy base casting from the VW Touran, but otherwise the move was simple and didn't involve engine hoists and lifting tackle.

Although the machine looked clean and tidy as viewed, on getting it into my workshop in bits it was obviously in need of a good clean up and paint. Years of grinding dust proved extremely difficult to shift and wire wool and soap (Brillo Pads) followed by hot water and a lot of elbow grease eventually did the trick. The



Photo 5. The MK2 slides are protected from grit.

machine was stripped down to the major castings and repainted. Because of the age of my machine, probably 1970's, all the fixings are Imperial threads.

The first thing that struck me about my Mk2 during restoration was the enormous amount of metal in the castings, the rigidity of the design and its overall simplicity. After all it was designed for hard industrial use by "semi-skilled" tool grinders doing a very repetitive job. It's no wonder there are still lots of these around in the UK still capable of good work.

Several users, including the Editor, advised against any sort of lubrication for the swivelling and sliding bits as oil or grease convert to a grinding paste when wheel and steel dust are added to it.

I reassembled my machine with a very small amount of Aeroshell Grease 15 which contains PTFE suspended in it applied lightly to all the moving parts. I'll find out with time if that was a good idea or not! This is helicopter grease, a car boot purchase, and it has a very high tech specification!

The Mk2 is somewhat better protected from grinding dust than the Mk1, having alloy covers over the rack and pinion ends and concertina covers over the dovetail slides, photo 5.

My machine had, at some time, been converted to roller bearings for the top slide. See photo 6, which clearly shows the grinding debris that had to be cleaned away. The slides were manufactured by Cleveland.

I say "converted" because the set screw and nut adjusters for the original gib strips are still on the front of the table, but don't seem to do much.

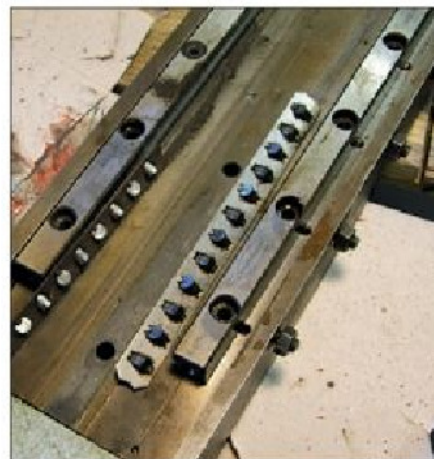


Photo 6. Table roller slides.

The roller slide movement became very free after cleaning and greasing but there was a lot of slop in the rack and pinion that moves the table. With the pinion shaft locked the table could be pushed several mm in either direction. I judged this to be unacceptable so I used a feeler gauge to estimate how much I could pack the rack down to get a tighter engagement on the pinion; then a 0.15mm (0.006in.) brass shim was made and inserted between the rack and the table bottom to remove the slop down to acceptable proportions, photo 7.

The only other signs of wear on my machine are the slide acme screw and bronze nut, (10tpi left hand thread) which at some point I shall replace. There appears to be no method of lubricating the wheel spindle assembly and I was reluctant to take it apart as it runs quietly and the measured run-out on the wheel side is below 0.0005in. I have a GA drawing of the Mk1 spindle and it seems that everything runs on "standard" ball races so replacement shouldn't be a problem.

In the next part I shall cover the addition of an inverter, wheel guarding and extraction. ■

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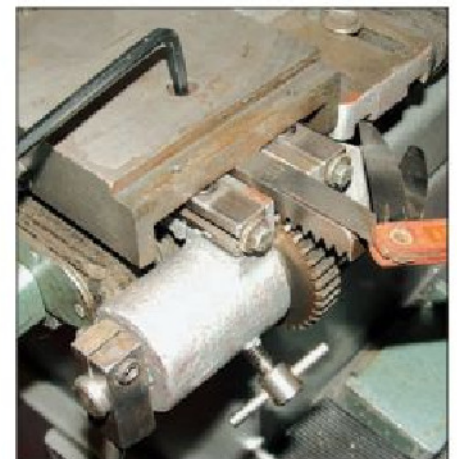


Photo 7. Adjustment of MK2 rack and pinion.

# A Clarkson Tool and Cutter Grinder 2

Mike Houghton adds an inverter, looks at extracting dust and discusses wheel guards

**M**y Clarkson Mk2, described in the first part of this series had a perfectly satisfactory 3 phase 0.75Hp (0.55Kw) 2850rpm dual voltage ASEA motor fitted. It would have been very easy to replace the motor with a single phase one as the foot mounting and belt tensioning is very simple. Many of the machines I was offered had already been converted to single phase by earlier owners. Some had been converted to 1450 rpm, definitely a bad idea, I think. I decided to stick with the installed three phase motor and add an inverter to run it from 240V single phase, something I have wanted to experiment with for some time as I have plans to convert several other machines in my workshop. Three phase motors are reputed to run smoother than single phase and the inverter brings with it control of the motor's speed and programmability.

I bought an Allen Bradley 160S inverter, from an advertiser you can often find on the Home Workshop site, ref. 11. The inverter isn't new, to save cost. It was new

old stock, an old model but I did see it demonstrated on a test motor before I bought it. The seller programmed the inverter to produce a maximum of 50Hz with a 2 second start up and 2 second slow down speed ramps. We reckoned that this would be pretty kind on the drive belt and the abrasive wheels and prevent any over speed. There is a speed adjusting pot hidden away in the operator's cabinet, but it's always set to maximum, 50Hz. The spindle slowing down to a rest in 2 seconds has proved to be a real plus as most grinders tend to take a long time to come to a stop. Experience shows that the motor gets a lot of stop/ start when I'm using the Clarkson to allow adjustments to be made to the tool position. The AB unit I used didn't need additional brake resistors but on a larger motor or more rotating mass e.g. on a larger lathe, one might be necessary. This particular Allen Bradley model has a removable programming panel.

The Allen Bradley Inverter ref. 14 is only IP20 protected, so in my opinion an installation with some protection from workshop debris and fluids is called for.

I have seen a number of inverters, of different makes, installed in home workshops since I started this project and many don't impress me with the safety of their installation. If you are just going to mount the bare unit on the workshop wall you really ought to be looking for an IP65 rated unit, in my opinion. IP65 is dust tight and water jet resistant. This option could double the purchase price of an inverter however. As an alternative I believe you should mount the inverter and its wiring in a lockable metal box. The metal box also helps shielding as inverters have a reputation for electrical noise creation.

Completely prewired inverter packages in well protected workshop proof control boxes, with or without motors, are available from Newton Tesla ref. 15

## The control cabinet

I built the electrical control stuff into a wall mounted steel box for safety and because of the comparatively exposed terminals on this Allen Bradley unit. I also wanted to add a mains RFI filter to reduce any electrical noise going back into the mains supply. The box also houses a low voltage supply for the machine light.

I have a Powerline Ethernet computer network in the house which uses the mains cables for data transmission so electrical noise could cause big data problems.

Because there are so many Inverters available from at least 20 manufacturers I won't describe the AB unit in detail. It happens to require a DIN rail mounting, easily substituted by a small alloy angle bracket in the box; other models will be different. What is critical is an isolating 2



pole switch and fuse on the power input side and an emergency stop button with twist to release. Both these can be seen in photo 8.

Some inverters have internal RFI (Radio Frequency Interference) filters; usually the cheaper basic models whilst others have external add-on RFI filters as backpacks or separate units. In my case the RFI filter was a separate unit which I mounted inside the steel box, photo 9. It is fitted before the inverter in the incoming power line. This particular model has mounting holes for direct connection to a Mitsubishi inverter but can also be panel mounted.

The eagle eyed amongst you will see the wall mounted cabinet has a vertical handle



Photo 8. Inverter wall mounted control box.



Photo 9. An RFI Filter.



Photo 10. Cutting holes in an old box.

on it; it was originally a cheap cash box from Staples and is key lockable. The plastic coin drawer was very easily removed and now finds use in my storage system for small parts. The box metal is quite thin, ca 0.6mm including paint and I had problems making neat 20mm holes in the case for cable glands. I did several tests on a rusty tin shown in **photo 10** and the old  $\frac{3}{4}$ in. screw up Q-max chassis punch, front left, gave the best result with least distortion. In this thin metal the chassis punch was superior to the step drill, the hole saw and a tapered chassis reamer, not shown.

### Power cables

For some time I have been using SY steel wire braid "control cable" in my machine restorations to replace the old flexible metal armoured conduit, which is now difficult to get and is usually damaged and rusty on older machines. I have noticed that many of the import machines, such as my ChesterUK 626 mill, use cheap corrugated plastic conduit, which doesn't give much crush and flex protection. The SY style of cable is shown in **photo 11**. It has a clear outer PVC cover with very tough braided galvanised steel visible through it. There are many variations on numbers of conductors and conductor sizes available in the SY cable range. See **ref. 16**. I found that I can buy SY cable in common sizes, by the metre, from a local electrical distributor at reasonable prices. I used 2 different conductor sizes for the light and the motor. In use I find SY cables tough and more than flexible enough

for most installations. The cable in the photograph actually has 3 conductors and an earth.

### RCD tripping

The following electrical comments are from my experience. Please consult a qualified electrical contractor if you have concerns about choosing and installing an inverter. Regulations in other Countries, non UK, will probably be different, please check.

I believe 30 milli-amp (mA) Residual Current Devices, RCD's, are now mandatory in the recently updated IEE 17th. UK wiring regulations. BS 7671 2008. An RCD measures the current imbalance between the live and neutral conductor and then very rapidly disconnects the supply when it detects an imbalance of approximately 30mA. Modern consumer units can have more than one RCD and your domestic workshop may have an RCD that could trip when you install an inverter.

My inverter tripped the house RCD on switching on the motor for the first time. It was a consistent fault always occurring as the motor ran up to speed. Hurried checks of all the wiring lead to nothing. The motor started to run up to speed then the RCD tripped. Repeatedly tripping the house RCD made me very unpopular!

Of course at this point I had to take all of the control wiring out of the steel box and try and work out logically what was causing the RCD tripping. It would have been a lot more sensible to test the system out of its box and then install it once it was bug free!

Removing the RFI filter completely stopped the tripping and the motor would start up and run as expected. Big sigh of relief!

At this point it should be noted that the 30 mA RCD reacts to the sum of the leakage currents in all the circuits it protects. Many domestic electrical items have small earth leakages and these are additive, so connecting an inverter may just be the last straw that takes the total leakage over the limit. Fluorescent lights can leak up to 1.5mA each for example.

Industrial installations often have higher current rated RCDs and several home workshop users of inverters told me they had replaced their 30Ma RCDs with 100mA to avoid nuisance tripping. DON'T DO THIS! You are putting anybody who uses the RCD protected circuits at risk.

Since electrical supplies to outside workshops (a hazardous area under the new UK regulations?) have to be installed by a "qualified person" and incorporate a protective 30mA RCD, I believe this RCD nuisance tripping could become a more common problem for workshop owners in the future.

I acknowledge lots of help and advice from three UK suppliers whilst I was going through the drama of RCD nuisance tripping. **Ref. 17**. It now seems that my original RFI filter made in the UK for Mitsubishi probably had an earth leakage of around 13mA. A "low" leakage replacement from the same manufacturer, spec <7mA and bought from Newton Tesla gave less nuisance tripping but didn't completely solve the problem. I have since learnt that even lower leakage RFI units are available <3mA for the motor size I have from IMO. **Ref. 18**.

If you are unfortunate enough to have RCD tripping problems due to earth leakage caused by an RFI filter the following observations may, I hope, help you sort out your problems.

Many of the less expensive inverters on the market have built in RFI units. These can be leaky and can't be replaced, because they are integral, should they cause RCD tripping.



Photo 11. SY Armoured Cable.



Photo 12. Delta Star connections.

Inverters with a back pack or separate RFI unit can be changed for a lower leakage unit.

The higher the power of the inverter and RFI unit, the higher the leakage is likely to be.

The new UK regulations don't allow for >3.5mA leakage for a plugged in device so inverters should be permanently wired to a switched, fused, spur or ring main.

Consider running a dedicated electrical supply from a separate RCD protected consumer unit to your inverter(s) so your inverters and the domestic power circuits are not connected to the same RCD.

Take advice from one of the inverter suppliers.

### More on using Inverters

The 3 phase motor on your machine must be dual voltage and should be rewired to 220 Volt operation before use with an inverter. This is usually just a simple resetting of jumpers inside the motor wiring box. Since most small 3 phase motors sold in the UK over the past 30 years were dual voltage ie usually 440/220v this modification, Star to Delta is frequently indicated in the box. See photo 12 of the Clarkson's motor cover.

