How to cut key ways, slots, and splines using a Shaper...

by Doug.

Taken from http://bbs.homeshopmachinist.net/showthread.php?p=172642

I will attempt to describe to the Shaper owners here, the procedures and setup for cutting key ways in a bore. Once mastered, you can move on to internal gears and splines with a few other attachments.

As you have noticed, if you have read some of my previous posts, I describe in detail how to complete a machining task, (it's not that I am trying to bore you). I can "only assume", when I am writing my reply to questions asked here, that there is Someone just starting a "new" hobby or learning a "new skill", the last thing I want to here, is that you hurt yourself. This is why the detailed reply is so…… o…o..o long winded, trying to accomplish this using typing and using a few pic's is "new to me", if I were there, in your shop with you, I could demonstrate much quicker, then, have "you" do it, to show me that, you have a full understanding of the lesson just taught.

The following procedure was taught to me by my mentors over 30yrs.ago, they, were taught by their mentors some 40 to 50 years before me (pre-dial indicator days) , when I came to the shop, there was only 1 dial indicator, and it was kept locked up, only to be used for "special jobs", not by an apprentice cutting key ways!

Ok, let's start,
To cut a key way in a bore the following "stuff" is required,

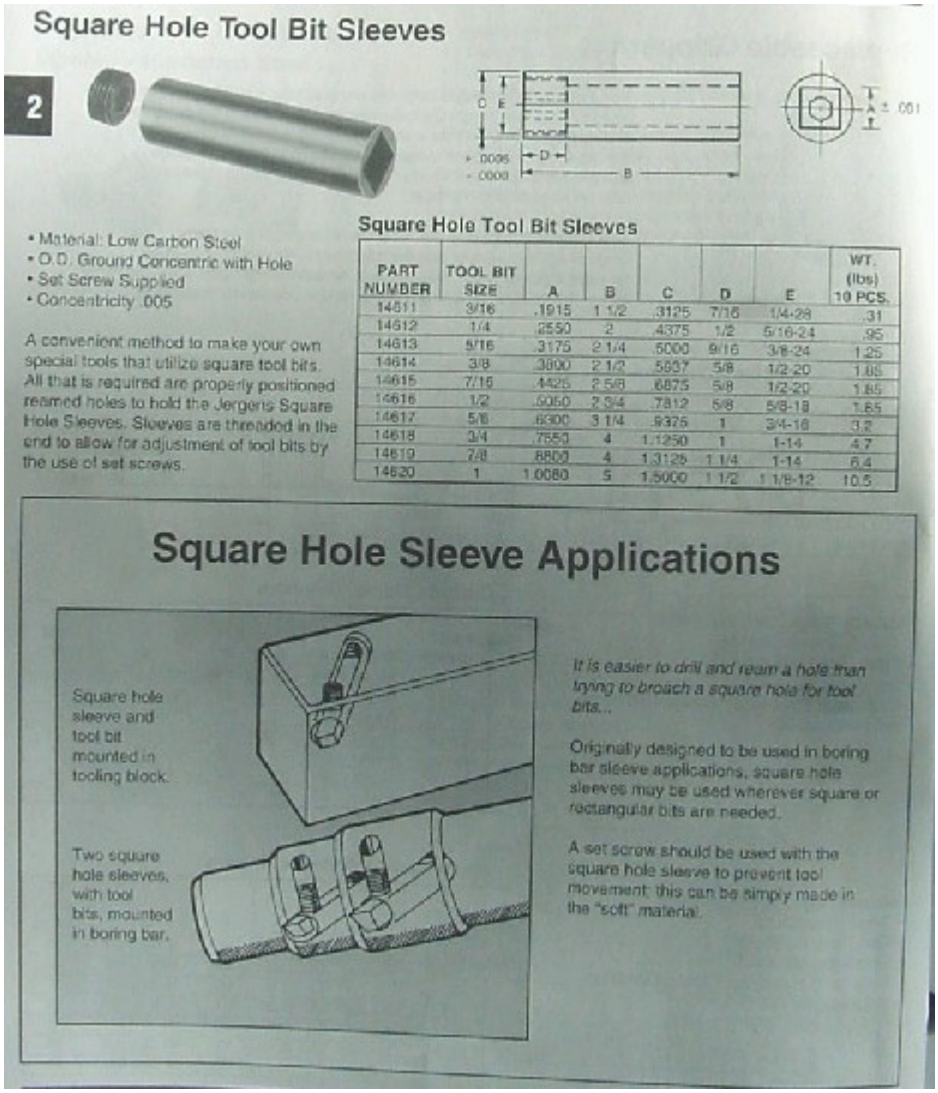
1 well lubed shaper with a long enough stroke to cut the key way + ¾", and a way of stopping the clapper from clapping. (If you read one of my replies to the "Alba 1A post", the "allen head cap screw", or set screws).
YOUR Safety glasses,"or lesson ends here" If you don't wear them,…….. hard to teach a blind guy this!!
1 shaper vise or large angle plate to hold the work
1 key seat bar that will fit in the bore with the finishing cutter installed
1 of each, ¼"wide roughing cutter and finishing key way cutter of the required key size
1 machinist square at least a 12" blade, 18" to 24" preferred
1 small machinist square 4"
1 flash light (torch) as the Brit's say
1 can of cutting lubricant and a 1" brush (we used an old soup can)
1 only 6" scale
1 can of layout blueing
1 scriber
1 only 6" half round smooth file
1 piece of key stock of the required size
1 HSS tool bit ½ of the width of the key to be cut
1 lead or brass hammer (dead blow)
1 set of matched parallels
1 work bench to put all this stuff on, shapers, are for cutting metal, not storing tooling!
"Oh, ya", we need the thing or things you want to key seat, sprockets, gears, pulleys, couplings, crank arms etc.

From the above list you can see that most of the tools and accessories are readily available in an

average machine shop. The two items that are not so common to find are the key seat bars and key way cutters.

The key seat bars are shop made to suit the shaper being used. They are made up as follows:

The bar is just like a normal boring bar from a lathe, with a ½"square hole through the end at 90°, but modified to attach to the tool post hole in the clapper. Bars are made of 1045 or 4140 steel, on one end a square hole is cut into the bar to hold the key way cutter bit. In this end of the bar, two set screws hold the bit in place one small set screw on the side to push the bit to the side of the square hole, and a larger set screw in the end of the bar to securely hold the bit in place. On the smaller bars you may only have room for the one large set screw on the end
.
The square hole for the cutter must be straight (up and down) through the bar, and the square hole is set square on the bar, what is meant here is, when the cutter is placed in the bar, it is not cocked to the axis of the bar, the cutter's corner cutting edges must enter the bore at the same time, if only one cutting edge contacts the work the bar will be pushed to one side of the bore, you will have cut a tipped key way (angled from the bore). This square slot can be done various ways, first, in the shaper using a vise with a V block, in a lathe using a simple milling attachment, in a miller using a staggered tooth saw, you cut a double depth slot then place a piece of square carbon in the slot , then a piece of key stock "V'd for welding or brazing to the end of the bar, or the "easiest method", in a drill press, Drill and ream a hole then use a store bought "square hole tool bit sleeve" pressed in, then checked for square, adjusted by inserting a piece of key stock held in a vise, until square hole is aligned as above then drill and tap for set screws.(Dam, another secret exposed) see pic below. Oh yes these sleeves allow you to build custom boring bars for your lathe as well as portable boring bars for field machining.



Square Hole Tool Bit Sleeves

2

- Material: Low Carbon Steel
- O.D. Ground Concentric with Hole
- Set Screw Supplied
- Concentricity .005

A convenient method to make your own special tools that utilize square tool bits. All that is required are properly positioned reamed holes to hold the Jergens Square Hole Sleeves. Sleeves are threaded in the end to allow for adjustment of tool bits by the use of set screws.

Square Hole Tool Bit Sleeves

PART NUMBER	TOOL BIT SIZE	A	B	C	D	E	WT. (lbs) 10 PCS.
14611	3/16	.1915	1 1/2	.3125	7/16	1/4-28	.31
14612	1/4	.2550	2	.4375	1/2	5/16-24	.95
14613	5/16	.3175	2 1/4	.5000	9/16	3/8-24	1.25
14614	3/8	.3800	2 1/2	.5937	5/8	1/2-20	1.65
14615	7/16	.4425	2 5/8	.6875	5/8	1/2-20	1.65
14616	1/2	.5050	2 3/4	.7812	5/8	5/8-18	1.65
14617	5/8	.6300	3 1/4	.9375	1	3/4-16	3.2
14618	3/4	.7550	4	1.1250	1	1-14	4.7
14619	7/8	.8800	4	1.3125	1 1/4	1-14	6.4
14620	1	1.0080	5	1.5000	1 1/2	1 1/8-12	10.5

Square Hole Sleeve Applications

Square hole sleeve and tool bit mounted in tooling block.

Two square hole sleeves, with tool bits, mounted in boring bar.

It is easier to drill and ream a hole than trying to broach a square hole for tool bits...

Originally designed to be used in boring bar sleeve applications, square hole sleeves may be used wherever square or rectangular bits are needed.

A set screw should be used with the square hole sleeve to prevent tool movement: this can be simply made in the "soft" material.