Caution, there are some industrial 3 phase motors that appear in auctions that are dual voltage but different voltages, 110/220v for example.

I was surprised at the number of manufacturers offering inverters in the UK, over 20. For this reason I have not given any wiring details for my AB unit. Most manufacturers have websites from which manuals can be downloaded.

Modern inverter units are getting smaller, lighter and have more features than you will ever need. Adding an Inverter will probably cause a complete rewiring of the control and emergency stops on your machine and can be quite a major undertaking.

The inverter unit contains a programmable computer (microprocessor) and a power output module which must be connected directly to the motor it controls. No switches or contactors must be present between the inverter and the motor as the computer continually monitors the motor condition by injecting a "high" frequency signal into it along the three phase lines. In some situations this signal is just about audible. Most inverter microprocessors are capable of detecting a number of motor malfunctions and shut down the power output module before any damage is done.



Photo 13. Low voltage Lamp.

Connecting more than one motor to an inverter isn't a good idea.

Some inverters have built in keypads for parameter settings; others have removable programming modules, like my Allen Bradley. Parameter settings might include the maximum and minimum inverter frequency, the speed up and down time ramps and how the inverter will respond to analogue or digital control signals. All the control signals to my inverter computer are low voltage and analogue. Hence operator switches and wiring for stop, start, forward, reverse and reset can be fairly undemanding and, in



Photo 14. Wheel Guard and Extraction Hose.

my case mounted on the cabinet. For machines more complex than this grinder all these commands can be collected together on a remote pendant. Work out what you really want from your inverter and ask a supplier specialising in home workshop situations.

### Low voltage lighting

Because the original machine lighting was 24 volt and ran from a 440v 3 phase transformer mounted on the Clarkson cabinet I decided to scrap it and convert the rather elegant machine light to 12v 20 Watt halogen. I found very inexpensive bathroom ceiling lighting kits with 3 MR11 bulbs, holders, cable, electronic "switching" transformer and wiring loom at a local DIY store. To mount the lamp holder I turned a 3mm thick alloy disk to fit the existing lamp shroud and bored it out to accept the lamp housing and its spring mounting clips, photo 12. The switching transformer was fitted into the steel cabinet with its own mains switch. Incidentally, these cheap switching transformers can also be a source of leakage and noise injection. Toroidal transformers are available as replacements, should you need them.

### Wheel and belt guarding

Several of the Clarkson's that I have seen in home workshops during this project have been operated without any safety protection around the grinding wheel. Having used the machine for some time I can understand why the wheel guards get in the way. The original wheel guards and extraction connection were often no longer present on many of the machines I saw. In a workplace that would be illegal! The same comments apply to unguarded drive belts. Please give consideration to wheel and belt guarding on your machine and wear eye protection.

Incidentally, the Mk2 operates at 4000 or 6000rpm with 2-step flat belt pulleys and a standard 2850rpm motor. The Mk1 is 4000 rpm only.

My Clarkson Operators Handbook, dated April 1979, that came with my Mk2 suggests, p44, that if extraction isn't to be used, the wheel guard extractor outlet should be blocked off with a steel plate.

Photo 14 shows the wheel guard that came with my machine. Photo 15 shows the style of blanking supplied with a March Mk3 machine.

I have added a 2.5 metre length of 73mm diameter steel reinforced PVC extraction hose available from Axminster Ref. 19. This hose is very heavy and I was forced to beef up the bracket that supports the rather flimsy wheel guard and to give



Photo 15. March Mk3 Guard.



Photo 16. Magnetic Grinding Dust.

some additional support for the hose with a wall mounted bracket. It is my intention to separate the extraction and wheel guarding functions at a later date.

### Dust extraction

It is said that the life expectancy of Sheffield cutlery and saw grinders and polishers in the early 1800's was as little as 20 years; no doubt due to working 60 hours a week in appalling conditions, hand grinding on silica containing wheels. They used natural Millstone grit stone wheels, often lying almost horizontal on wooden boards, hence the old "nose to the grindstone" expression.

Grinding dust cannot be good for your lungs and the bare minimum protection you should use is a dust mask and safety spectacles.

Clarkson supplied a separate dust extractor to fit their tool grinders. I have seen several of these units at Machine Spares. Unfortunately one didn't come with my Mk2. In the tool grinding industry, guarding and extraction have to be used to meet HSE Regulations. Fires in dust extraction equipment aren't uncommon in industry. The Clarkson extractors used flame retardant cotton bags as filters and were fairly simple in design. Tool grinding dust is pretty dense compared to wood dust for example, so should be simple to remove by centrifugal separation followed by a filter element.

Most small bench grinders don't generally have provision for extraction. If you set a 6in. grinder up on a clean work surface covered with white paper and sharpen a few tools there will soon be a thin layer of grinding dust on the paper. If you put a modern powerful magnet inside a thin plastic container you will find that the magnet will pick up the majority of the grinding dust, indicating that it's mostly iron or iron oxide. See photo 16 where the magnet inside the box has attracted a fuzz of grinding particles. Closer examination shows the grinding dust has a very small particle size. If you are grinding HSS tools there is bound to be Cobalt, Tungsten, Chromium, Molybdenum and Vanadium metals in some chemical form in the

grinding dust. Not a pleasant cocktail. Incidentally, if you shake the magnet in its plastic box you should be able to dislodge the magnetic particles into the waste bin. This doesn't work as well for carbide dust as it's not as magnetic.

I have been using a wet and dry domestic vacuum cleaner attached to the Axminster extraction hose, which is about 2.5 metres long. Of course the Axminster flexible isn't compatible with the extractor and an adaptor was made up from a 63mm rainwater adaptor and a home turned Polyethylene adaptor. See photo 17.

I am very careful NOT to use this vac for any other purpose in the workshop. The last thing I want is a smouldering fire inside the vac. For this reason I would not recommend using an extractor designed for woodworking nor the very thin Polyethylene 100mm ducting that is often supplied with some inexpensive power tool dust extractors or domestic extractor fans. Remember, a lot of hot sparks will be going into the extraction hose.

Ideally your dust extractor should have an induction motor. Mine has a brush motor and is very noisy.

### The grinding department

There is no denying that any grinding operation causes a lot of abrasive dust that isn't good for you or the other machines in your 'shop. The arrival of the Clarkson has caused me to collect together all these dirty items into a dedicated corner of the 'shop. I do make an effort to wipe the machine down after every grinding session because, despite extraction, a lot of dust and debris escapes.

### Operators manuals

Machine spares, Ref. 13 can supply original March manuals. Scanned copies of manuals and CD's containing several scanned manuals for different tool and cutter grinders are available quite cheaply on the internet from EBay. I have found that the Clarkson Operators Manual to be limiting when it comes to actually using the machine. It gives detailed blow by blow accounts of operations for resharpening end mills, slot drills, side and face cutters, tee slot and dovetail cutters but leaves some more complex operations to a series of small booklets

that they and March supplied along with the attachments I list here:-

- The air bearing flute grinding attachment, code 98100 English, 98101 Metric.
- The controlled spiral grinding attachment, code 98200.
- The radius grinding fixture, code 97112 English, 97114 Metric.
- The drill and tap lead grinding attachment, code 94100.
- The universal and swivel vices, code 94200 Universal, 94250 swivel. I don't believe these vices had booklets.

Although the vices listed above are comparatively common the other attachments are rare and command exorbitant prices at dealers. Fortunately some attachments from other makers' machines will often fit on the Clarkson/ March.

### Standard equipment.

The Clarkson/ March manuals contain lists, part numbers and images of the standard equipment supplied with each machine when new.

In part 3, I will deal with grinding wheels and make a start on using the Clarkson for cutting off and drill sharpening. **To be continued.**

### References

- Ref. 11 <http://www.homeworkshop.org.uk/> Click on latest Ads tab (Repeated from part 1)
- Ref. 13 <http://www.machinespares.net/index.html> (Repeated from part 1)
- Ref. 14 <http://www.ab.com/drives/> AB is now owned by Rockwell Automation
- Ref. 15 UK Home Workshop Inverter suppliers. <http://www.newton-tesla.com/products/imo/index.htm>
- Ref. 16 <http://cse-distributors.co.uk/cable/sy-steel-wire-braid-cable.htm>
- Ref. 17 UK Home Workshop Inverter suppliers. <http://www.powercapacitors.co.uk/transwave.htm>  
<http://www.drivesdirect.co.uk/contact.htm>  
<http://www.newton-tesla.com/products/imo/index.htm>
- Ref. 18 IMO Jaguar drives available from Newton Tesla and Transwave, ref 17, above.
- Ref. 19 <http://www.axminster.co.uk/>

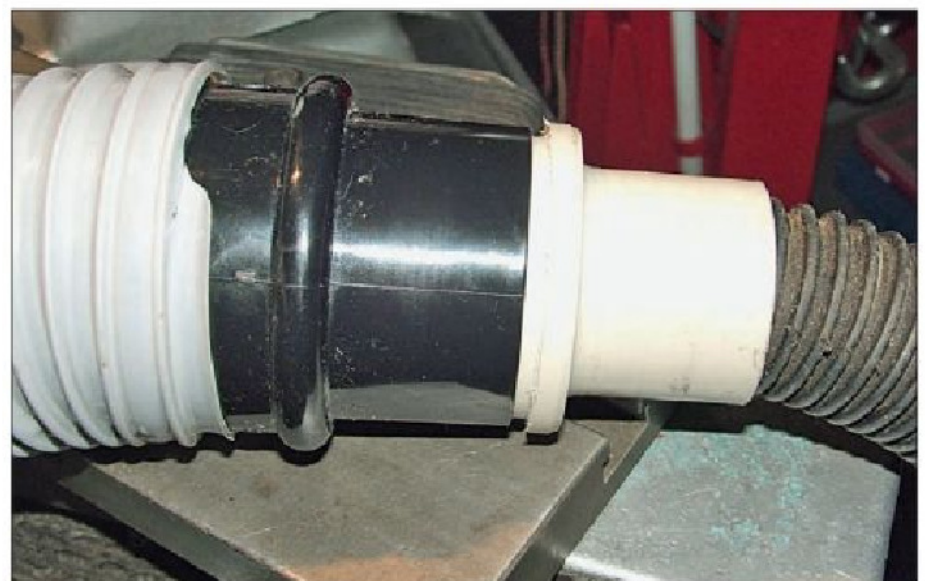


Photo 17. Extraction adaptor.

The two Clarkson standard wheels were chosen for general purpose re-sharpening of High Speed Steel tools. A model Engineers objectives are likely to be wider than just re-sharpening and include the manufacture of tools from hardened HSS blanks and possibly from Carbide blanks. I find that for faster rough shaping of HSS a coarser grit is desirable. I have been using 48 grit wheels for roughing out shapes in HSS e.g for the manufacture of D bits.

I avoid wheels that come with or are offered as replacements for 125mm 5in. offhand bench grinders. These are frequently dark blue or green, they are still aluminium oxide in composition but a lot less pure and less refined (cheap) general purpose grades. For high speed steel, hard white alumina wheels are best and worth paying a small premium for. They seem to cut HSS cooler and with less burning. These wheels are quite brittle and need careful storage and handling. I prefer to keep wheels flat, as a single layer in a drawer with a soft anti-slip lining under them.

#### 4) Mounting the wheel

I checked the spindle of the MK2 for any end float in the bearings with the wheel and belt removed and then measured the run out of the spindle with a DTI, see **photo 19**. In this photograph the spindle extension piece had been screwed on, it's a left hand thread 0.5in. x 16tpi Whitworth form (BSF). The run out on the clamping face was negligible < 0.0005in. (<0.01mm).

The Clarkson should come with two pairs of steel wheel flanges 1/2in. bore and 1.5in. or 2.5in. dia. Mine came with several more sizes that somebody had added at some time. It's good practice to choose pairs of equal size flanges and always use paper blotters just bigger in diameter than the flanges being used. Don't make the mistake of over tightening the spindle wheel retaining nut, you could crack the wheel. The Clarkson uses a tommy bar and spanner. The Clarkson does not use the Quorn drawbar and wheel arbor system, so changing wheels and then dressing them takes a little longer.