At the other end that attaches to the clapper, the bar is machined and externally threaded so that it replaces the regular tool post, the bar is inserted from the back side of the clapper, and held securely with a nut, another way to hold the bar (the larger dia. ones) is, when the bar's dia. is too large to go through the clapper hole, the end of the bar is machined down to go through the hole, the length of the reduced dia. is about a 1/4" less than the thickness of the clapper "small bore" length, and, less the counter bore in the back of the clapper. The end of the bar is drilled and taped for a good size allen head cap screw or 82° countersunk machine screw ½"NC minium, a thick holding plate to accommodate the head of the cap screw, is machined with a step to fit the counter bore, and small bore of the clapper, a counter bore hole is drilled in larger dia. end to accept the cap screw when the bar is assembled in the clapper there should be a small space between the bar and the plate so when the cap screw is tighten the bar is held firmly in place. Neither the plate or cap screw can protrude past the back side of the clapper, if they do the clapper will not sit down in the clapper box, the bar will be tipped up. You may have to shorten the length of the head of the cap screw so it doesn't stick out past the plate, a 1/16" off each face will do, "they do make "shallow head" cap screws" but maybe hard to come by. They are perfect for holding the bar.

The pic's below shows some various type bars and holders, first right, small bar with holder to get close as possible to the vise without hitting the vise, 2nd from right, eccentric bar, also to get close to the vise without hitting vise, 3rd from right, 1-3/8"dia. bar, waiting for square hole, and set screws, left side of pic, a factory made bar with 3/8" square hole, from Elliott Machine Works, note change square head set screw to safety set screw. Notice that the bars are different lengths, for longer or shorter bores.

The shorter the bar, the more ridgid it is (that's a good thing). But there are times you may need longer bars, the second pic is of an assortment of bars from work, left behind as our two shapers left the mill over 7yrs. ago. Both of our old shapers had the same size hole in the clapper, we had around 15 to 20 bars that the two shapers shared.
Both our shapers had a 5/16"dia safety set screw in the bottom of the clapper that tightened on the bar as a safety device to keep the bar from "rotating" in case the regular hold down nut or bolt came "loose" while cutting a key way. The clappers, both had an allen cap screw through the clapper into the clapper box to prevent the clapper from lifting up. On some smaller shapers they use set screws on the side of the clapper box through to the clapper.

Next how to make and sharpen key way tool bits Part 2

Part 2a
How to make and grind shaper key way cutters

Oh, Hi there! You actually came for “more”…… Ok,

The Roughing Cutter

The cutter most used and abused, while cutting key way slots, is the” roughing cutter” It’s not too big, I call these roughing cutters “beavers”. The beavers knaw out 97% of the key way slot so, the “fancy finishing cutter” can be slipped in the bar and remove the last .040” to .050” on the sides of the key way slot in one glorious pass, and claim all the glory for the perfectly formed key way !

To make a beaver (rougher) you start with a ½” or 3/8” piece of HSS tool bit, usually I cut them in half, using a zip cut disk in a mini grinder holding the HSS tool bit in a vise, just like cutting “butter”, the old way, “pre zip disk”, notch a HSS tool bit on the 4 corners in the middle of the bit, using the pedistal grinder, then connect the notches grinding a groove around the perimeter of the HSS tool bit, now wrap the HSS bit in a rag, and resting one end on a raised surface(like the base flange of the mechanics vise), the other end on the steel work table top, then hit the rag where you think the groove is on the HSS bit, once or two, or 3 smacks it breaks in two, the rag is to keep flying pieces of the bit from imbedding themselves in you or a bystander. Caution to be used when unwrapping the tool bit, very sharp needle like pieces are hidden in the rag, best is to lift one corner of the rag, sending the pieces of the broken tool bit out on to the steel table.

Anyway with a zip disk it’s just a few seconds, no flying projectiles!!! The edges of the bit where the zip disk cut through will have sharp burrs, handle with gloves. I will usually cut up 2 full HSS bits so that I can make 4 roughers at once, I stagger the cut off center around a ½”, the reason being these cutters are the first one’s in the bore, cutting, some have to go into a 1-1/4”dia. bore or smaller, so you need a variety of lengths.

The rougher is ground back, narrowing the cutting edge to ¼” wide, and various lengths of tooth, also, a rougher that chews out a 1-1/2” wide key way has to be ground back at least 15/16”, to get to the bottom of the key way, while a rougher for a 5/8” wide key way only needs to be ground back ½”, as the longer ones wear, or chip, and need regrinding, they become the shorter roughers.

The bits, are ground from both sides, so that, the cutting tooth, let’s say, ends up in the middle of the HSS tool bit. The actual cutting edge is not more than ¼” wide, if it is too wide, being mounted in the springy bar the cutter will chatter, and give a poor finish, as well, that’s when the tooth of the cutter will break off, rendering your roughing tool completely useless, If your lucky, the vibration from the bouncing of the cutter won’t loosen the grip of vise on the work(rolls out of the vise). It is best to leave a small radius in the ground back corners, this gives the tooth a more rigid support or footing, now take the 4” square and grind the cutting end square with the flank (side) of the tool bit, care is to be used to do this, as the rougher can be pushed over in the slot if the end is not square to the flank, grinding all cutters, roughing and finishing, so the cutting edge is 90° to the flank of the tool bit, will be shown later, to be a benefit to you, when changing out different cutters, “you only set up one cutter” per bar change.

Next you grind the end clearance on the cutting edge (3 to 4°) being careful to keep the cutting edge square to the shank. Next step is to taper the sides of the tooth on the face of the tooth, back to the radii of the tool bit (1° to 2°), if you grind too steep of an angle the tooth will be prone to snapping off, you don’t want the tooth, cutting on it’s sides, only on the end of the bit.

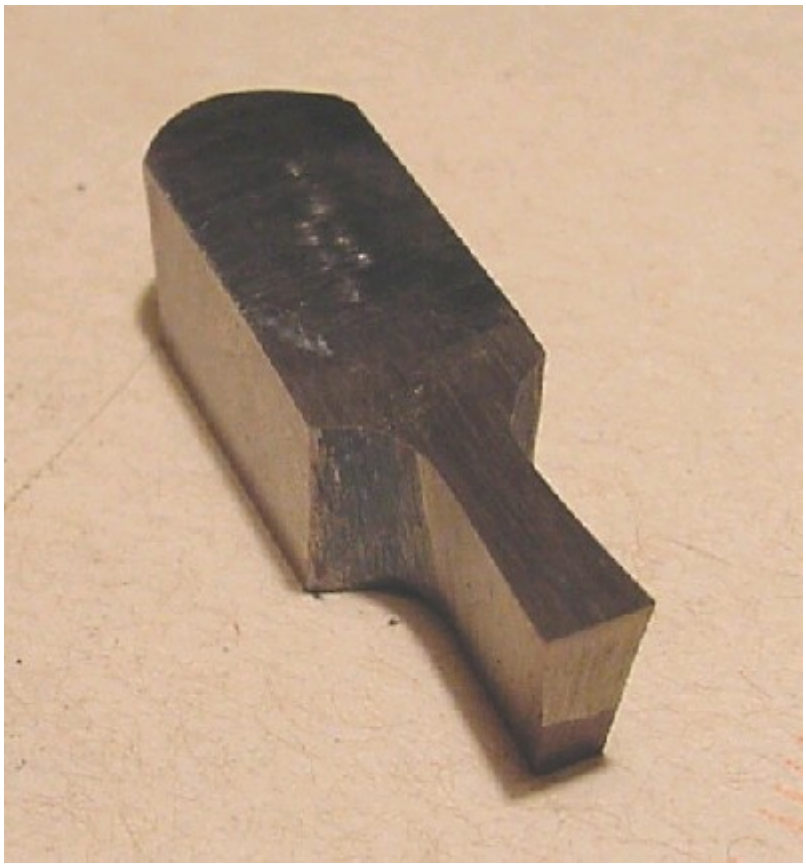
Next you need to grind side clearance on each of the sides of the tooth (2° to 3°) the side clearance angles are not critical as long as when the bit is placed in the inside corner of the 4” square, the top face of the tooth touches the square, and at the bottom of the tooth, you can see a little clearance when held up to a light.

Lastly you want to give the tooth a little top rake, using extreme care and a pair of vise grips hold the bit from the bottom edges of the tool bit, on the un-ground shank of the bit, just behind the radii of the tooth, you want to lay the top face on the face of the grinder so that the stone contacts the tooth in front of the radii, the grind stone will form a shallow top rake on the top of the tooth, this helps reduce the bulldozing of the metal, you will know if the top rake is sufficient by observing the chips coming off the work , they will almost curl into a figure “6” or “9” shape, also the sound coming from the cut will be that of “frying bacon”. This top rake also helps reduce the "crowning" in the middle of the key way , "crowning" is, the cutter, is too blunt at the cutting edge, and pushes itself away from the cut making the key way too shallow in the middle of the bore, I have seen as much as .060” crowning in key ways, cut with a dull, or too blunt of a cutter.

Now, to protect the bore of the work above, or opposite end of the tool bit, a radius is ground on the non cutting end of the tool bit, as well, the 2 sharp edges forming the radius where it meets the top and bottom surfaces of the tool bit, are ground off, the radius is to make the cutter more compact in the bore, the rounding of the edges of the non cutting end of the tool bit, keep the bit from cutting or scoring the bore 180° away from the key way.

Well, if you followed the above instructions, your roughing bits (beavers) should look like the one in the pic below.

Working end



Safety end

This is a pic of things to come "Part 2b"

Part 2b
The Finishing key way cutter

To make finishing key way cutters, (spoilt premadonna's) you need some square shank HSS tool bits, these square shank HSS bits (same size square as your roughers)and are made from ½ length pieces of HSS tool bits, these cutters are used for key ways that are the same width or smaller width than the roughing cutter body (1/2" sq.). Here is a pic of what you start with.

When the width of the key way is wider than the roughing cutter body, "we cheat", well not really (Alistair will like this) we use a piece of key stock or "to recycle", the shank off of a ½" sq. scrap brazed carbide tool bit, because once you cut the broken carbide off, it's the perfect length!.(2-1/2")
To the soft steel shank we weld (use stainless #309 rod for welding dissimilar metals)or sliver solder a piece of parting blade (we, used 1-1/4 x 3/16" wide parting blades), you know, the short used up one's, (more recycling) or at work no one liked the old unground parting blades made by Armstrong, or Williams, among others, the boy's would only use them nice shiney ground ones for parting off. And they even quit using "them", when they brought in the HSS Seco parting blades with the carbide insert!
If your silver soldering the un-ground blades you will have to grind a clean area on the blade so the silver solder can bond to the blade, the same must be done to the soft steel shanks. We found it quicker to weld the two pcs together, the parting blade pulls a little bit from the weld, but Ok for what were doing. It is helpful if a welding jig is made to hold the two pieces to be welded in the correct orientation, when using a jig, you can cut your parting blades closer to finished size, let me think on it a while, I'll sketch something up.

The old parting blades are cut 1/8”to 3/16”(less if you use a welding jig) over size for the key ways cutters required, this over size is to allow for misalignment when welding the parting blade to the shank. Cut parting blades using the zip cut disks in the mini- grinder, hold the parting blades in a vise again. Please wear a face shield. and Safety glasses. Caution DO NOT try to pick up those pieces of parting blade right after you cut them off, their” HOT”, wear leather gloves, and make sure your “ZIPPER” is done up!!!!!!!!!!!!!!!!

For those of you who don’t know what a zip cutoff disk is, it is a cutting disk, but the thickness is "only .040” to.045” thick", when spun at 10,000 + RPM = hot knife through butter = zip disk, your local Wallymart doesn’t carry these thin ones, too dangerous around “Homer Simpson type guys"). We buy them from an industrial supply house, but (I have seen them at our local NAPA) they come in various dia. from 3” to 7”.

Short story here: an Uncle of mine, Bob, (and he is even Scotish) came over to change out the rusted tail pipe from his car, after removing the clamp the pipe was still firmly held to the catalic converter, he grabbed my grinder with the (new zip disk) to just cut the exhaust pipe, he slid under the car and flipped the switch to the grinder, I didn’t have enough time to tell him how fast the zips cut. The next thing I heard over the sound of the grinder was a LOT of cursing about cutting into the GD catalic converter, as he was coming out from under the car, he was hollering and shaking the grinder at me,“WHY didn’t you tell me how fast them new fancy disks cut?????????? I had to leave my shop to get the smirk off my face……EXxxxxCUUUsssssseeeeeeeee me.

Ok, back to the key way cutters, you will have two styles of finishing cutter blanks now , square shank HSS, and mild steel shank with a piece of parting blade attached. By looking at the drawing in my last reply, you will see the required angles that need to be ground on the blanks. If you look closely at the drawing, at the cutting edge, you will notice that the middle of the cutting edge is ground back, starting in 3/16” in from the actual cutting corners of the cutter, “why”, well, as I have said, the finishing cutter, just cuts on the corners to “size” the key way, it doesn’t even finish the bottom of the key way, the little rougher bit finishes the bottom of the key way!!! By grinding back the middle of the cutting edge around 1/16” to 3/32” back, you prevent the finishing cutter from trying to cut the full width of the key way at the bottom of the key way seat.

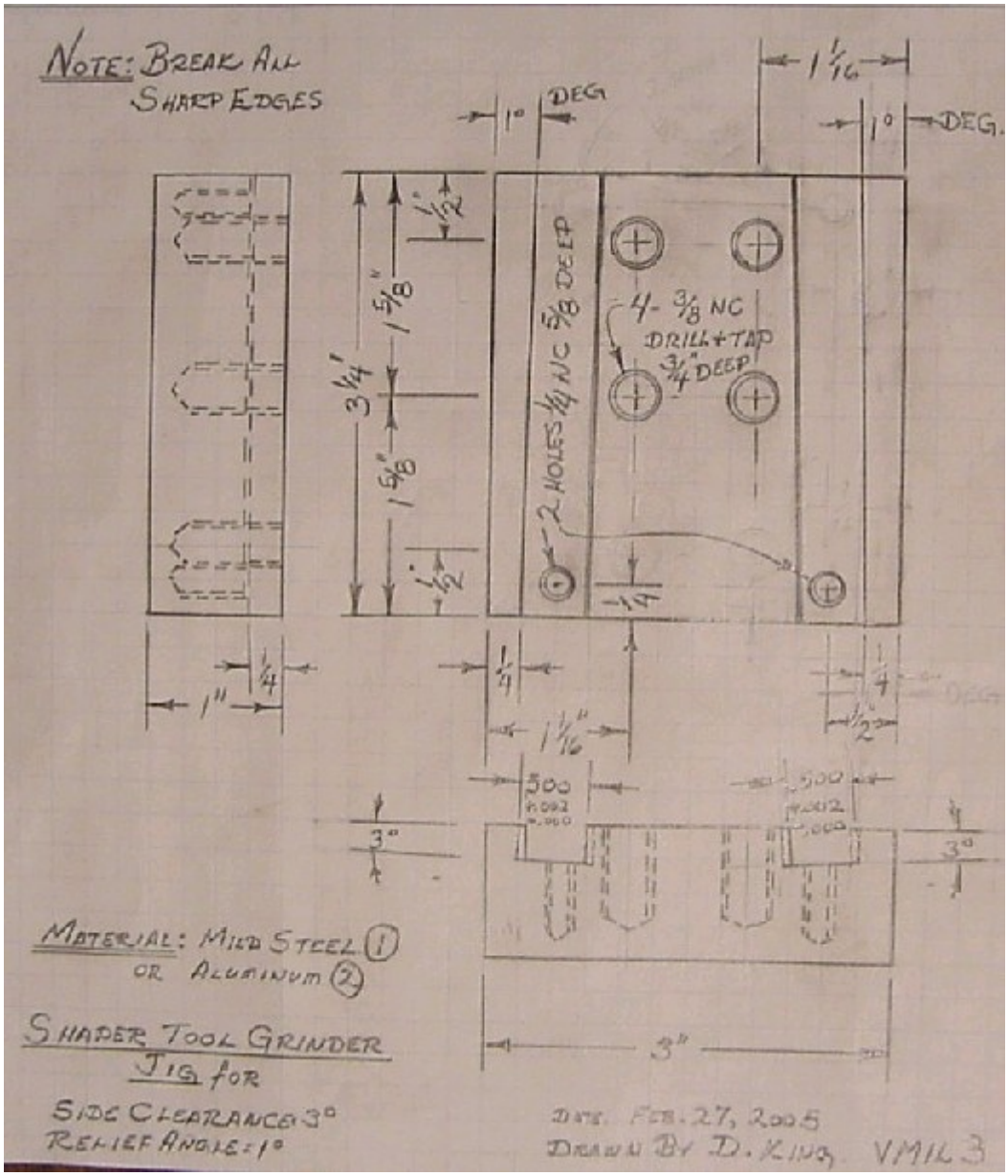
If this ground relief was omitted, the cutter would really chatter, when trying to cut the “full width” through the key way, the first time you forget, you may need an under ware change (“Alistair is exempt” only if he is wearing the kilt!!!) it's sort of like a space shuttle liftoff, you swear the ground is shaking, horrible noise, you rush to hit the clutch, too late, busted cutter, and damaged key way slot, you call for God, "NO answer". The key way cutter mounted in a bar, is not held in the most rigid set up, those key seat bars can be very springy, the longer the bar length is, the more amplified the chatter becomes.
We are trying to give the cutter, by grinding the grind back on the cutting edge the most optimum conditions to cut, under the circumstances.

More on setup and chatter in the actual cutting procedure, later, we have to finish grinding the cutters, You will want to have selection of different width cutters, inch widths, "maybe metric widths", "maybe oil grooving cutters", "maybe radius cutters", maybe “even gear or spline” cutters (do I know how to “dangle a carrot” or what)“you decide”, what types and range of cutters "you will be using" to complete your projects.

Ok enough dreaming, you have work to do, the small square shank HSS cutters can, with care, be ground by hand, using a 4” square, a 1” micrometer, a protractor is helpful to verify clearance and relief angles, but not absolutely necessary. Clearance and relief angles are “just that”, “clearance”, they are ground on the cutter so as, to “only present the actual cutting edge to the work” (the two

corners), no other part of the cutting bit, the relief on the sides, the side clearance on the sides, the end clearance on the cutting corners, the back grind in the middle of the cutting edge, is “all clearance”, only the cutting edge corners of the tool bit should be contacting the work.