**Photo 19.** Measuring the run out of the spindle with a DTI.

#### 5) Truing and dressing the wheel

Having mounted a new wheel on the machine it needs to be trued with a single point diamond on whichever parts of the wheel you are going to grind with. If you don't true the wheel, parts of the cutting surface will be pounded when you grind with it. The wheel will also be out of balance and this affects the quality of the ground surface. There is no provision for balancing wheels on the Clarkson, as one might find on a higher power and faster machine with bigger wheels. My machine



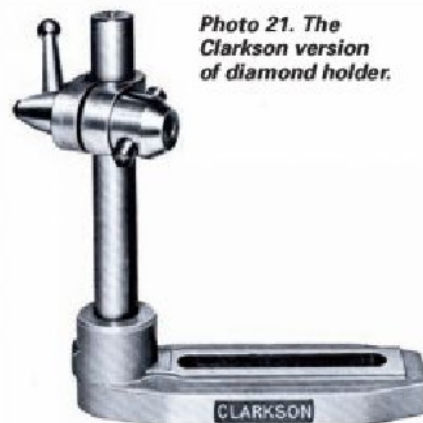
**Photo 20.** My machine came with a mounted diamond, not a Clarkson one.

came with a mounted diamond, **photo 20** that certainly didn't come from Clarkson! The Clarkson version is illustrated here, **photo 21**. I have been using a 0.35 carat diamond mounted in a short steel rod and then the rod is then held in a 2in. Three way vice, **photo 22**.

A wheel that has had some use will slowly stop cutting as freely and when looked at closely will look glazed. This is particularly obvious on white aluminium oxide wheels. This glazing is a result of the grinding debris blocking pores in the wheel. A well used wheel will also cut more slowly and produce more heat due to the abrasive particles becoming blunted; think of them as mini cutting tools. Wheel dressing will remove these blunt particles and their vitreous support to reveal the new sharp particles below. The only remedy is to use the single point diamond again with the very lightest of passes. The diamond dresser must be about the wheel centre height and is used in a dragging mode; it mustn't be able to dig into the wheel surface. If you do dig in, the wheel may give dressing lines, ridges on the work when you grind with it. On the side of the wheel you should dress from the centre outwards and the dressing diamond should always be moving.

Silicon carbide dressing sticks can also be used, by hand, to remove the glaze and re-profile the wheel should you need a corner radius for work on, say, flutes on taps and reamers. Silicon carbide is hard enough to blunt the aluminium oxide abrasive particles and a mounted diamond dresser is really the best choice in most situations. The dressing diamond may itself become dull with a lot of use and it's a good policy to occasionally rotate it if it's in a fixed holder. Personally I don't like, or use, star wheel dressers.

Both these operations must be carried out cautiously taking the minimum amount off the wheel. The quantity of abrasive debris produced, even with a good extraction system, makes it a necessity to cover the machine before use and clean it all down afterwards.



**Photo 21.** The Clarkson version of diamond holder.



**photo 22.** I have been using a 0.35 carat diamond in a steel rod held in a three way vice to dress the wheel.

#### 6) A three way 2in. vice

The use of this inexpensive vice is going to appear several times in my grinding operation descriptions so it's probably appropriate that I describe it now, see **photo 23**.

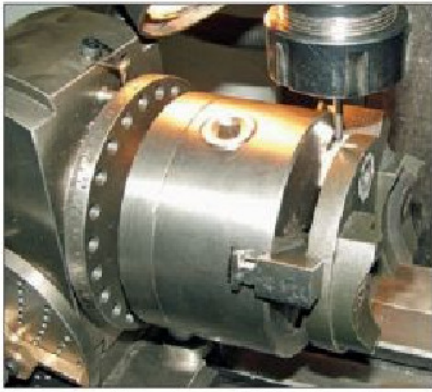
This vice came from Warco, Ref. 22 at one of the ME shows and is very nicely made. After some use, I have found some operations where this design causes problems and something more like the Clarkson design, **photo 24** would be a



**Photo 23.** A three way 2in. vice.



**Photo 24.** The Clarkson designed vice.



**Photo 25. Engraving additional marks on the base at 90deg. to each other.**

better choice; you live and learn! This Warco three way vice isn't truly universal. The base rotates through 360 but is only calibrated  $\pm 90$ deg. so I engraved three additional marks on the mill at 90deg. to each other using the mill and a very small centre drill as **photo 25**. The next axis up from the base rotates  $\pm 45$ deg. but is only calibrated 0 to  $+45$ deg. The top axis rotates through 90deg. and is calibrated 0 to 90deg. only. Be careful to check what you are actually getting before you purchase one of these. Several of our suppliers offer similar imports from India and China.

#### 7) Cutting off HSS tool bits

A number of thin Norton, **Ref. 20** cutting off disks came with the Clarkson marked 57A 60 P B25. These disks are not white but a dull brown. 57A is a semi friable aluminium oxide, 60 is the grit size, P indicates a hard bond and B a resin bond. These disks measure just over 1mm thick and must only be used to grind on the thin edge.

You will probably have in your collection HSS tool bits that have been nibbled away on an offhand grinder then snapped in a vice. The sort of effect is shown in **photo 26** and is just a waste of HSS and the corner of the grinding wheel. And a bit dangerous when you fracture the end off.

I find the ability to cut off HSS tool bits very useful either to remove an unwanted tool shape (somebody else's mess!) or to make a short tool for a boring bar. These wheels are shape 41, i.e. flat. They can be purchased from MSC/J&L Industrial, **Ref. 20**.

In **photo 27** you can see this cut off operation in progress using the 2in. three way vice again. Note where the sparks are going, despite the extractor being switched on during cutting.



**Photo 26. Cutting up HSS tool bits.**

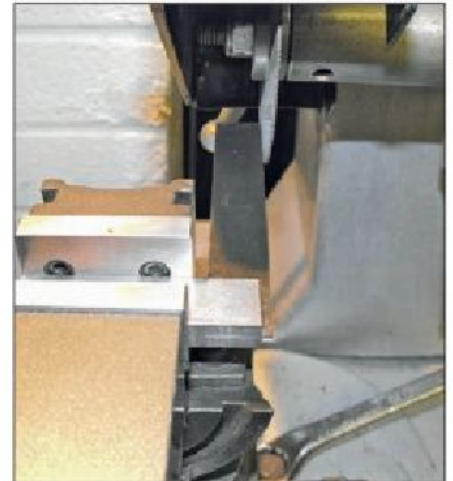
**Table 2**

Operation - Cutting Off.	
ABRASIVE WHEEL	1mm wide flat cutting off disk. 57A 60 P B25
WHEEL HEAD	Raise wheel head to pass over vice support
Spindle length	Use spindle extension piece.
Swing Table Pivot	Set at 90° to wheel head spindle
Top swivel plate	Set to 0°
3 way vice	Set jaws horizontal and 90° to wheel
Feed	Use rack and pinion smoothly with a pecking action.

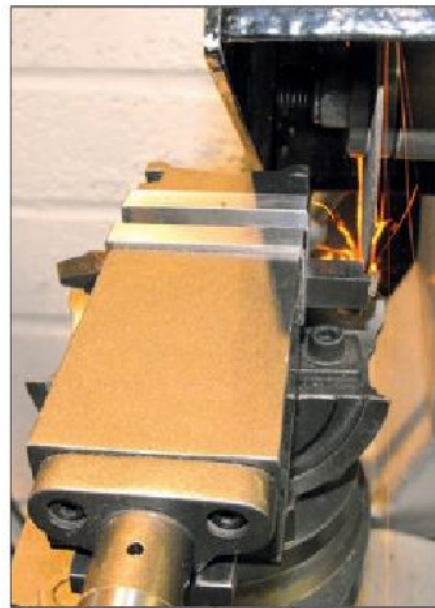
In an attempt to shorten descriptions of setting up the various grinding operations that follow, I have adopted an approach used by Prof. Chaddock in his book on the Quorn and summarise the set up in **table 2**.

I have found that these cut off wheels have to be mounted between absolutely perfect flanges so there is no run out at the periphery of the wheel. It's advisable to actually measure this with a DTI before you commence cutting. Should a run out be detected suspect and check the wheel flanges because even a small run out will dramatically shorten the life of these thin wheels. Don't use cheap stamped wheel flanges, they probably won't run true. The authentic March/Clarkson ones have been turned from solid then ground.

The wheel must be exactly at right angles to the work piece. It's important to set the swivel table at 90deg. to the wheel head spindle with a square and then put a



**Photo 28. Put a square in the vice jaws to align the side of the cut off wheel.**



**Photo 27. The cut off operation in progress.**

square in the vice jaws and align it with the side of the cut off wheel as in **photo 28**.

If you feed the work on to a cut off wheel with a significant run out you will get rapid wheel wear and a fairly disgusting phenolic odour from the resin binding the wheel together as it overheats and decomposes.

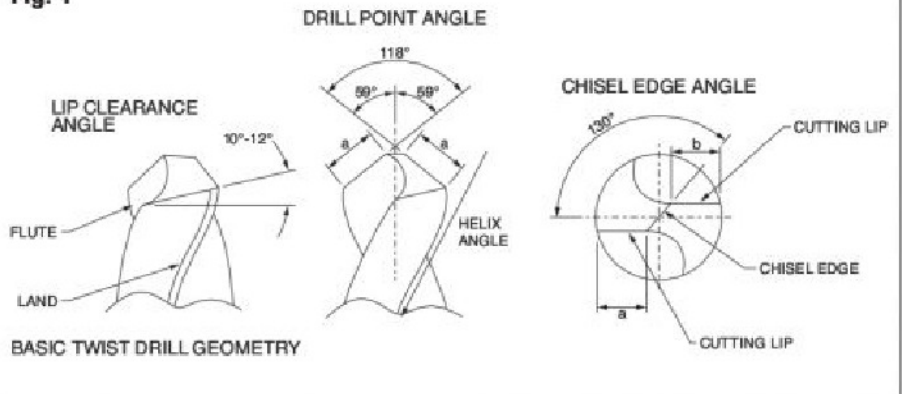
These cut off wheels seem to work best if you peck gently at the work and don't try to cut it off in one go. You will get a lot of grinding dust. I usually have to remove the side cover from the wheel to accommodate the vice.

The cut off surface is extremely smooth and uniform.

#### 8) Twist drill sharpening

I'm sure that to some, the use of a tool and cutter grinder to sharpen drills is a total over kill. I used to think that way but I've been converted, for precise drilling at least. Due to the need to carefully study drill bit forms and damage before commencing re-grinding, I have become much more aware of different drill

**Fig. 1**



formats. (And I'm still learning!) Twist Drills are deceptively complex.

There is a lot to be said for maintaining two sets of drills in your workshop: an everyday set for rough work where the final hole diameter isn't critical and a precision set or sets for tapping, precision drilling, deep drilling and drills modified to deal with difficult materials.

Get an eyeglass (watchmaker's loupe) and critically examine the drill to be re-sharpened. Can you see evidence of wear, point thinning and multi facet sharpening? Has somebody re-sharpened it before? See Fig. 1 for some terms.

The close up, **photo 29** shows the sort of horror story that you might encounter. This example came from severe industrial use, but was successfully re-sharpened on the Clarkson. The cutting edges are chipped and worn and the centre chisel almost destroyed.

It's important to decide what type of drill you are about to re-sharpen. What was it made for in the first place? Close up **photos 30 and 31** show different drill point styles. The lip clearance in **photo 29** is conical, in **photo 30** there are 2 facets and 6 facets in **photo 31**. Manufacturers use all sorts of in house codes for drill sharpening styles. The generic names Split Point and Modified Split Point are common in quality drills as in **photos 30 and 31**.

**Table 3** might help you decide what you are attempting to re-sharpen, but it certainly isn't definitive. Note that there are at least 3 helix angles in commercial use. Every drill manufacturer will have their own solution to a drilling problem and you will see a large variation in the web shape and thickness when viewed from the cutting end. This has a big effect on drill point styles.

Measure the drill point angle of the drill you are going to re-sharpen. I usually use a gauge, **photo 32** provided with the J&L Black Book. There are many useful and not too deep references you could follow up if needed, **Ref. 24**.

**Ref. 25** is Graham Howe's very interesting web page on home shop drill sharpening by several methods and jigs. You may have to look up manufacturers' websites for variations in drill profiles.

**Photo 33** shows a "reliance" style drill sharpener mounted on the Clarkson. This is actually a new purchase from Axminster, **Ref. 22** simply because I seldom got good results from this style of sharpener when used on the side of a bench grinder. These are pretty cheap and I decided on a fresh start. **Table 4** gives the method.

This style of sharpener produces a conical point relief and easily achieves two cutting edges of equal length and angle; very important for good drilling performance. Experimentation is the order of the day, with test drilling into a scrap block of low carbon steel to see how things are going. You should see two equal width ribbons of swarf emerging from the drill cutting edges and end up with a hole close to the drill diameter.

Adjustment of the setting finger and the degree of drill point overhang were the biggest problem variables in my setup. Once you have got your technique sorted out you can rapidly sharpen a lot of drills in a short time. The drill overhang in relation to its diameter influences the lip clearance angle you end up with after sharpening.