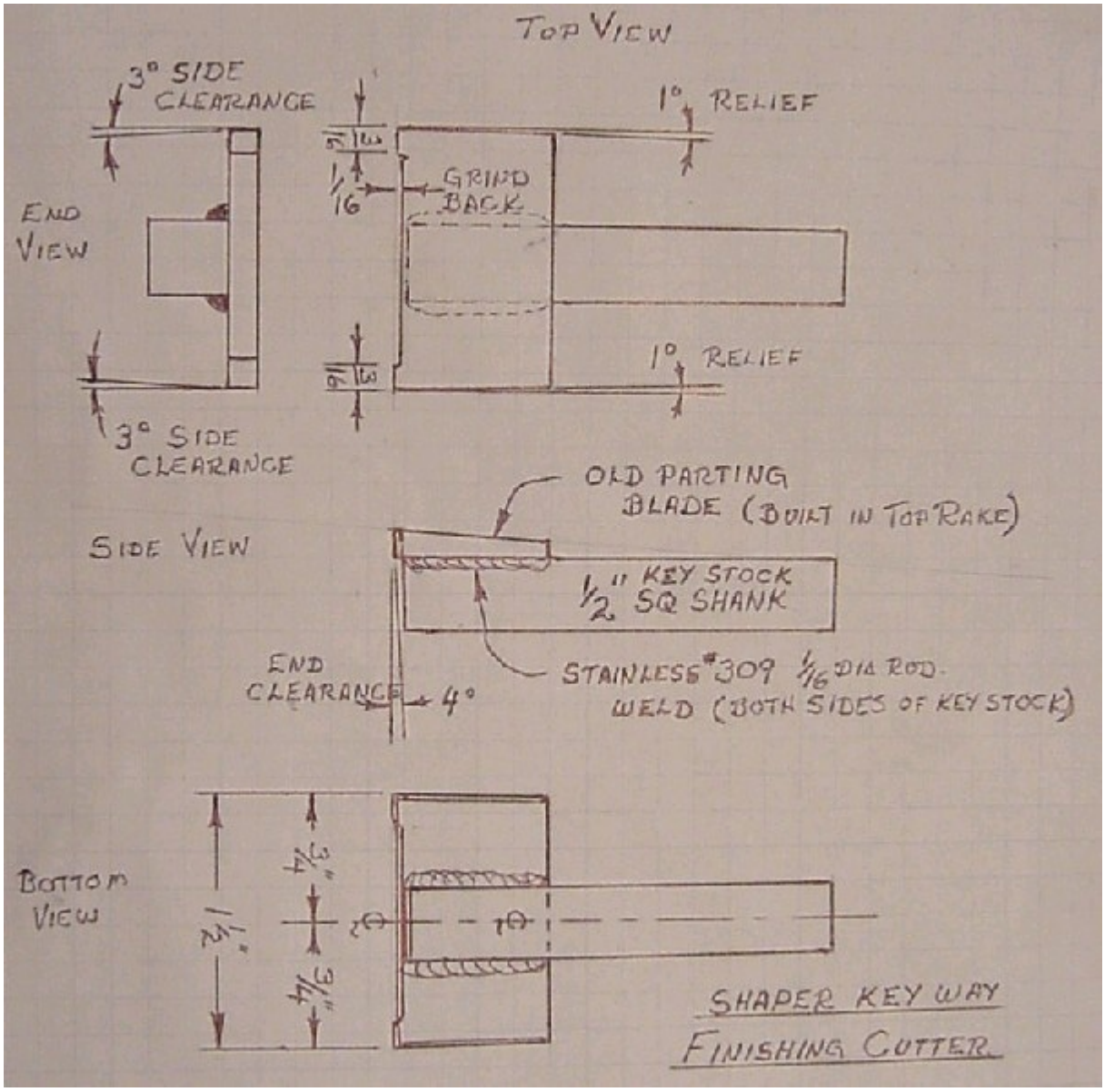
The drawing (or carrot) that I gave you in the post above was/is, the one I used at work when I was on the tool cutter grinder, it is a “just” reference guide to work from. You use the guide whether hand or machine grinding a cutter. You can make up simple jigs (on the Shaper, or if you’re a “WUSS” you can use a miller!!) to hold the cutter in the correct position for grinding or for checking for square to the shank of the cutter, and, for the cutter to be centred to the shank. You can use some simple blocks(1.2.3 blocks) or spare HSS bits, (it is best if you have different sizes) or the jig below.



Here is a simple jig (fixture) to mount the cutter in to grind clearances and relief angles. This jig lays or leans the cutter shank over 3°, as well it also locates the tool bit angle to relive the sides of the cutter 1°. This is a neet job for you to make as an accessory for your Shaper. I had designed it to do all the finishing cutters large ones with the old parting blade, and also the smaller cutters, HSS solid sq. bits. This jig is made for half inch shank cutters, but can be made, or you can modify this one to do the three-eight’s shank cutters. I will come up with another jig for you to do the cutting

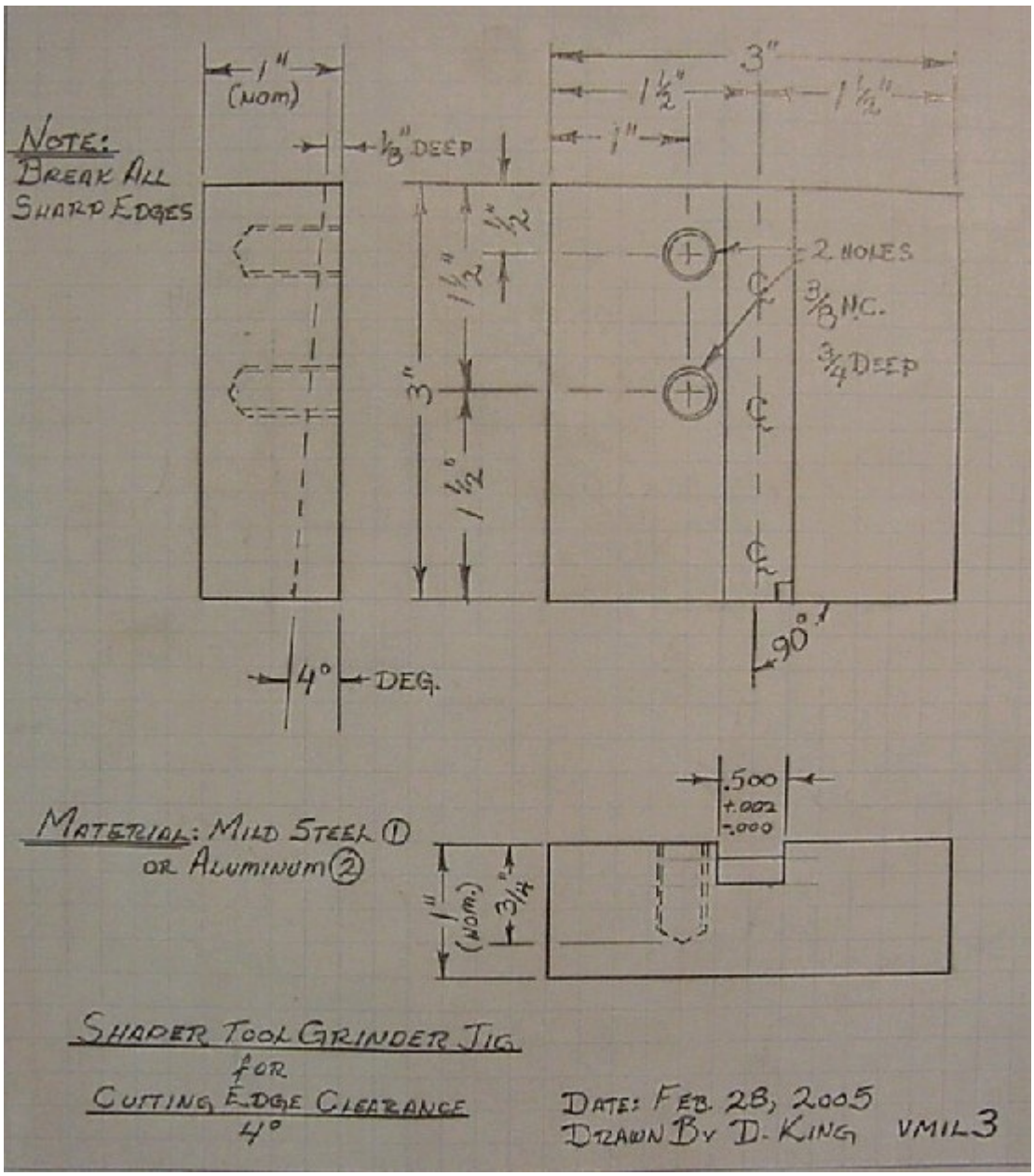
edge square to the shank and end clearance (front) of your tool bit, Ok,……..(your suppost to say yes!!!) Ah just nod your head.

Tune in later if you want more.



The first grinding step:

You will have an easier way to accomplish the first grinding step, if, …. “you build this simple jig before hand”. If you make two of these, make one of them with a straight key way not tapered, it will be your welding jig to hold the parting blade to the soft steel shank for the BIG cutters



This jig presents the cutting edge at 90° to the shank of the cutter, the jig also tips the working end of the cutter up at a 4° to provide end clearance for the cutter. The jig is simply a squared block of metal with a tapered key way running down the center of the block, a clamp is attached to hold the cutter in place for grinding or welding. If you sharpen or just dress (re-sharpen) all your cutters (even the beavers)…….. (J.H.Ch *%$%^&* "what the hell's a beaver again", this guy writes in code,…he's driving me nuts!!…….. "A ROUGHING TOOL", …..OK……CHILL Out) using this jig, your key way shaping will be a quick and easy task from now on! .

Well……..maybe a little shaping experience here "for you"! First, set the fixed jaw of your Shaper vise parallel to the ram. Open up the movable jaw of the vise, loosen the 2 vise hold down nuts, or on some shaper vises, the 4 base nuts, which ever one's allow the vise to rotate. By eye, and don't take that literally (or your gona be sent back to the BP millers!!!!! And you will forever be known as a **WUSS**), use your hands, and swivel the vise so the jaws are parallel with the ram. Wipe clean with a rag, the face of the column (large flat machined surface behind the table) cross rail ways on the body of the shaper. Using a 12" or longer blade square, place the base of the square against the column face, now slide the square towards the fixed jaw, all the while, keeping a firm pressure with your hand on the base of the square until they just touch, look at both ends of the fixed jaw, "is there

a gap at one of the ends of the jaw where it meets the blade"? If so, lightly tap the handle end of the vise to have the fixed jaw contact the blade the full length of the vise jaw, snug the vise nuts up, (half tight), reposition the square and check again using a piece of paper between the square and both ends of the fixed jaw at the jaw face. If each piece of paper has the same drag while lifting the paper out, the vise is within .001" of being parallel with the face of the cross head ways, BUT, not necessarily parallel to the ram stroke of the Shaper.

To check parallel with the ram, mount a dial indicator on the side of the clapper box, not the clapper!! Adjust the stroke length to keep the dial indicator tip from leaving the vise. Set the shaper in low gear, "table feed off", tighten cross head locks, energize ram, watch the indicator for arm movement, if the jaw is out, just tap the handle end of the vise to have the dial show no movement at it's arm, Now stop the ram, and "now" you can really tighten "them vise nuts"(pretend it your bosses Nu?!!), energize ram and check one last time.

This is the correct way to align your vice, angle plate, or other holding fixtures, including a "dividing head or rotary table" to the "shaper's ram", (more carrots, you guys are starting to look like bunny's). It is the RAM that does the traveling, not the cross rail column. All fixturing must be aligned to the moving RAM,…… "everyone bow to the moving RAM" ……. RAM!!……... You mean 426 cu.in. Hemi RAM POWER. Sorry, got a little carried away there……I'm ……Ok……..I ….guess?
Now it's a quick job to machine your block in "your shaper", JUST a minute here,…….. you might as well learn from the start how to check and adjust your machine, only then,……. will "you produce accurate quality parts", and may just put a few millers to "shame to boot", first loosen the cross rail lock, to adjust vise height, then apply the lock again, "then,… then,…. Then…. "AFTER" set and lock the front table leg/foot.

If you reverse the lock sequence, your front table leg will not be resting on the shaper base. This mix up in "lock sequence" is just one cause of vibration especially while cutting key ways, like when keying a 10" long stepped bore of a $20,000.00 stainless steel pump impeller, the last thing you want is one of those "shuttle launches".

While you have the dial indicator on the ram, set, a "known" (actually measure with a mic) full length parallel on the base of rail ways of the vise, position the dial's tip on top face of the parallel, energize the ram watch the dial, it should read "0" movement, if not, stop the ram, and shim with paper or shim stock "under" the parallel on the low end to correct, re check. You wouldn't believe how may scrap bins are filled because " the operator didn't check BEFORE doing"!!!!!

Back to the jig, set the rough block on parallels after removing any saw cut or torch cut burrs or lumps (slag). Shape (that's what us Shaper type guys say for machine, Kool, Eh ya Shape) "First surface (this is the first cut on your block)", mark with marker, rotate plate 180°, the newly shaped surface is now on the parallels, tap the block down for full contact on parallels, shape to size, rotate block 90°, set on parallels, just move the parallel at the fixed jaw away from the fixed jaw(1/8") to allow you to place a square on the parallel or the top of the fixed jaw, tap your block square to the blade, check with paper shim, shape the 3rd surface, remove burr, check again with square NOW on the 1st or 2nd surface and the 3rd surface using paper, if the block's surfaces are square with each other, loosen vise jaw, rotate block 180°, shape to size, one note here remove all burrs from ,(the just shaped surface edges) before rotating to next surface to be shaped, if NOT……. Your best customer will be the "dumpster" Ok one last step for the shaper, set block in the vise with "first surface" (now you know why you marked it) on fixed jaw face, block on parallels, take a .010" to .020" cut on the 5th surface of the block, sharpen up finishing tool bit and put a smooth finish on the 5th surface with .005" depth of cut, remove all burrs, rotate block 180° and shape 6th surface the same as the 5th

Now all that's needed is a slot for the key seat cutter at a 4° tilt. If you are using my measurements from the drawing, you need a spacer at the far end of the block, away from the ram, or at the end of cut on your block, This spacer needs to be approximately 3/16" high, and in from the edge of the far end of your block, I have stated earlier, clearances are approximate for key way cutters, we don't need 0°0'5" accuracy here, take a piece of 3/16" square key stock, cut 1/16" shorter than the width of the block, next lift the block up and place the key stock under the block's bottom surface at the far end, the key stock should not stick out past the end of block , the key stock is flush with the far face of the block, straddling both parallels, tighten vise, tap block down with dead blow hammer to insure full contact on both parallels and 3/16" key stock, check that the 3/16" key stock is flush on the whole far edge of block. It helps to keep a couple of fingers on the key stock to keep it from moving. Note remove your fingers from the key stock, prior to any further shaping.

Ok, now you can cut "just cut a key way down the center of the block",……. WAIT, Wait, …… wait….Ummm, There is a "setup for the vertical head of the shaper", you "HAVE TO DO" in order to "cut a key way", and "MUST" (this is why we "Shaper Guys" have it over those "BP miller WUSSES") be done before cutting any key way, "IF" you have moved the vertical head" from" perfect 90° to the work, for any reason, you must reset to 90° and verify, yes test again!

Much time will be saved if you learn to leave and shape with the vertical head "setup" for cutting key ways (perfect 90°) unless you, really,…. Really,…….. really, need angular travel (eg: machining dovetails) then it's Ok!?…. I.??. guess!??……. If you have to?!.

You want to cut the compound angle key ways for the Shaper tool jig!! Well...""it's for the Shaper""... .."Ok"....but remember, there are Left and Right Hand key ways, and the Vertical slide goes back to perfect 90° as soon as your done! "I MEAN IT"

Ok, prior to cutting any perfect 90° key ways, (no "leaning key ways" that are off center of the shaft centre, "Oh, off center, that's done with every key way cut using a HSS helical flute end mill"), Oh, you didn't know "eh", ask a seasoned machinist sometime, "NO not now",……. that's another lesson. Quit trying to side track me, I'm doing quite well on my own…….Thank you!!

Now back to the vertical slide. Ok, prior to cutting any perfectly centred 90° key ways, like properly set up shapers can, dead center, through the center of the shaft, or bore, you have to set up the shaper, I explained in detail how to check and setup the "shaper vise" to the all mighty RAM, well……. You also have to check the table for square, and parallel, (you know, where the vise sits) you also check the T slots of the table, are the T slots parallel to the travel of the RAM?

A well seasoned machinist will know his/her machine much better than they know their own spouse, no, that isn't a joke, it is a fact. Only when the machinist knows the condition of the machine, good or bad, can they produce accurate, parts.

How does he do this, "even with a worn out machine", he does a series of checks (tests for accuracy) of the machine he is about to operate. If you know the wear spots or where the inaccuracies are, you can compensate for them, just like I taught you to do concerning the shaper vise, remember!!!!!, you checked, tested, compensated, tested again, or maybe this will ring a bell

"While you have the dial indicator on the ram, set, a "known" (actually measure with a mic) full length parallel on the base of rail ways of the vise, position the dial's tip on top of the parallel, energize the ram watch the dial, it should read "0" movement, if not, stop the ram, and shim with paper or shim stock "under" the parallel to correct, re check."
You checked, you measured , you tested, you compensated, and you tested again, "only when you

found and corrected any inaccuracies, did you proceed. That is a learned skill that puts you way "out in front of the rest".

There's an old saying
"Only a poor tradesman blames his equipment/tools, for his mistakes"
And it is very true!

Setting Vertical Head to 90°

To cut key ways, the vertical head (slide) must be set to 90° to the table, the gib of the slide should be adjusted to just remove looseness in the slide. There should be a "small" amount of drag when turning the feed screw through it's travel. Some vertical slides on shapers have been fitted with a small dowel pin and nut This dowel pin is to automatically fix the slide at 90°. The removal nut is used to pull (unseat) the dowel so the dowel pin can be removed to allow the slide to rotate for angular travel. Some of these shaper rams also had dowel holes at 45° and 60°.
If your machine doesn't have the dowel pin that's Ok, you just have to set the vertical slide to 90° manually.

How I was shown this "for key ways" was to raise the table enough, so you could place a machinist square on the table with the blade slide up to the machined side of the top half of the vertical slide (the part that moves). Hold a flash light so the light beam is behind the blade where the blade touches the slide. You will see if you need to loosen the vertical slide locks/nuts to adjust to 90°. Paper can be used instead of the flash light, like you did on the vise. This is not accurate enough to use the vertical slide for long or full length travel of the slide.

Here is a pic of squaring the vertical slide

For long or full length travel you "very lightly" clamp (just so it can't move) a square (We had a big 24" Starrett) to the table and attach a dial indicator, to the top half of the vertical slide (part that moves) , then set dial tip on the edge of blade of the square, now traverse (move the top slide) through it's travel. Note dial arm reading (you want "0" movement) adjust if necessary. Tighten lock/nuts of vertical slide, if you don't have a dial indicator, you can use a paper feelers, checking at both ends of slide travel.

At work we had two shapers, one of the shapers was always left set up for cutting key ways, "NOBODY" moved the vertical slide off 90°, if you weren't cutting key ways use the "other shaper".