**Photo 29.** This drill has suffered from severe industrial use.



**Photo 30.** Four facet sharpening.



**Photo 31.** Six facet sharpening.

**Table 3**

Drill Point Angle	Lip Clearance Angle	Helix Angle	Work Piece
118°	10-12°	35-40°	Mild Steel: General purpose jobbers drills.
118°	9°	45-50°	Extra long drills. (Crankshaft Drills)
118°	15°	22.5°	Aluminium, Brass & Soft Bronze
135-140°	7-9°	22.5°	Tough steels: High Tensile Steels.
130-135°	7-9°	22.5°	Stainless Steels:
100°	12°	22.5°	Copper and some Copper Alloys
118°	17°	22.5°	Bakelite, Plastics, Moulded Materials
60°	12°	22.5°	Wood, Hard Rubber & Fibre



**Photo 32.** A gauge provided with the J&L Black Book.

With care, drills from about 3mm to 19mm diameter can be sharpened. The jig can't handle long drills, over about 180mm in my case, which is very limiting if you want to sharpen Morse taper shank drills and long series drills. Larger versions of this jig are said to be available to deal with longer and bigger diameter drills.

I have found that the results I get depend a lot on the type of web shape and helix angle formed on the drill when it was manufactured. When re-sharpened the two cutting edges should be straight but if you re-sharpen at a different point angle from the original, a curved cutting edge can result. This seems to be mostly a problem



**Photo 33** A Reliance style drill sharpener.

with "modern" high production drills sourced from a local factory using CNC machining centres. Many of these drills by manufacturers like Guhring, Dormer, and Titex that I have "acquired" have drill point angles of 135 to 140deg. and thick strong webs and are intended for drilling tough materials like stainless steels.

I think the failure to deal with small size drills stems from the inaccuracy of the indexing finger and the clamping device. Also you need magnification and good lighting.

I find that some cheap HSS imported drills actually improve in performance if you sharpen them straight out of the box.

**Table 4**

Operation - Drill Sharpening, Reliance Jig	
ABRASIVE WHEEL	WA80 -JV1 Straight Cup
WHEELHEAD	Adjust height so drill bit is approximately at centre height
Table	Set at 90° to wheel head spindle
Top swivel plate	Set to 0°
Drill grinding fixture	Mount at 90° to wheel face. Set drill point angle. Set drill overhang to 1 drill diameter, set finger so the drill cutting edge to be ground is vertical.
Feed	Lock the rack and pinion. Use cross slide feed. Swing drill point from centre of wheel outward. Return at same setting. Rotate drill and repeat on second lip.
Notes	Resist the temptation to take too big a cut with the cross slide feed. <0.25mm (0.01") is an absolute maximum for a 10mm drill. Smaller drills need smaller cuts.

OK, so this removes the TIN gold coloured coating, but this is so badly applied in some cases I doubt its presence is much more than cosmetic. You have only got to compare the appearance and feel of a cheap import against a quality drill. The cheap stuff is rough on the flutes and has very dull coatings. I know that some will maintain that it's not worth re-sharpening drills, especially small sizes and cheap imports. It's your choice!

**10) Thinning the drill web and the drill point**  
It is said that twist drill webs get thicker towards the shank so if you shorten a drill the web thickness will increase, leading to a longer chisel edge. The longer the chisel edge the higher the drilling force.

Occasionally you will come across an old drill that has been repeatedly used for

shallow holes and this leads to wear of the drill land close to the point. When you attempt to drill a deeper hole the drill has a tendency to dangerously jam in the hole. The only remedy is to scrap the drill or grind away the tapered bit at the end and then re-sharpen.

If you drill from a lathe tailstock with a long slender drill you can often see the drill flute "unwind" as the hole gets deeper and the torque increases. Longer "crankshaft drills" (intended for boring oil ways) are extremely useful in the lathe tailstock and are usually made with thicker webs to withstand this winding action. Similarly, some drills made for tough materials have thickened webs by design. Many of the import drills have very thin webs, perhaps to save on material and to avoid point thinning when sharpening. (Or maybe they just copy from each other!)

The chisel edge at the centre of twist drills has a negative cutting angle and it needs a lot of force to push the chisel edge into the work. In some workpieces work hardening can occur and friction heating follows. Because the chisel edge is flat it provides very little self centering action. We often drill a small pilot hole and then open it up with a succession of larger twist drills because the follow-up drills are not cutting with their chisel edges. Once a pilot hole has been drilled the chisel diameter of the next drill isn't cutting and drilling forces tend to be less. This is particularly noticeable when drilling from the tailstock on a lathe. Examination of the drills described above show that many have thinned points, see **Photos 30 and 31**. *To be continued.*

**References**

- Ref. 20 Engineers Black Book ISBN 0-9580571-1-1-7 and Norton grinding wheels are available in the UK from [www.msclindustrial.co.uk/cgi/insrh.m](http://www.msclindustrial.co.uk/cgi/insrh.m)
- Ref. 21 MEW 139, 140 by M.Christiaens
- Ref. 22 Warco <http://www.warco.co.uk/index.aspx>
- Ref. 23 Axminster <http://www.axminster.co.uk/>
- Ref. 24 Drill references: Tubal Cain "The Model Engineer's Handbook" ISBN 978-1-85486-134-4. Also by Tubal Cain (T.D.Walshaw) "Drills, Taps and Dies" ISBN 0-85242-866-9 Workshop Practice Series No12. Also Harold Hall's "Tool and Cutter Sharpening" ISBN 1-85486-241-3 Workshop Practice Series No 38. These books are all available from [www.myhobbystore.com](http://www.myhobbystore.com)
- Ref. 25 [www.homepages.mcb.net/howe/Newssmalldrill.htm](http://www.homepages.mcb.net/howe/Newssmalldrill.htm)

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# A Clarkson Tool and Cutter Grinder 4

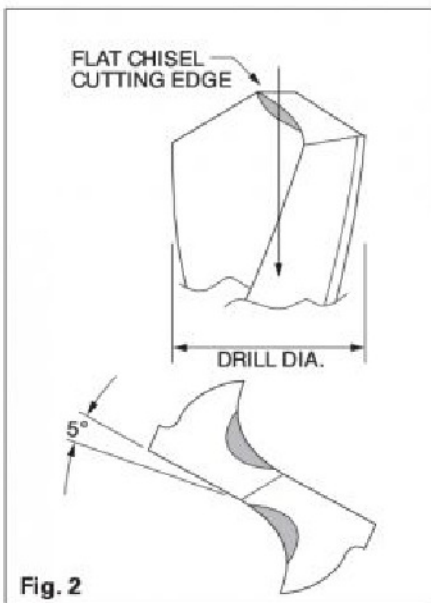


Fig. 2



Fig. 3



Photo 34. The Clarkson/March drill point and tap lead grinding attachment.

Mike Houghton finishes looking at drill sharpening and introduces the Clarkson method of sharpening the end teeth of milling cutters etc using the Clarkson system of sleeves used in the Universal Head and his own adaption's using collets.

Unfortunately I don't own a Clarkson Drill point grinding attachment; they occasionally appear for sale at ridiculous prices. However, I do have a copy of the March operator's booklet and the following drawings are taken from that. See Figs. 2 and 3. Photo 34 shows the Clarkson/March drill point and tap lead grinding attachment mounted on a Mk1 machine. You will notice that Clarkson/March use a rather expensive precision six jaw self-centering chuck to hold the drill by its flutes. To copy the Clarkson attachment would be a large task and I opted for a 3 way vice holding a 5C collet block that is inexpensive and more than accurate enough for our purposes.

I have used ER32 collets in the range 0.5mm to 20mm mounted in an ER32 to 5C collet adaptor, which in turn is mounted in a 5C collet block. The various parts are shown in photo 35. Much of the drill



Photo 35. 5C collet holder blocks used for holding cutters.

sharpening that follows uses this arrangement. The ER32 to 5C adaptor conveniently has a shoulder with 2 flats that can be seated against the ground bottom edge of the three way vice.

My method uses the set-up shown in photo 36 and can thin the web or produce something like the commercial modified split point. I have set the drill at an angle of 55deg. and raised the wheel head. The angle of 55deg. elevation is outside the engraved scale on the vice. These scales are in any case hard to read and I have "cheated" by using a digital angle gauge from Machine DRO. Ref. 26. This device,



Photo 36. The setup for thinning the web.

Table 5	Operation - Web Thinning/Point Thinning
ABRASIVE WHEEL	WA80 -JV1 Straight Cup, dress small radius on edge.
WHEELHEAD	Adjust height so drill bit is approximately at centre height
Table	Set at 90deg. to wheel head spindle
Top swivel plate	Set to 0deg.
3 way vice	Mount at 90deg. to wheel face. Mount drill in ER32 collet and 5C adaptor. Mount adaptor in the 5C square fixture. Mark 2 opposite faces of the block. Place fixture in the vice and slide backwards to rest adaptor flange against the bottom edge of the vice. Use digital angle gauge to set vice at 55°. Adjust drill bit projection so the wheel misses the vice. Adjust drill rotation in ER collet by eye for thinning you require.
Feed	Lock the rack and pinion. Use cross slide feed. Feed in cautiously; adjust the rack to get correct cut into web. Lock the rack. Note the slide reading and withdraw. Turn the collet block over and reseal against flange. Slowly advance the slide feed to the noted position.
Notes	Resist the temptation to take too big a cut with the cross slide feed. <0.1mm (0.004in.) maximum

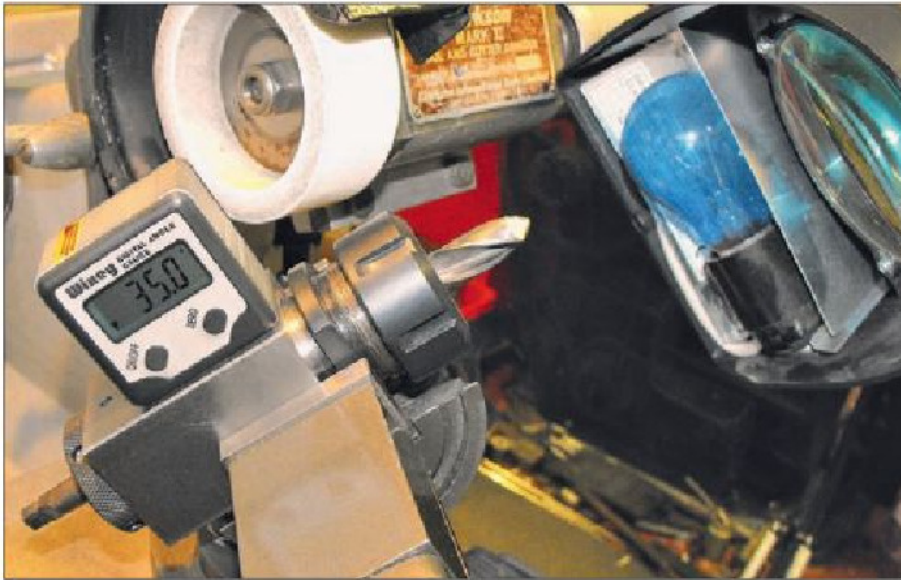
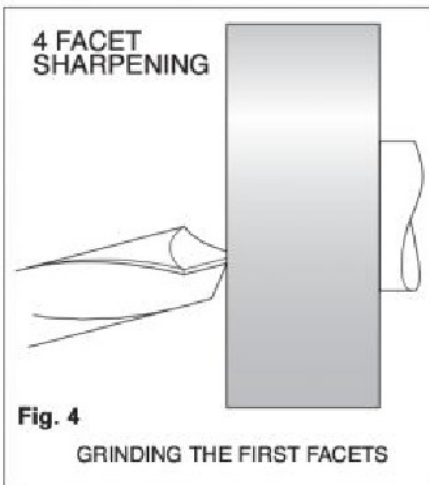


Photo 37. Using a digital angle gauge.



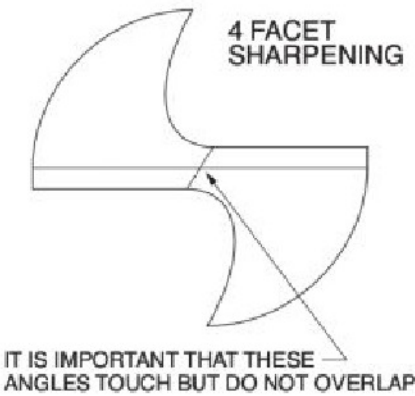
which has a magnetic base, is shown in **photo 37** and will appear in several set ups that follow. There are several points to note. Any length of drill that can be held in an ER32 collet can be sharpened. The block can be removed to observe progress and replaced. The light and lens shown is there for just that purpose. **Table 5** describes this web thinning operation as shown in **photo 36**.