Ok. Now you can get busy and finish the 3 jigs, 1 for welding, 2 for grinding, I would suggest you pre drill & tap the two holes in the bottom of the angled key ways PRIOR to shaping the key ways. Counter bore/drill the holes with an "F"size drill bit 5/16" deep, then tapping size 13/64"dia. another 5/8" deeper. Well…….!

Coffee break is over.

Remember to "OIL"(Vactra #2 way lube) especially the RAM ways & crank pin/block on the rocker arm of your shaper "BEFORE" starting.

To cut your key ways in the jigs, you won't use the bars, they, bars are used for getting into a hole

or bore and to reach out past the travel of the ram. You use your straight tool holder that you use for regular shaping. If you have a smaller machine, your holder will be smaller than ½" or 3/8", in those cases use just a ½" or 3/8"tool bit and a spacer to fit in the tool post. Grind the cutting end of your bit square with the side of the bit, then grind thegrind relief and clearance angles, and using the corner of the grind stone back grind the middle of the cutting edge of the bit, leaving 1/16" flats instead of 3/16"wide flats . Yes it's just like the one's in the bar. They can, with a radius ground on the back side of the bit, be used for key seating "shafts" when you get some experience under your belt.

You will want to swivel the vise from parallel with RAM, to 90° to the RAM, for rough setting, open the jaws of the vise so you can hold the blade less the base from your square, on it's edge up against the face of the fixed jaw, using a small scale, measure from column to blade on both sides of the vise adjust the vise to have the scale read the same on both sides of the vise. For dead nuts square (Kentucky term) use a dial indicator fixed to the clapper box, traversing the table back & forth, note dial arm reading, you want"0" reading, when "0" is found across the length of the jaw, tighten vise nuts and test again to verify.
You will need a roughing & finishing bit same as I described earlier, for the smaller shapers, the rougher might have to be even narrower than a ¼", remember to keep the cutting edge square to the side of the bit when grinding.

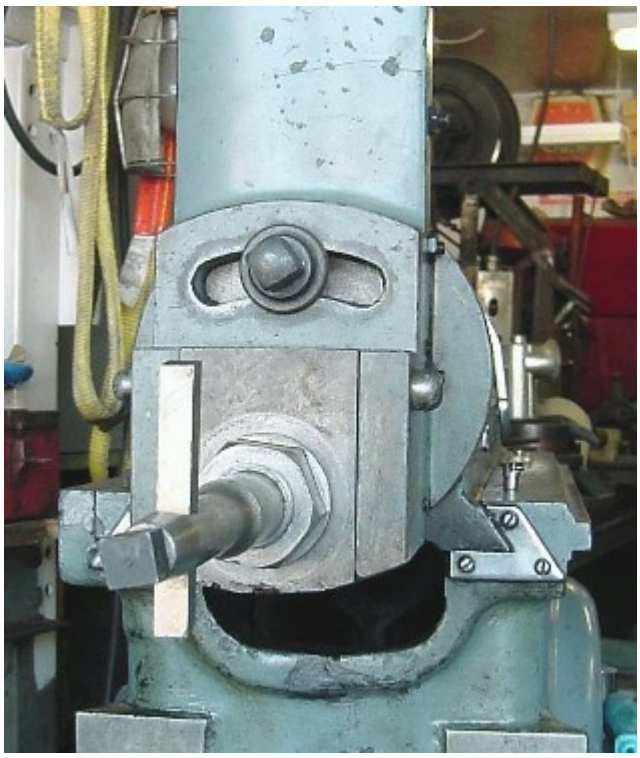
Why I have been repeating myself "edge of cutter to be square with side of cutter"

Here is "why you want the cutting edge square" with the side of the bit.

You want the slot or key way to be in the exact center of a bore for a hole, or you want the sides to be 90° to the top surface of your jig and the bottom of the key way to be parallel to the top surface of the jig. Confused, that my fault, it's easier and much quicker to "show you " then have to put it in words. "NOW I know" why this is not in any text book!!!!.

Hang in there it will be clear as mud, let's go back to cutting a key way into a hole or bore! The vise is empty, you put the key seat bar in the clapper, align the square hole in the bar to be straight up & down before tightening the nut, it helps to put a full length bit (just snug the side set screw) to help you, your doing this by eye (not critical here)

Using the long bit to roughly have cutter at 90°, then tighten bar holding nut



Note; “We did the following to any new bars, we tightened up the set screw on the bottom of the clapper, which would leave an indent in the bar for next time we used the bar” Ok, let the bar down, install the cap screw that keeps the clapper from moving (clapping), on some shapers they have 1 or 2 set screws through the box into the clapper.

Now place a high parallel or stack 2 regular parallels so the top face of parallel is above the top of the vise. Take out the long tool bit and replace it with a finishing bit, it can be wider than the key way, it’s just used for setting the side of the square hole, in the bar, that just happens to hold “all the key way cutters”, I know your drowning, just a bit more, hang in there .

Lower the vertical slide with the bar and finishing cutter (just snug 1st the side screw, then front set screw) towards the top of the parallel Move the RAM so as to place the cutter directly over the parallel. The RAM is not energized, loosen the nut on the “clapper”,but snug so you can tap the clapper box around, get the flash light (torch). SLOWLY lower the vertical slide so the cutter “just touches” the parallel. Only one of the corners will touch the parallel,(unless you have a horse shoe up your ass!) NOW gently tap the clapper box to have BOTH corners of the cutter touch the parallel at the same time, shine the flash light from behind the parallel, you will have to raise & lower the vertical slide a few times, you can test with paper at the corners too, tighten the clapper nut. The tool bit cutting edge (the 2 corners) is now parallel with the top of the parallel and, the side of the tool bit is 90°,*** THIS IS WHY you want the cutting edge square” with the side of the bit*** so “what ever key way cutter” you place in the square hole will be exactly the same, both corners just touching the parallel with the cutter’s shank at 90°, or parallel to the vertical slide. This ***allows you to interchange any of your cutters after without the above setup procedure***!. “To cut a key way is, less than a 15 to 20min. job” If your still wondering “why” the cap screw in the clapper, …… the clapper is cocked, be it ever so little, but enough that it will jamb if allowed to lift and tilt to one side, on the return stroke. Your using the clapper to tweak the cutter cutting edge to be 90° to the vertical slide, and at the same time the side of your cutter is parallel with the vertical slide,

Ram out of position,”unless” you have more table hiding somewhere, the stroke is already set

Ram position now set to cut key way, with ram at start of stroke.

Now, move RAM back by moving table(moving the table puts the position of the Ram to one side of the vise), from the vise, place your gear, or sprocket, or pulley, in the vise to one side of the vise, in the jaws but away from the bar, “why”, you have to adjust the length of stroke of the RAM to the length of the bore, the RAM’s travel is adjusted to place the cutter edge ½” to ¾” at start of stroke and ¼” to ½” past the bore at end of stroke, you may also have to reposition the RAM so the correct length of stroke at the cutter is where the work is in the vise. Setting length of the RAM stroke is one action, (the RAM lock on top of the RAM is still locked) positioning the RAM so the cutter will traverse the work is another and completely different action (you must loosen the lock to reposition the RAM for this action!!). Now you place your work (the gear) in the center of the vise jaws. Never have the work at one end of the vise by it’s self. It will lift out, if it has to be there, you must use a spacer of the same length at the other end of the vise jaw. This prevents the movable jaw from cocking in the vise and pushing your work out of the vise.
I have had to do this when cutting 20° to 35° angular key ways on the ends of pump sleeves, the key way is to keep the sleeve locked to the shaft, you use a spacer of exact length on the other end of the jaws, and angle the vise to the correct angle, AND the key is cut into the side of the sleeve, I feed the “table”, not the “vertical slide”!!

As I proof read this article, “DAM” it’s turning into a novel. I see me going off on tangents, this is, because for me, to set up and “just” cut a key way, no problem ah,…all these tangents (“what to watch out for”) are automatically programmed into my brain, I don’t have to think about them, but YOU have “NEVER” done this before, then, like I said before, I have “to be in your shoes and I have to ask why”& "why not".

Ok, back to the main point here “ You set the gear or part, that needs the key way in the vise in the middle of the jaws, make sure the bore is high enough from the top of the vise jaws to let the cutter cut to the bottom of the key way, ½ the width of the cutter +1/8”, “WITH OUT” hitting the vise jaws, OK !, tighten vise jaws. One point here, if the work has a hub, and you don’t have very much of the hub below the top of the vise jaws, THE CUTTING ACTION could and can LIFT the work from the vise. You will have to lower the work in the vise to the point of not having any hub to cut the key way in above the vise jaws, your key way will have to be cut on the top of the bore, NO PROBLEM, just turn the cutting bit upside down.

You see “you all ready set” the side of the square hole parallel to the vertical slide, (“hey” remember, I kept saying, “cutter cutting edge “square to” the side of the shank”) that’s one reason why! It is also “why” you can, “if you center the cutter tooth or blade width, center, to the tool bit shank center, YOU can cut key ways 180° “exactly” apart, or 4 key ways 90° “exactly” apart “NO ROTARY TABLE” required!

I will know if you understand this center of cutting edge, centred, to center of shank” IF YOU”, reply to this post asking how to check this, center to center thing, THAT thing, I have left out of this post, your all ready on **OVER LOAD**,… Ok……Say yes……..Nod your head then…..Ok

Now by cranking the table and moving the vertical slide, position the key way bar in the center of

the bore approximately, place the shaper in neutral, some shaper gear boxes (transmissions) a lever drops down, so one of the levers move in between gear ranges, you want to be able to move the RAM by hand crank and shaft, the same one you use to adjust stroke length. Crank the RAM to position the cutter inside of the bore.
On larger bores (3" and larger), have the cutter just come out of the bore a ¼", take and set a square and a 6" scale, on top of the movable jaw, so the base of the square is going away from the bore, the blade (not the 6"scale, you will need it shortly, just have it close by), the blade of the square is close to the bore's edge, now take a small rod ¼" or a pencil, place into bore, horizontal,(parallel to bore) slide, the rod/pencil up the side of the bore, and at the same time move the square to contact the rod/ pencil half way up the side of the bore, don't move square, put rod/pencil at bottom of bore, take scale and measure from the edge of blade of the square to the nearest side of the cutter, at the cutting edge do this to the other side of the bore, compare scale readings, move table ½ the difference in measurement, do the measurement again, until scale measurement are equal. It sounds harder than it is to do, what you are doing is centering the cutter, roughly with in .005" of bore center.

Now with the cutter back in the bore, lower the cutter just enough, until one of the cutter's corners touch the bore, look from the front of the shaper, into the bore, yes the flash light again, shine light from back of bore, behind the fixed jaw. Looking into the bore, you will see one corner not touching,(who knows you may have 2 horse shoes stuck up your ass), you want to move the table to bring the bore closer to the cutter corner, you move the table to reduce this space by half, now both corners will have space in the bore, lower the vertical slide a little more, and repeat until the two corners of the cutter are just about to touch the bore at the same time. Now lower your vertical slide a few thou at a time and crank the RAM through it's stroke, each time before the cutter enters the bore lower the vertical slide a few thou until the corners scribe two lines at the same time, through the bore! Look at the scribed lines are they the same width?

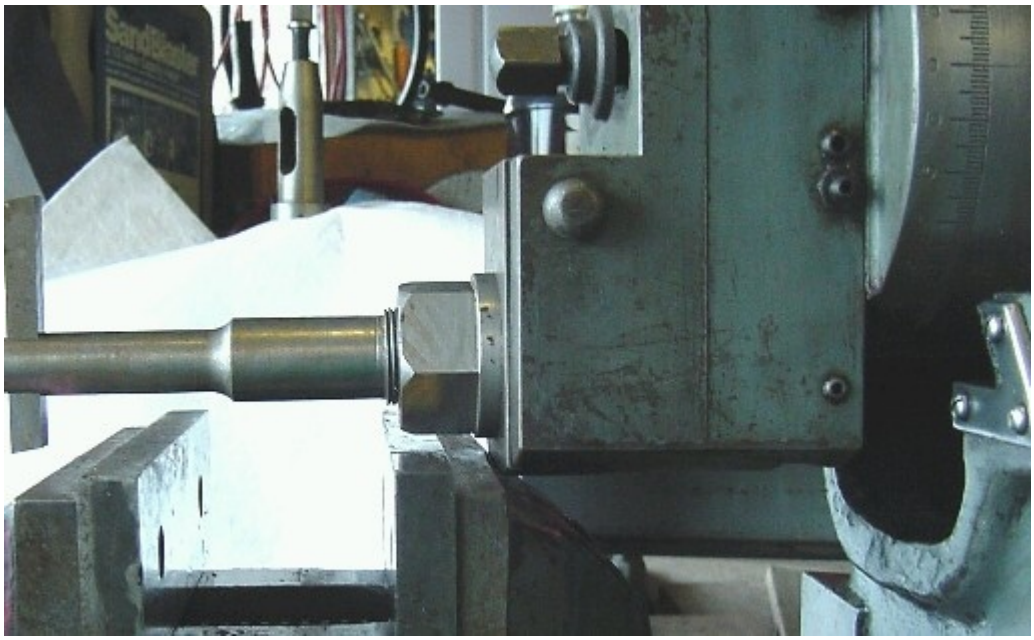
Yes, "YOUR READY TO CUT A KEY WAY" *****"WHO OOO"***** "YIPPY**

A couple of little points here, set your dial on the vertical slide to "0"after any cutter change out, and snug up the lock on the vertical slide, not so you lock the slide, but so that it has more resistance when feeding down while cutting the key way, also, seeing you have 2 scribed lines and your square, layout dye (blueing) you can scribe layout lines on the gear face for your key way, the depth of key for inch keys, is half the width of the key +.010" to .015", measured from the side of the key.

Before I remove the finishing cutter I cut down into the bore .010" to .015", this leaves a pocket or notch to realign the finishing cutter back to center. Then (lift cutter clear of bore or you will chip the cutter&^%$#), then backup the RAM to start of stroke, change out finishing cutter, installing roughing cutter, leaving enough of the roughing bit sticking out for depth of key + 3/16" (if I can, sometimes the bore is so small, I can only leave 1/16"). I bring the cutter to the inside of the scribed line - .030" to .040"away,(you leave .030" to .040" on each side of the scribed key way, so the finishing cutter has "something " to do, yes size the key way) of course!!. I touch the bore with the corner of the rougher, set vertical slide dial to "0", DOUBLE CHECK THAT THE TABLE FEED IS IN NEUTRAL, sometimes if there is no neutral detent I will "take off the feed rod", otherwise you will cut heilical key way for a bit of time anyway!, till the emergency shuttle launch!!!!!!!!!!!!

AND VERY VERY IMPORTANT, run the RAM using the crank handle, through it's travel, make ABSOLUTELY SURE, the "nut holding the key seat bar" WILL NOT SMASH INTO the vise, while cutting the key way to depth, UNLESS YOU REALY WANT TO ACTUALLY SEE THE POWER OF THE "ALL MIGHTY RAM" tight vise nuts or not…….

You also need to check the clearance at the bottom of the clapper,(it's lower than the nut) see pic



.I was on one of the millers at work when the not so tiny 32”G & E’ shaper, operated by a 1st year apprentice, didn’t check, ……. He needed clean shorts, and, he shook for about an hour or so after!, BIG eyes, boy real BIG eyes!!!!!! HE had a lot of respect after that, for the G & E Shaper.

I swear..... that shaper was laughing at the kid!,..... maybe it was the oil girgling.

You cut one side of key way, then the other side of key way, then chew out the rest, feeding down to the required depth checking the vertical dial, but watching the cut.

As how to feed the cutter, I bump the handle or ball of the crank on the back side with palm of my hand, just as the cutter, “on the return stroke leaves the bore (you have about 3 to 4 seconds, too early, you will chip the cutter. To cause the slide to advance down .003” to .005” per stroke, bump the handle or ball at the end of the back stroke, then about every 6 strokes, no down feed for a couple of strokes, this will shave down the crowing of the key way, then feed down another 6 or 7 strokes, keep repeating until you have reached the bottom of key way, it would be good to practice, to get the “feel” prior to cutting a key way, to get the right feed rate and rythem, YOU gota BOOGY Ya BOOGY,Boogy, BOOGY.

One more note here, before starting roughing of the key way, ONLY, half fill the soup can with cutting oil “ONLY HALF FULL”, don’t ask why....., if you fill the can full it’s going to “some how” spill, and of course on YOU, it NEVER, NEVER, FAILS, THIS IS EXPERIENCE TALKING, don’t belive me,Eh..... I DARE YOU,... naw,.. I DOUBLE DARE YOU!!!! GO AHEAD…… FILLER UP……..YOU”LL SEE!!!!!!!!!

This stuff just keeps trickling out of my brain, I never realized how much of this was automatically programmed into me, HELL, I’m impressed!!

Another point, when to paint(apply) the cutter with cutting oil, you can paint (brush)or oil can) the bore with cutting oil just before you start to cut, it makes everyone think you started smoking stinky cigars!!, and, or, as the cutter pushes out of the bore, on the forward stroke, paint the cutter at the end of it’s push stroke, if your cutting bit doesn’t extend out of the top of the bar, you can fill the remaining square slot in the bar with cutting oil. The oil will weep down the shank of the cutter onto the cutting edge, this doesn’t work too good on the wider cutters, you know 1" & 1-1/2” or 2” wide key ways.

WHERE do we have key ways that big,…… Oh, on a 71 ton Sym Z roll, cost $1.5 millon U.S Dollars, (it has 42 hydraulic cylinders inside to adjust the crown on the roll, while it’s rotating), speed of roll on circumference of roll 4800 feet / minute, driven by a 1200Hp motor, the paper machine, the roll belongs to, makes 800 tons of news print a day (24hrs).

This is a lot for you to digest today especially without any pretty pictures, I will go and try to set up some shots for you, and post later, Ok.

PS; I hope I haven’t scared you off from grasping how to cut key ways, like I said “IF I were there, “WITH YOU” it’s a 20 to 30 min. lesson,…no more than 40min.….Honest, don’t believe me, I taught a 72yr old member “of this group” a couple of yrs ago.