The results from this system are good and the system is flexible enough to achieve the Clarkson style web thinning and/or point thinning or both. My operating description will have to be adjusted to get the result you want. There is no need to tightly close the ER32 collet, just hand tightening is sufficient as the grinding forces are low. **Photo 38** shows a 135deg. drill sharpened on the reliance type jig with thinning of the web and point. The performance of this drill is better and has a lower drilling force, but it does not self center any better.

#### 11) Four Facet Drill sharpening

In his book on the Quorn Prof. Chaddock describes four facet drill sharpening, but not the conical point relief. **Figs. 4 and 5** show the concept of grinding four flat facets and the effect on the drill point. The chisel edge becomes an apex of two edges instead of a single flat edge, which improves drill centering. The point is effectively thinner than it was. The primary clearance used by Prof Chaddock was 10

Fig. 5



to 12deg. and the secondary clearance 25 to 30deg.

Clarkson provide a four facet sharpening method for their drill point sharpening attachment. They use the angles 6 to

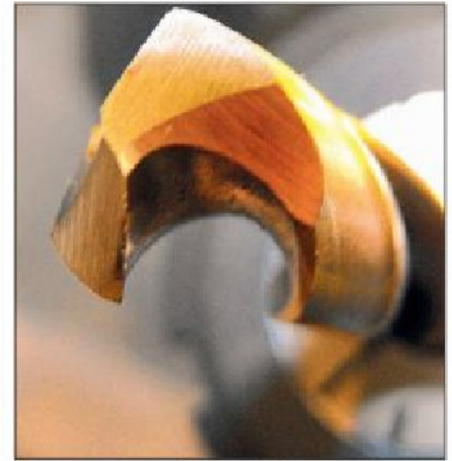


Photo 38. A 135deg. drill sharpened on the reliance type jig.



Photo 39. A drill sharpened using the four facet method.

10deg. for the primary and 35deg. for the secondary. The choice is yours. I have been able to sharpen by the four facet method using the collet adaptor and block described above. To prevent grinding on a wide surface of the wheel, Clarkson swivel the bottom casting 1 to 2deg. to transfer

Table 6 Operation - 4 Facet Drill sharpening.	
<b>ABRASIVE WHEEL</b>	WA80 -JV1 Straight Cup
<b>WHEELHEAD</b>	Adjust height so drill bit is approximately at centre height for each facet.
<b>Table</b>	Set at 90deg. to wheel head spindle then move 1 to 2deg. anticlockwise.
<b>Top swivel plate</b>	Set to 0deg.
<b>3 way vice</b>	Mount at 59deg. to wheel face. (118deg. drill point). Mount drill in ER32 collet and 5C adaptor. Mount adaptor in the 5C square fixture. Mark 2 opposite faces of the block. Place fixture in the vice and slide backwards to rest adaptor flange against the bottom edge of the vice. Use digital angle gauge to set vice at 10deg. Adjust drill bit projection so the wheel misses the vice. Adjust drill lip orientation to horizontal. For the secondary clearance set the vice to 30deg. inclination and raise the wheel, repeat as before.
<b>Feed</b>	Feed with the rack and pinion. Advance the cross slide until a cut is obtained. Turn the collet block over and reset against flange. Feed with the rack and pinion and observe the new edges. If a lot has to be removed to create a new primary edge you may have to rotate the drill in the collet to make the new edge horizontal.
<b>Notes</b>	Resist the temptation to take too big a cut with the cross slide feed. <0.1mm (0.004in.) maximum. If the primary and secondary facets are not parallel a small adjustment of the drill in the collet may be required. Smaller drills require smaller feeds.

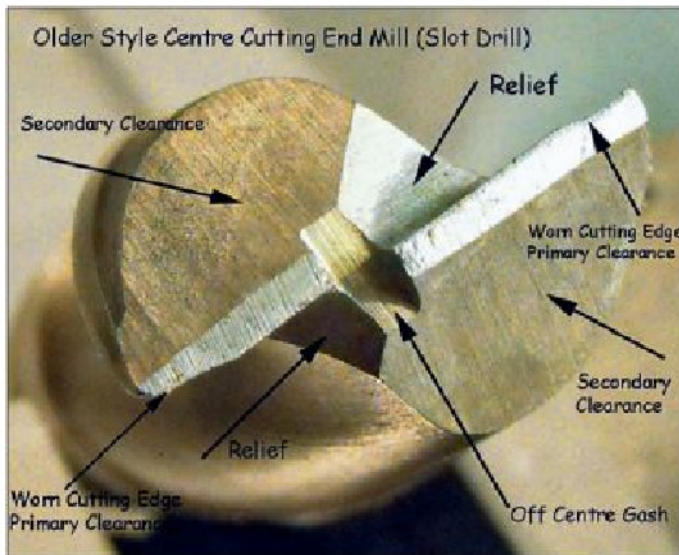


Photo 40. A two flute slot drill.

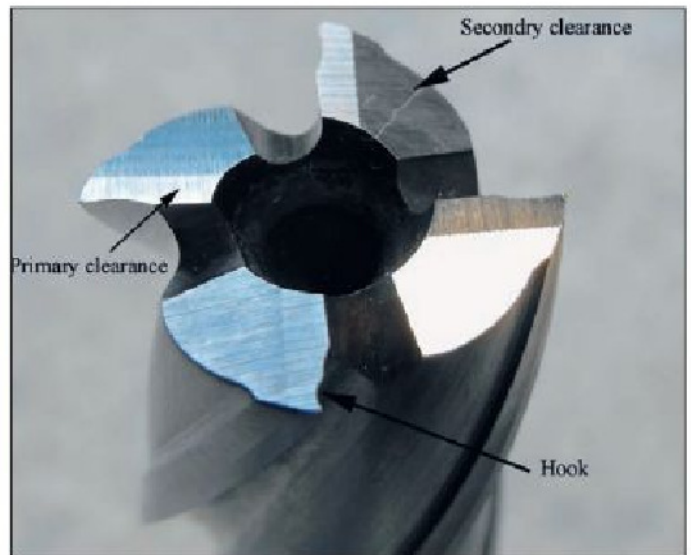
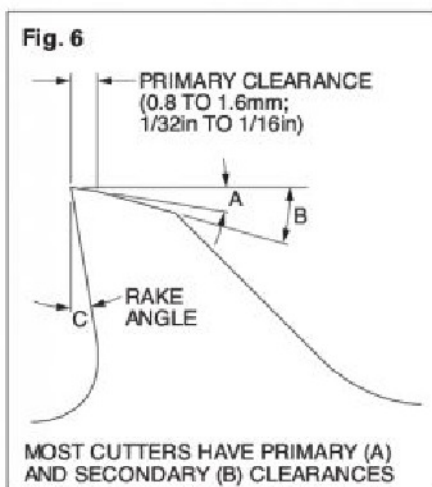


Photo 41. Four flute end mill.



the grinding action to the edge of the wheel. When I come to describe lathe tool sharpening in a later episode this is the approach to adopt; it reduces rubbing which just generates heat.

Photo 39 shows an old 35/64in. 1MT drill with an unusual web design that I sharpened to a 100deg. point by the four facet method. Although the lip shape isn't perfect, more practice is required, it self centres very well and drills smoothly from the tailstock into low carbon steel. The tapered first facet is probably because the web wasn't designed to be sharpened at this point angle. The final sharpening cuts by the four facet method have to be very cautious with frequent close examination of what's going on. You can get curved cutting edges if the drill point is ground at an angle the manufacturer didn't intend. I

don't think the four facet method makes a lot of difference for drills below about 6mm; otherwise it's worth the effort for precision hole drilling.

### 12) Six Facet Drill Sharpening

See Ref 27. for Derak Brown's description of this modification. The angles used are 10, 25 and 45deg. I need to do some more experimentation to assess if this modification is worth the extra effort. The end result isn't unlike some of the commercial modified split drills.

### 13) Basics of milling cutter design.

You should closely examine any cutter you propose to re-sharpen with some sort of magnification before you decide on a course of action. It's a good idea to have a new cutter of the same design to compare with the used one.

The clearance and rake angles vary with the manufacturer and the material to be worked, Fig 6. Photo 40 shows a used older style HSS 2 flute slot drill (centre cutting end mill). You should be able to see the two sharpened facets (clearances) to each cutting edge plus the off centre gash. The 2 primary cutting facets are unequal in length to provide centre cutting and the secondary clearances have been relieved to provide better chip clearance and to provide a rake angle. The primary facets are worn, with most of the wear concentrated at the end of each cutting tip. This cutter has almost certainly been (badly) re-sharpened before and is fairly typical of the sort of used cutters you will come across. Photo 41 is a slightly used 8% cobalt HSS 4 flute end mill. You can easily see the primary and secondary clearances on each tooth plus a hook shape to the outer edge of the cutting edges. This is produced by the flute shape and could be there for easier cutting of long chipping softer metals. You will come across other styles of end mills that do not have secondary clearances, so be careful. Photo 42 shows a Hall Powerbor® cutter, as used with magnetic base "broaching" machines. These cutters are usually used on structural steel and have no secondary clearance but a very obvious hook shape to the teeth. These cutters are used to bore large holes, the solid centre being ejected once the cutter has passed through the workpiece.

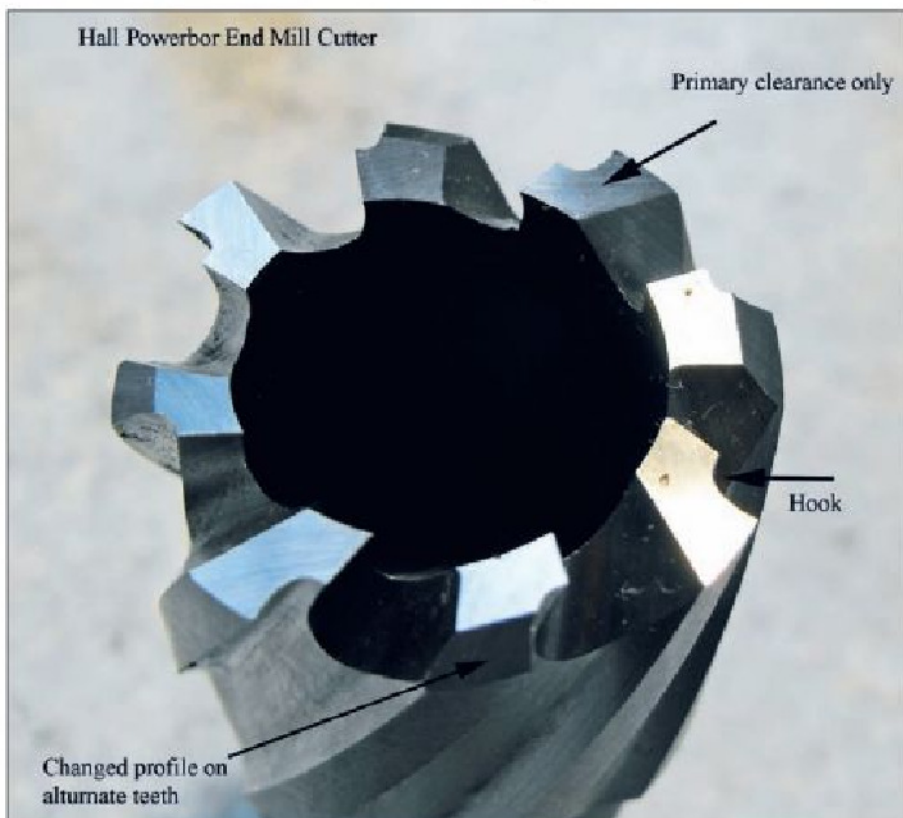


Photo 42. Hall Powerbor® cutter.

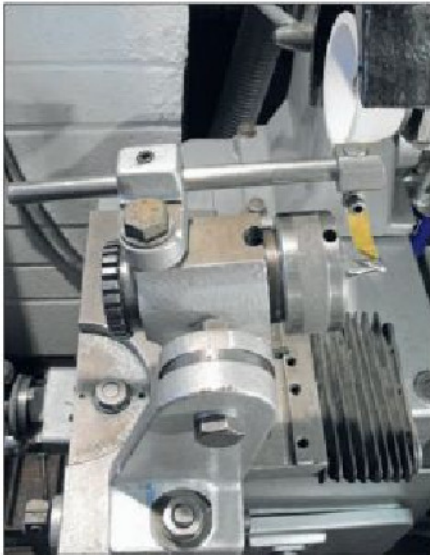


Photo 43. The Universal head mounted on the table.

#### 14) Sharpening the end teeth

Assuming for the moment that we have no damage to the flutes and only the end teeth need to be re-sharpened. The Clarkson standard equipment consists of a Universal Head and some form of tooth rest to index the cutter teeth. **Photo 43** shows the Universal head mounted on the table with the general tooth rest mounted on top. In my MK2 machine the Universal head has been bored out to accept a non-standard collet holder, for which I have a set of 5 imperial collets which I have been unable to identify. They have a very small clamping range. The original Clarkson sharpening system utilised adaptor bushes for each cutter shank diameter and parallel concentric sleeves that slid into the Universal head. Indexing of the cutter was by a tooth rest. **Photo 44** shows a group of genuine Clarkson sleeves and bushes. If you could look closely at them, they are each etched with the Clarkson Logo and a part number. Bushes were available to suit all the standard imperial and metric milling cutter shank sizes plus Morse taper sockets and a regrind mandrel for saws and side and face cutters, shown centre back. My problem was these sleeves were un-usable because my universal head had been bored out to 1.625in. and the standard Clarkson sleeves are 1.250in. The Stent, being based on the Clarkson uses sleeves based on 1.000in. dia. The Clarkson sleeves are deceptively simple and were obviously turned, hardened then ground to very precise sliding fits in each other. I have turned a number of sleeves to accept R8, ER32, 5C and a reducing sleeve to use the Clarkson sleeves and bushes shown above. The starting material was a metre of 2.25in. 20 carbon steel from a local shop said to be En3 Ref 28. An interesting exercise in parallel turning and a lot of swarf! The internal bores were finished with a brake cylinder hone. The desired fit is a smooth slide with no shake.

**Photo 45** shows some of the sleeves and commercial 5C and ER32 to 5C adaptors. ER32 will take collets up to 20mm, the larger sizes having a closing range of 1mm and those below 3mm, 0.5mm. 5C collets go to at least 1 $\frac{1}{4}$ in. dia. but beware the collet body will only pass about 25mm.



Photo 44. Genuine Clarkson sleeves and bushes.



Photo 45. Commercial sleeves and adaptors.

The reason for making an R8 adaptor is to mount tooling I use on my vertical mill, particularly arbors for slitting saws. Both 5C and ER32 can grip milling cutters over their flutes and this is necessary because the distance between the wheel and the universal head is fairly small. Hence sharpening long cutters that will pass through the collets are not a problem.

Sharpening the end teeth of milling cutters is one of the easiest of operations, provided you take the time to set the machine up correctly before you start grinding. **Table 7** summarises the operations, but a bit of additional information is in order. The Clarkson swing table has no angular calibration, a total pain I find, so I commence by setting a large angle plate on the top swivel plate set at zero degrees and use this to set the wheel parallel to the table. Having mounted the universal head on the machine with a piece of ground rod in the collet I use a square to check that the rod is perpendicular to the wheel, **photo 46**.

Although the universal head has no adjustment at the base, there is sufficient

play in the table slot and base tongue to make a careful clamping of the base necessary. Having got the head aligned you then rotate the top swivel plate by about 1deg. to leave the cutter front teeth concave, so they only cut on the periphery. If you stand a sharpened cutter on its end on a machined surface you should be able to see daylight through the centre of the teeth. It should also be standing vertically on the outermost point of each tooth, unless it only has 2 teeth!

Clarkson quotes primary clearances of 8deg. for end mill cutters below 20mm and 6deg. above that size. Secondary clearances for cutters above 20mm are given as 15deg. but I have seen bigger numbers elsewhere.

Clarkson advises operators to make their own tooth rests from bits of hacksaw blades, **Fig 7**. I prefer springy brass for end mills so the cutter tooth can be advanced past the tooth then moved backwards to find the new position against the rest.

Once you are set up and getting good results a lot of milling cutters can be sharpened in quite a short time. Try out

Table 7 Operation - Milling cutter end teeth sharpening	
<b>ABRASIVE WHEEL</b>	WA60 -JV1 Flaring Cup (shape11) 100mmdia x 40mm deep. No wheel extension. Dress the wheel cutting face.
<b>WHEELHEAD</b>	Adjust height so milling bit is approximately at centre height of wheel.
<b>Table</b>	Set at 90° to wheel head spindle
<b>Universal Head</b>	Mount at 90° to wheel face. Elevate head to obtain primary or secondary clearance angle. (use of digital angle gauge preferred) Install collet or sleeve and cutter to be sharpened. Install tooth rest support and select a suitably shaped tooth rest. Adjust first milling cutter tooth edge to be horizontal.
<b>Top swivel plate</b>	Set to 1° to give teeth slight concavity.
<b>Feed</b>	Cautiously advance the cross slide so a slight cut is produced when the rack and pinion moves the cutter across one tooth. Grind only one tooth at a time. Rotate the cutter to the next tooth and repeat. Remove the sleeve and cutter to observe progress. Replace and repeat.
<b>Notes</b>	Resist the temptation to take too big a cut with the cross slide feed. <0.025mm (0.001") is an absolute maximum for a 10mm cutter. Smaller cutters need smaller cuts. Go around all the cutter teeth until no further material is removed. Least is best to extend the life of the cutter.

<b>Table 8 Operation - Milling cutter- end mill, re-cutting end teeth</b>	
<b>ABRASIVE WHEEL</b>	WA80 -M6V Saucer Shape 13 or 12 Dish 100mmdia x 10mm deep. Fit wheel extension. Dress the wheel cutting edge to profile.
<b>WHEELHEAD</b>	With the wheel stationary adjust the wheel height to enter the existing
<b>Table</b>	Set at 90° to wheel head spindle
<b>Top swivel plate</b>	Rotate to approx 90°. Adjust with static wheel to produce positive rake to tooth.
<b>Universal Head</b>	Mount to left of the table. Install cutter in a collet. Elevate head and rotate collet to obtain a close fit to the existing gash in cutter. Adjust rotation of cutter to give a good engagement in the existing slot. Install tooth rest support and select a suitably shaped tooth rest. Adjust to index against the positioned tooth.
<b>Feed</b>	Bring the wheel slowly downward into the cut and note the depth. Rotate to the next tooth and repeat.
<b>Notes</b>	Resist the temptation to take too big a cut. Feed the wheel down slowly. If need be, advance the cross slide by a small amount <0.025mm (0.001") to produce a clean positive rake to the cutter teeth. Go around all the cutter teeth until no further material is removed. Least is best to extend the life of the cutter.



Photo 46. Checking for square.

the ones you have sharpened; most tool makers in industry never used the tools they sharpened for others (but they got plenty of flack if they weren't any good). The moral has to be, resharpen tools early and frequently for the best performance on the machine. Even if you don't get the primary relief quite parallel with the cutting edge, so long as the edge is sharpened it will cut well.

#### 15) Recutting end teeth on end mills.

A time will come when repeated re-sharpening has removed so much cutting

tooth that the cutter will have to be recut between the teeth. The idea is to cut the front of the tooth to a positive rake of about 10deg. The best wheel profile to use is found by offering different wheels into the existing slot when the wheel is stationary, photo 47.

This testing also gives a good indication of the angle that the cutter must approach the wheel. I usually find that a 15deg. taper wheel gives the best results, the white wheel in the photo probably needs to be dressed to a better shape. It's worth keeping a wheel for just this operation. Notice the brass indexing finger.

The sharpening sequence is described in table 8.

The next stage should be to re-sharpen the cutter end teeth, described above. I usually sharpen the secondary relief first then follow with the primary. If you grind a "lot" away the cutter may have to be rotated slightly to allow for the helix angle of the flutes.

#### 16) Recutting end teeth on centre cutting end mills

Older style 2 flute slot drills photo 48 require two recutting operations. I usually cut the longer of the 2 teeth first trying to leave the cutting edge radial, using a flat wheel. The cut is made by lowering the wheel into the existing cut to deepen it.



Photo 47. Checking for best wheel fit.



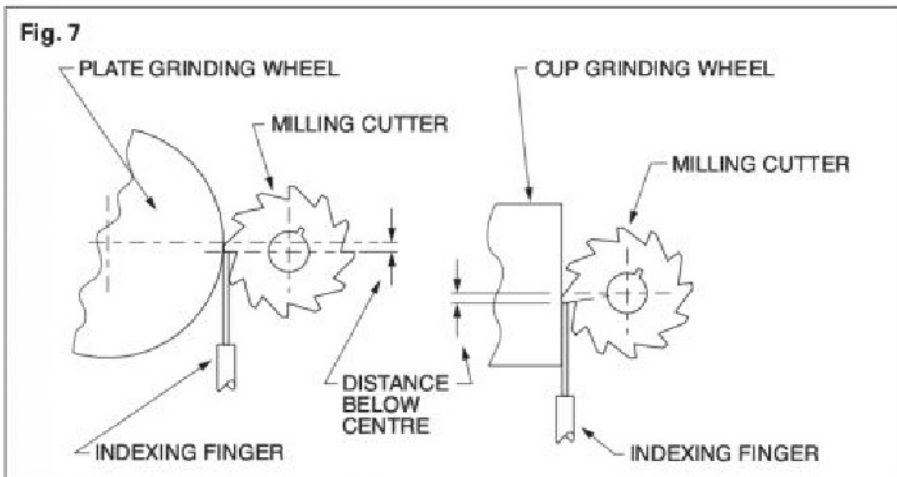
Photo 48. Old style slot drill.

This takes some practice, especially as you have to maintain the positive rake of the cutting edge. Repeat for the shorter cutting edge, which is supposed to lag slightly behind the centre. Again difficult to set up, but worth ruining a few old cutters to work out how to do it. Finally the central gash is made with a very narrow cut off wheel or a thin dressed dish. The secondary and primary clearances are then sharpened as described above. There are a number of centre cutting end mills available with 3 flutes, one cutting edge being longer than the other 2. These cutters will probably require a dish to recut the leading edges of the teeth.

#### References

- Ref. 26 [www.machine-dro.co.uk/](http://www.machine-dro.co.uk/)  
 Ref. 27 D.A.G Brown, Model Engineer p38 7January 1993; p152 4 February 1994; p194 16 August 1996; 20 September 1996; 20 December 1996.  
 Ref. 28 <http://www.oldengine.org/members/diesel/Tables/steel.htm>

To be continued.



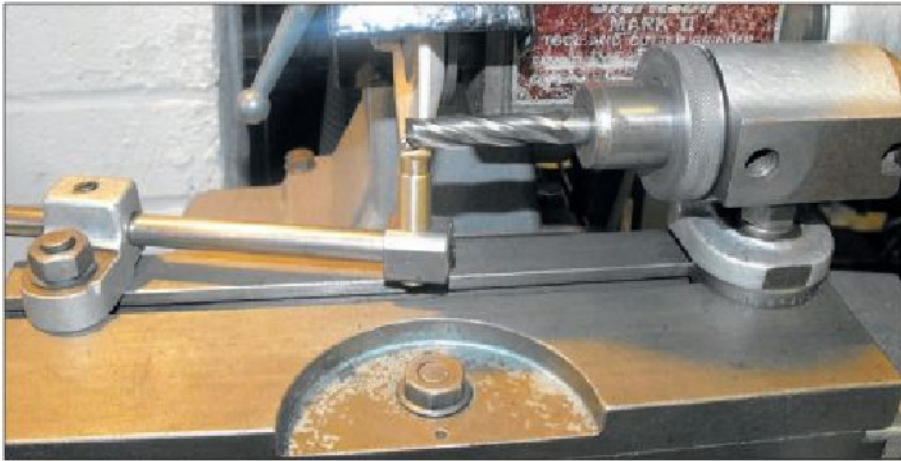


Photo 52. Using the universal head.

**Warning:** after sharpening, the flutes can seriously cut your fingers, they are razor sharp.

Should your milling cutter not have centres at both ends, the cutter can be held in a collet or sleeve in the universal head. If you decide to use a collet, you should be using the fixed tooth rest detailed above. Using the Clarkson collet system allows one to use a tooth rest attached to the table and to advance the cutter being ground by sliding and twisting the cutter against the tooth rest as it traverses the wheel. Unfortunately the centre height of the universal head when mounted on the table, with its graduated circular base is only 2%in. (approx 67mm) so you have to allow for this when adjusting the wheel head centre height. Photo 52 shows the set up, which is used in a very similar fashion to the between centres method described in detail above except the tool and sleeve slide left to right across the face of the wheel. I have found a few problems with this method. To sharpen cutters smaller than 10mm dia. you need a grinding wheel greater than 125mm dia. otherwise the head fouls the wheel head. The way around this is, as above, to rotate the bottom swivel by say 10 degrees clockwise. The index fingers need very careful positioning and shaping to get under the tooth being sharpened and under the point where the wheel strikes the cutter flute, especially for cutters below 10mm.

Clarkson introduced an air bearing flute grinding attachment but unfortunately I only have the booklet! The idea of an air bearing is to reduce the "stiction" and make the movement of the tool over the wheel very free. Probably for really small cutters grinding on the side face of a cup wheel would be easier. Results show that cutters with resharpened flutes and end teeth really give a good performance and are worth the effort, especially in the larger, more expensive sizes.

#### 18) Resharpening slitting saws

I use quite a lot of these HSS saws in my vertical mill. They get through a lot of work but eventually, well quite quickly really, become blunt and accumulate in the drawer. I seem to have a large number of bore sizes, both metric and imperial and hence the R8 holder was made. R8 fits the mill of course. The Clarkson sleeve I have is only for 1in.

bore saws and mills. There are a lot of inexpensive imported slitting saws about, which if you examine them closely, seem to have never been tooth sharpened after hardening! The clearance(s) are not bright. Some when used on the mill only cut on some of the teeth, probably because their bores are slightly off centre? A properly sharpened slitting saw should "sizzle" when it hits the workpiece, with all the teeth cutting.

The tooth shape on slitting saws follows the primary, secondary and rake angles given in the table above. Normally, I only resharpen the primary relief.

However, many smaller saws with small teeth show only one sharpening angle. Photo 53 shows the set up. Because the space for the indexing finger between the wheel and saw are so small, the brass finger is shaped to come in from the side.

By mounting the finger to the right of the saw the saw arbor can be moved left, indexed round and the next cut made with the rack and pinion in seconds. The hook shaped tooth rest is shown in photo 54. The only limitation to this method is on larger diameter saws with very fine teeth. You may notice that having gone round all the teeth of a saw the wheel no longer cuts. This is simply because of wheel wear, for the best work it's good to advance the wheel again and go around a second time.

#### 19) Resharpening side and face cutters

The peripheral teeth are tackled in the same way as the slitting saw above. Relieving the side teeth of a side and face cutter involves a bit of creativity! The older



Photo 54. The hook shaped finger for sharpening saws.



Photo 53. Sharpening a slitting saw.

Clarkson method was to mount the cutter on an arbor, work between centres and to raise the left hand centre on two small packing pieces to incline the arbour. In later operators manuals the universal head was used with a tapered cup wheel and the head inclined 3 degrees.

#### 20) Resharpening tee slot and key slot cutters

A typical small tee slot cutter is shown in photo 55. You will notice that the face teeth are angled alternately and there are no secondary clearances. Fortunately there is plenty of space between the teeth to work in. Using the universal head and a cup wheel it is possible to sharpen all the cutting edges on cutters of this type. As before, offer up a static wheel to the existing cutting facets to estimate the angles involved.

#### 21) Resharpening reamers

For reamers with Morse tapered shanks, Clarkson supplied sleeves. If the reamer has a good centre at each end, I prefer to use the centre brackets and centres described earlier for milling cutter flute sharpening. Obviously, if you sharpen the flutes of a reamer it will cut a smaller size. Old collections of reamers often show specimens with engraved marks indicating how much has been taken off by re-grinding. This flute regrinding could be OK if you are sharpening an old metric reamer down to the next imperial size (or vice versa) or you need a "special". There is a distinction between machine and hand reamers in that the lead length and angle differs. The lead is the tapered bit at the

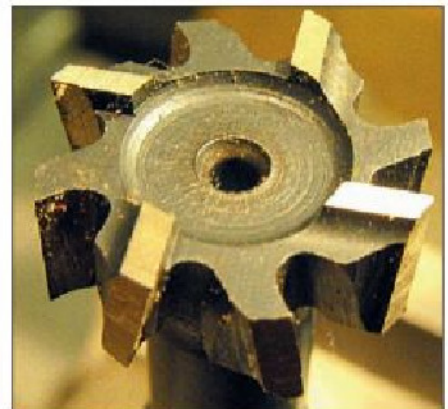
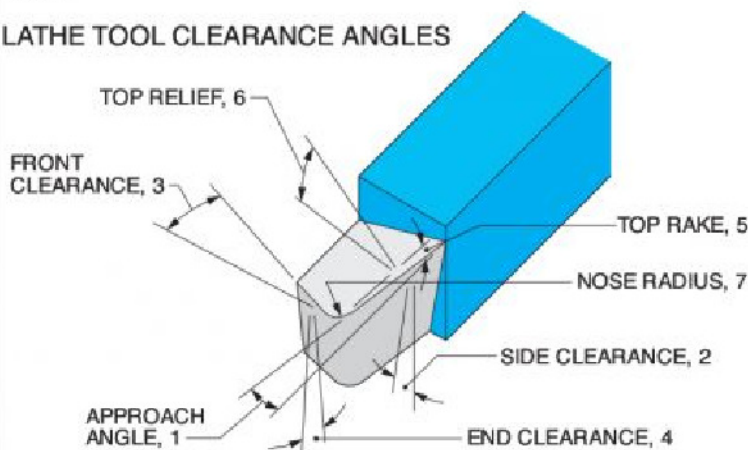


Photo 55. A typical Tee slot cutter.

Fig. 8

LATHE TOOL CLEARANCE ANGLES



entry end of the reamer. It can be safely sharpened without affecting the final diameter. In a hand reamer the lead can be 1 or 2 degrees and on a machine reamer up to 45degrees. These angles can be achieved by swinging the top swivel plate and sharpening with just a primary relief.

Further notes

If you decide to use an arbor in the Universal Head mounted on its bracket, you get the benefit of a greater centre height, 4in. on my machine, but corrections again have to be made when setting the wheel head height to produce clearances. The angular scale on my Universal Head was checked against the digital scale described in part 4 and found to be 2.7 degrees out, compared to the machine table.

22) Making and resharpening single point lathe tools

You are likely to find a mixture of turning tool materials in the average home workshop. Most probably they will be made from either solid High Speed Steel (HSS) or HSS butt welded onto a tool steel shank or carbide pieces brazed onto a tool steel shank. Few will have solid carbide lathe tools although they do exist and few will still use tools made from hardened and tempered 1+% carbon tool steel ("silver steel", "drill rod" etc). In these days of indexable carbide insert tooling it's easy to forget that the older HSS types work well under the sort of machining conditions we normally have in our shops and HSS can very readily be resharpened or reshaped for a "special" or one-off.

The traditional HSS resharpening method is offhand grinding on a bench grinder, so why use something more complicated? You only have to look at some collections of used and reground lathe tools to see weird clearance (relief, rake) angles, grinding marks from coarse wheels and "personalised" shapes. I will remember a very skilled machinist who would regrind a great deal of a new Myford butt welded HSS tool right out of the packet to achieve his preferred shapes. What a waste? Fig 8 shows a generalised drawing of the seven clearances (relief and rake) on a right handed (cutting to the left) lathe tool. The numbers 1 to 7 are the grinding order that some references seem to use, Ref. 29. To resharpen a used lathe

tool it will probably only require resharpening on at most four of the above. There seems to be quite a bit of variation in the use of the terms, rake, clearance and relief. I have tried to be consistent and use clearance and rake. The actual clearance angles should, for the best results, reflect the material being turned and the following is a typical guide for tool grinders, Fig. 9.

I have been using the three way 2in. vice described in part 3 of this series to hold lathe tools for grinding. For smaller tools, especially round ones, life is much easier if you mount the bit in a square or rectangular block and secure it with a grub screw with a flat on the shaft to aid relocation. You can grind the shaft flat on the Clarkson. My original blocks were made from 20mm square black bar; this fitted the lathe four way tool post. Lately I have moved to a quick change tool holder system on the Chester UK Craftsman that will only accept tools that are up to 16mm high so I now use blocks machined down to 19 x 16 x 90mm long. The additional length allows me to place a tool bit in each end, if necessary.

Photo 56 shows the three way vice set up for hand regrinding the clearances, rakes and the nose radius. As before the digital angle gauge is invaluable for setting the clearances. For general purpose use I use a 7degree inclination for the end and side clearances. The 10mm thick top plate shown has a square tongue attached to its underside so this can be clamped in the vice. You can see one of my small tool bits mounted in a block next to the digital gauge. This is a very rigid support for the tool bit and far superior to a bench grinder. Also, your average cheapie bench grinder has wheels that are too coarse A36/A60 and probably the wrong bond.

The wheel is a cup shaped white aluminium oxide wheel with the front edge dressed back at about a 5 degree angle so it only cuts on the outer corner. If I am roughing out a new HSS tool blank it can be quicker to do the preliminary grinding on a bench grinder then switch to the Clarkson for accurate angles. Don't use water to cool the tool bit as the shock can lead to cracking.

An 80 grit white wheel gives a better surface finish and hence edge to the tool than the bench grinder but it can be

Fig. 9



High Speed Steel Tool Angles

Material	End Clearance 4	Side Clearance 2	Top Rake 5	Top Clearance 6
Aluminium	9deg.	9deg.	30deg.	15deg.
Brass	7deg.	6deg.	0deg.	5deg.
Cast iron	5deg.	4deg.	10deg.	9deg.
Mild steel	8deg.	6deg.	20deg.	15deg.
Plastic	10deg.	8deg.	25deg.	25deg.



Photo 56. Three way vice set up to grind lathe tools.

improved upon for the best turned surface finish. I have been using a very fine diamond plate to "file" or "burnish" or "hone" lathe tool cutting edges straight off the grinder and it is just a small step to try diamond wheels on the Clarkson. The diamond plate is 600 or 1200 grit, available from Ref. 30. These steel plates have diamonds nickel electroplated on one surface.

23) Carbide turning tools

We have had carbide tooling for quite a number of years now. Initially as small pieces brazed onto tool steel shanks and more recently as solid carbide. See my series of articles on insert tooling in MEW 136 (March 2008) to MEW 139 (May2008) if you would like to read about carbides and how they are made etc. Traditionally carbide was resharpened using silicon carbide green grit abrasive wheels because the white aluminium oxide wheels described earlier in this series will not work. Silicon carbide dressing sticks can be used to dress and reshape white wheels. My Clarkson came with a number of Norton flared cup 85mm dia. Wheels marked 39C60-JOV. The marking follows

the convention described in part 3. i.e. Silicon Carbide, 60 grit, soft bond, 62% abrasive and a vitrified bond.

I have experimented with the set-up shown in **photo 56** with a green 60 grit silicon carbide cup wheel to "rough out" shapes in HSS for profile cutters, but found that the wheel wear was quite fast and the dressed shape was quite quickly lost. Similarly when I sharpened brazed carbide lathe tools on the same wheel the wheel soon lost its dressed shape and the edge appearance was rough and scratched.

**Photo 57** shows a 125 mm dia. resin bonded diamond wheel from **Ref. 31** substituted for the green grit one. This wheel does sharpen brazed carbide efficiently and leaves a better surface finish. I will give more details on Diamond wheels later.

Sharpening brazed carbide tools with a diamond is little different in process from HSS. Carbide tipped tools for turning often have a flat top and 7 degree side and end clearances and they are usually very simple shapes, which makes re-sharpening quite easy. Some cheaper tipped lathe and boring bars seem to improve in performance if they are re-sharpened before you use them! A used and re-sharpened tipped boring bar is shown in **photo 58**.

In **photo 57** you can see a 5C collet block held in the three way vice. To sharpen the second edge the top slide has been swivelled through 90 degrees, the tool inverted and the clearance reset.

#### 24) Diamond grinding wheels

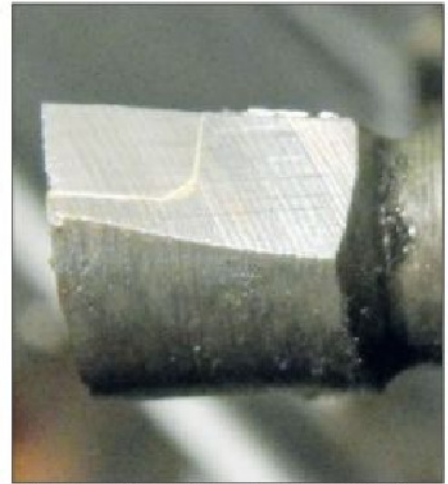
Along with Cubic Boron Nitride (CBN), Diamond wheels are often described as "Super abrasives". CBN wheels don't seem to have come down to a price where they can have home shop use, but they are very extensively used in industry. Diamond wheels seem relatively cheap and very available in smaller sizes although still perhaps twice the price of a white aluminium oxide wheel. Four distinctly different diamond technologies are available but only two of them are likely to find use in our workshops, **photo 59**. The wheel on the top is 100 dia. x 1mm thick, including the diamond layers that are on both sides. The actual diamond layer is approx 0.2mm thick and appears to be nickel electroplated. The wheel appears to be steel, magnetic. According to the supplier, Arc Euro Trade **Ref. 32**, the diamond mesh size is 200, usually written #200. The other two wheels are aluminium alloy with a resin containing diamond particles bonded on. The unused wheel in the box is a pink colour resin. After use, the colour dulls and becomes grey with metal particles, as in the wheel above it.

A quick survey of the 10 or so diamond wheels I have shows that only one, from Arc Euro Trade, actually has a description etched on it; all the others are unmarked! The box descriptions from either supplier are none too useful either. They usually describe the wheel shape and size and the dimensions of the resin cutting area.

e.g. D12A2 13x20x5x3 or WCW03 125\*32\*3285\*3. In both cases the 5X3 are the dimensions of the resin layer containing the diamond particles, that is, 5mm wide and 3 mm thick. In most cases there is no mention of the diamond concentration in the resin or its particle



**Photo 57. A resin bonded diamond wheel sharpening a carbide tipped boring tool.**



**Photo 58. The resharpened boring tool.**

size. Both of these are critical factors in my opinion. I have asked the two suppliers referenced and they are both asking their importers or manufacturers for more information.

My marked wheel is 12A2 100x13x20x5x3 C75 D150. The vital information is the D150, diamond 150 mesh size and the C75 the concentration of microdiamonds in the resin. 100 concentration is 72 carats of diamond per cubic inch of bond. High concentrations, 100, are very hard and will last longer but cost more. Low concentrations, 50, behave as a softer wheel.

See the very useful Argon website, **Ref. 33**, resin bonded wheels and the FEPA website, **Ref. 34**.

#### 25) Mounting and dressing diamond wheels.

None of my diamond wheels fit the Clarkson without bushes. You really need accurate bushes as any run out of the diamond resin or plated diamond disk is undesirable because dressing will remove the resin bond and there isn't much there. I have carefully turned brass bushes for my wheels to bush them down from 32mm or 20mm to 0.5in. They have to be as true as you can make them. I found that the plastic wheel bushes often supplied with white wheels are not accurate enough. The plated diamond cut off wheel in **photo 59** cannot be dressed as it only has a single diamond layer on the edge and both sides. These wheels are disposable and fortunately cost less than the resin bonded variety. I notice that "fleabay" has several Hong Kong suppliers listing these but be careful, some are intended for use on stone and on angle grinders.

Reshaping resin bonded wheels can be done with a mounted diamond, but you will seriously shorten the life of the wheel. It's a better bet to get a wheel that is as close to the profile that you need and use that, hence all my diamond wheels. Also, most resin wheels have only one small abrasive area. I have been dressing my resin bonded diamond wheels very lightly with a fine white aluminium oxide stick to remove resin and debris, **Ref. 33**.

#### 26) Diamond cut off wheels

My experience of these is based entirely on the wheel shown in **photo 59**. This



**Photo 59. Various diamond coated grinding wheels.**

wheel will cut off HS steel and solid carbide to give a very polished surface. The general set up was described in part 3. It will gash end and slot mills, see part 4 but is really too thin and square edged except for the smallest cutters. I was reluctant to use the sides of this wheel and made a 3mm aluminium alloy backing plate to mount behind the side being used for grinding. It seems to work. I have no idea what the life of this wheel will be.

Some of the websites of professional tool regrinders shows that they often manually modify carbide tool edges with a diamond hone, after diamond wheel sharpening. This particularly applies to solid carbide tooling. Of course they don't tell you how they do it! **To be continued.**

#### References

**Ref. 29.** Basic lathe tool sharpening <http://www.sherline.com/grinding.htm> also The Engineers Black Book ISBN 0-8580571-1-7 Sutton Tools Pty Ltd, Australia distributed by JLIIndustrial in the UK.

**Ref. 30.** <http://www.arceurotrade.co.uk/Catalogue/Diamond-Tools/Diamond-Stones>

**Ref. 31.** [http://www.rdgtools.co.uk/acatalog/DIAMOND\\_GRINDING\\_WHEEL\\_S.html](http://www.rdgtools.co.uk/acatalog/DIAMOND_GRINDING_WHEEL_S.html)

**Ref. 32.** [http://www.arceurotrade.co.uk/projects/d\\_wheels/dwdoc.html](http://www.arceurotrade.co.uk/projects/d_wheels/dwdoc.html)

**Ref. 33.** <http://www.btinternet.com/~argoncorp/resin.htm> Click on the brochure link to see advice on dressing diamond wheels.

**Ref. 34.** <http://www.fepa-abrasives.org/>

# A Clarkson Tool and Cutter Grinder 6

Mike Houghton concludes this series by finishing his look at diamond wheels, then looks at solid carbide tooling, "specials" and simple surface grinding on the Clarkson.

## 27) Resin bonded diamond wheels

I'm beginning to think that the resin layer on these wheels is colour coded. Those from RDG are a dark green and appear to behave as if they are a coarser grit than those from Arc Euro Trade which are a pinkish brown. **Photo 58** (last issue) shows a boring bar that was sharpened with a silicon carbide green wheel and then with an RDG diamond wheel. You should be able to see that the diamond wheel has almost removed the deeper and coarser scratches from the green wheel.

I have resharpened a number of brazed carbide lathe, boring and milling cutters with resin bonded wheels using the set-ups described earlier. In just about every case the end result cuts well and was worth doing. The ground surfaces appear to be polished and free of the grinding marks that a typical 80 grit white wheel will leave behind. This is probably indicative of a 150/200 grit wheel and is getting close to a "honed" surface finish. I notice the same effect when sharpening HSS tools with resin bonded diamond. In both cases the only restriction is the need for very light cuts. One remedy is to rough grind to shape on a 60# white wheel then complete the job with a resin bonded diamond wheel.

## 28) Solid carbide tools

Solid carbide has replaced HSS in many industrial applications, especially for working difficult materials at high speed. Solid carbide cutters have been used for engraving and printed circuit board drilling for some time and are readily available. The cost of carbide may take

your breath away, but used examples and new old stock from stores clearances do appear at times. Solid carbide is instantly recognisable because of its weight (density); something like 2x the density of steel and 15X that of water. Solid carbide tooling is sharpened on diamond or CBN wheels and the diamond wheels described above will grind it well. The clearances used for HSS seem to work for carbide. Used carbide, because it is so hard often shows different wear and damage patterns to HSS. For example **photo 60** shows an end mill that from this angle doesn't look too worn, but when viewed from the side shows extreme tip wear and chipping. **photo 61**. It's very debatable if this is worth re-grinding unless you are prepared to take the time to completely reshape the end of the cutter. With the cut off wheel you could recover the shank, which will be as hard as the rest of the cutter, unlike HSS, and reform it into a "special".

## 29) "Specials" and tool making

The traditional method of shaping tools from Silver Steel (drill rod) then hardening, annealing and finally sharpening can be revised if you have a tool and cutter grinder. Most of the tool shapes recommended by the old masters were very simple. D bits, single



**Photo 60.** The end of a used carbide end mill.

edge reamers, half round drills and spear pointed drills could be made, especially in the smaller sizes, by grinding HSS rod which is available already hardened and ground accurately to size. You could even have a go at solid carbide.

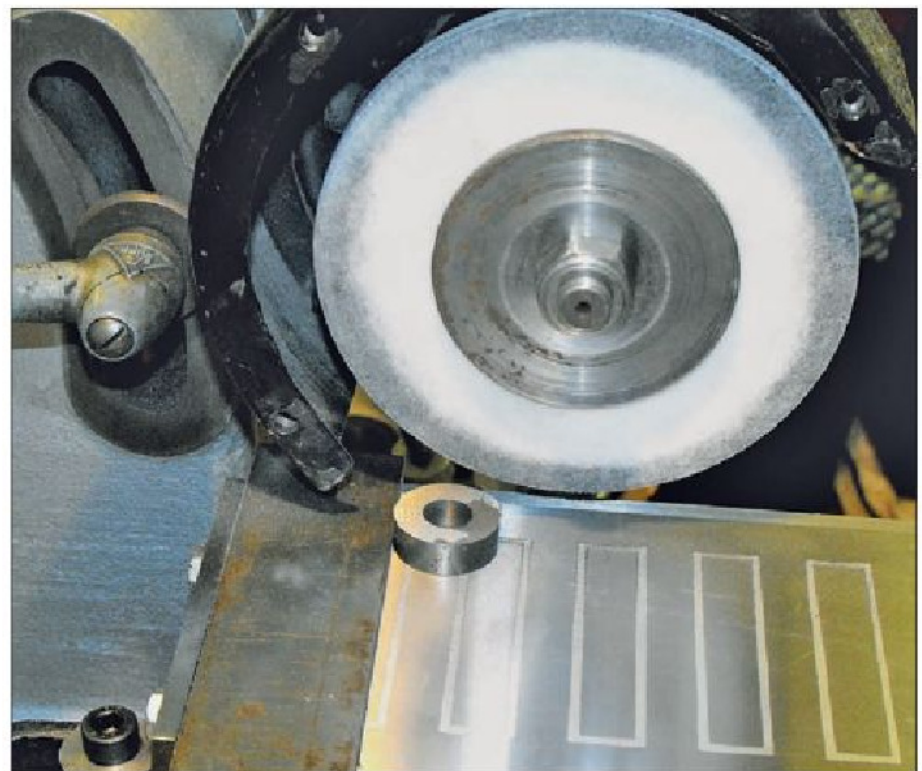
## 30) Surface Grinding

Prof Chaddock, in his book on the Quorn describes using the Quorn grinding head in a Dora Westbury mill to surface grind some small components. I seem to remember a lot of unfortunate comments (flack) about his use of double sided tape to hold down the components on the machine table!

The Clarkson table is pretty limiting but I have ground things like washers and spacers stuck to the table with double sided carpet tape. With extreme caution it works. A better solution is shown in **photo 62** where I have mounted an inexpensive 180mm x 100mm magnetic chuck to the Clarkson table, Ref 35. It's deliberately



**Photo 61.** The side of a used carbide end mill.



**Photo 62.** The magnetic chuck used for surface grinding.

mounted overhanging the table by about 35mm to increase the useable area, which is around 45mm x 100mm. The spindle extension is being used. Cheaper magnetic tables have a smaller number of poles and there are areas around the perimeter of this table where there is very little attraction for small items. Hence I have raised the end table fence and introduced a flat bit of steel to move the thick washer, spacer, being ground so it lies across 2 pole pieces. The down feed of the wheel head has to be very cautious, but it works.

#### Conclusions

I would recommend a Clarkson Tool and Cutter Grinder to anybody with interests in tool making or refurbishing cutting tools. There are plenty of these machines about at prices that won't break the bank, especially by private sale. The special purpose Clarkson accessories are another matter but you can improvise along the lines that I have described. I have not yet cracked the problem of grinding radii, but no doubt inspiration will provide eventually. Or maybe somebody has already cracked this one?

Buying the Clarkson has caused me to reorganise my workshop to place all the grinding, finishing, polishing and wire brushing stuff into one place, "The Grinding Department" **photo 63**. I feel happier now that all the dirty dust and grit making stuff is all in one place and the extractor is available to clean up. The bench in the photograph was constructed especially to fit the space available, there are more wheels and accessories than the Clarkson cabinet can accommodate and I had to find places for the Quorn bits and castings! Someday!



**Photo 63.** The grinding department.

The top of the bench isn't really that cluttered, I'm afraid this is a posed shot. I have one position on the bench with M8 tapped inserts and the grinder in use is screwed down into these. As you can probably see I have a white wheel on one grinder for sharpening woodturning gouges, a wire wheel and a polishing mop on the other and a small finisher cum sander that has proved very useful for general small scale shaping.

As far as the Clarkson goes it is teaching

me how to sharpen tooling and a bit of tool making. The next project might just be to add a motorised head for between centre grinding.

Contact me on [mikehaughton@btinternet.com](mailto:mikehaughton@btinternet.com) or email Postbag if you would like to make comments or need more information on the Clarkson. ■

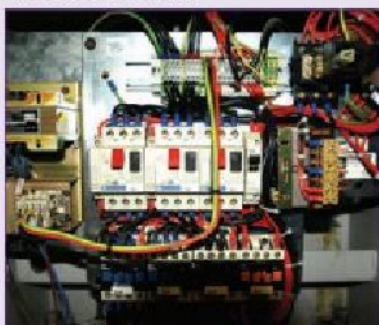
#### References

Ref 35 <http://www.chronos.ltd.uk/> Search for magnetic chucks

## IN OUR NEXT ISSUE

Coming up in issue 154, on sale 7 August 2009

FITTING AN INVERTER TO A HARRISON M300 LATHE



HAROLD HALL CONTINUES HIS LOOK AT FACEPLATES

DAVE FENNER LOOKS AT RIVETS AND RIVETTING



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