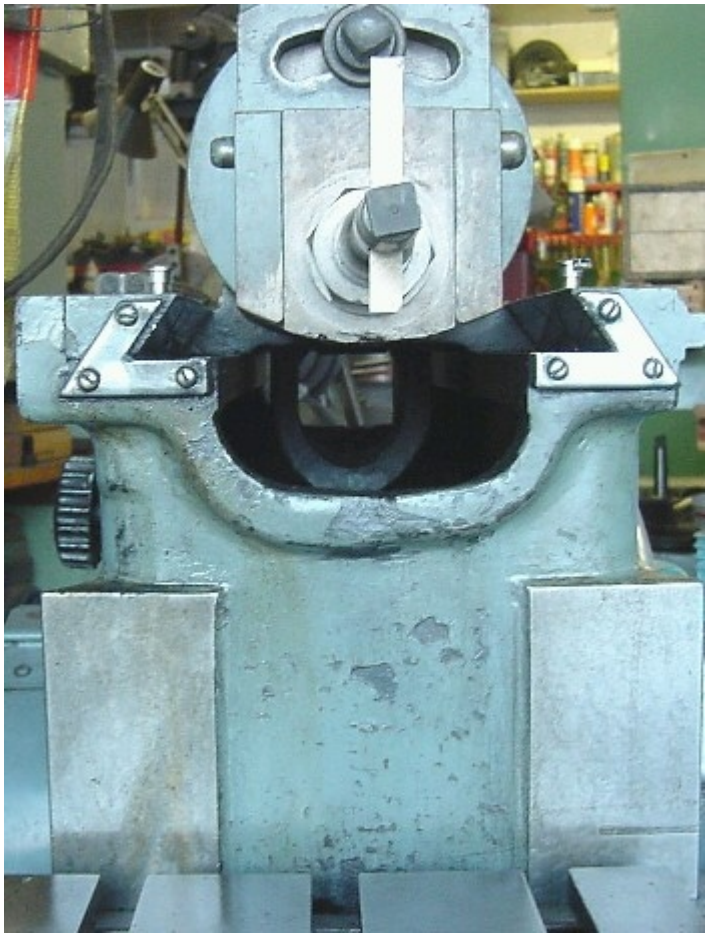
BUT writing “EVERYTHING”, YOU MUST have to be aware of , while grinding cutters, what to watch for when setting up cutters, how to center cutters, how to hold the work, are the locks on or off, checking that the mighty RAM isn’t going to give you cause for an under wear change is something else.

My mentors were taught, they taught me, I taught our apprentices, and I hope I can pass on this knowledge on to you, to keep shapers around to enjoy, and have you “experience the feeling” of learning to “Master the Machine”. In case you didn’t know, “that’s why they call us” Machinist’s”,Eh, we, make the machine, do the work! What a novel idea!!!!

There is more but you need to rest,……I’ll be back
Take Care

Starting Position of Vertical Slide when cutting key ways as well as most other shaping jobs, it is of importance, that the operator should insure, that top half of the vertical slide’s bottom surface (under side) should be flush with the bottom half of the vertical slide for the start of the cut.

Pic of correct starting position for the vertical slide when shaping



There are a couple of reasons for this, the first is for greater rigidity, never allow the vertical slide or the tool holder to overhang too much, if necessary, raise the table as required. Too much over hang can cause chatter because of springing in the slide and/or tool holder.

Second, when cutting internal key ways, the ram, is often positioned to the far, rearward position, this also positions the vertical slide inside of the main body of the shaper, with the ram ways on either side of the vertical slide. Look at the pic above, notice the open space under the vertical slide,

in the main body of the shaper, this is the amount of travel the vertical top slide can move down, less a quarter inch, if the slide starts in an “all ready low position”, it may run to (crash into) the main body of the shaper, during the stroke of the ram, and be badly damaged.

The open space under the ram has a couple of purposes as well, as stated above, it allows the top half of vertical slide to travel down past the bottom half of the vertical slide without colliding into the main body of the shaper, when the ram is in it’s most rearward position, and the vertical slide is inside of the main body of the shaper.

Now the second purpose of the hole, and this is NOT on all shapers, is to allow a small diameter shaft (1”to 2”) but long in it’s length, to be positioned through the body of the shaper, through the yoke in the top of the rocker arm. This is only used when cutting key ways in a shaft that are not at the ends of the shaft, but, in between the ends, closer to the middle of the shaft.

This requires a “very high degree of skill”, by the operator, to setup the shaft in this way, and should “NOT” be attempted in anyway what so ever by the inexperienced operator, which “MEANS YOU”, I have only mentioned it here as a second reason for the hole under the ram. If the shaper does not have a yoke that connects to the ram, (not all shapers do) this setup can NOT be used.

The standard way to “key seat a shaft”, using a shaper, that is long or short, is to off set the vise to the far side of the shaper body, so when the fixed vise jaw is set parallel to the ram, the shaft can be placed in the vise and along side of the shaper body. The vertical slide is then angled at a 45° angle to cut the key ways in the shaft. The position of the ram, as well as the stroke of the ram must be set with “great care”, so as to NOT have the vertical slide CRASH into the ram ways of the main body of the shaper on the return stroke of the ram.
You probably didn’t know that shafts can be keyed in a shaper also, well, before milling machines and portable key seaters, that’s how key ways were cut in a shaft! Ok, back to key seating bores.

Holding the Work
The work must have it’s bore parallel to the ram, do not “assume” that by placing the work in the vise, the work is parallel to the ram. The best example to show you, is think of a weldment, such as a sprocket or gear with a hub. You can bore and face both ends of the hub, then weld it to the sprocket or gear. If the work is a good size, and you place the work in the vise jaw, only grabbing the work by the un-machined faces, the bore will not be parallel to the ram, failure to notice this, and cut the key way, will give you a crooked key way in the bore. You must always make sure the faces, you are holding the work by, are square to the bore, you may have to set the work in a lathe and take a light surface cut on the faces where your holding the work in the vise of the shaper. Also when holding work in the vise you must make sure that the moveable jaw of the vise is not lifting the work upon tightening of the vise jaws,(this happens on long bores) if the hub can be set on parallels in the vise , you can check after tightening, by trying to insert feelers between the work and the parallels, if there is any gap, tap hub down onto parallels using a dead blow hammer. A double check is, to look at the work where it meets the fixed jaw face, there should be full contact between the work face and jaw face, a flash light is handy for this check, shone from the back side of the work towards you.

As stated earlier if the vise is holding only, by a small amount on the hub faces, of the work, it will move in the vise. If the work can be lowered in the vise, and the key way cut on the top edge of the bore, then Ok, but this is not always the case. When work of this type is set up in the vise it is shakey, you will have a bad experience trying to cut a key way, one way to correct the shakey setup is to hold the work on a 90° angle plate. This plate is made for the shaper, using heavy plates or heavy angle iron with support gussets, then a hole or slot is cut on one of the faces of the plate, the pic below is an angle plate from work, this is looking from the back side, you can see the slot.

Pic of Big angle plate for shaper

This plate can be mounted directly to the shaper table, using 4 bolts, the face with the slot is set at 90° to the ram, just like the fixed jaw of the vise, for small work, the face, the work mounts to, is facing the column, for larger work, where the table can be lowered enough, the face the work mounts to, is facing away from the column, at the end of the table, this allows the work to over hang the table. The work is held on to the plate by at least 2 clamps or more if required, the plate is drilled and tapped . The portion of the bore where the key way is to be cut is placed in the slot portion of the plate to allow the key way to be cut without cutting the plate.

We used to cut a 1-3/4” key way in a 16” bore of an 80” bull gear on a 24” Hendey shaper using the angle plate in the pic above, we had removed the concrete in front of the shaper to allow the big gear’s O.D. to be lowered into the hole so, to allow it’s bore to be low enough to cut the key way, the bull gear was held in place using 4 bolts and clamps, a metal plate (cover) was placed over the hole in the concrete after the job was done till next time.

Crowning of the key way is, when the cutter, is too blunt at the cutting edge, and pushes itself away from the cut, making the key way too shallow in the middle of the bore. This can also happen when using a long key seating bar, and/or the bar is too small in diameter (springy).

Once the key way has been cut to depth, a check is done, if you take the piece of HSS tool bit (from the list) that is half the width of the key way. Place this tool bit in the key way, you have taken the 6” half round file and taken the sharp edge of the key way in the bore off. Move the bit to one side

of the key way, place your finger on top of the tool bit, then move your finger towards the bore. If a ridge is felt as your finger has reached the bore, that's good, your at least the correct depth in the key way, but now do the same check along the length of the bore, on both sides of the key way, if at any point the ridge disappears the key way will be too shallow. Just touch up your roughing bit on the grinder to give a good sharp cutting edge to remove the crowning in the key way. With a sharp roughing cutter, you will contact the high spot in the key way, usually in the middle of the bore.

The last check of your key way is to try the actual key in the newly cut key way, the key should just slide through the key way, then file off the burrs at each end of the key way.

Chatter at the tool bit can be from many places

1. Too small dia. bar, or too long of a bar, use the thickest bar for the bore, allowing for key way cutter, only use a bar that is long enough to cut the key way. If the bar is small because of bore size, reverse cutting sequence, cut on the back stroke, or pull stroke instead of forward or push stroke.
2. Locks left loose, wrong sequence of tightening locks, check before start of cut that the cross rail lock is tight, then check and adjust front table leg support, and lock. The vertical slide too loose, adjust tension lock. The vertical top slide too long of overhang,(springing of the vertical slide.) Failing to lock down clapper to prevent clapper movement.
3. Dull or chipped key way cutters, always check cutter condition prior to cutting key way, sharpen as necessary. Roughing cutters need a little top rake, also, too wide of a roughing tool bit can cause chatter, for small machines 3/16" wide, for larger machines ¼" wide for roughing cutters. Too wide of a finishing tool, failing to grind back the finishing tool in the middle of thee cutting edge.
4. Weak, or wrong setup of work, work too high in the vise, holding by too small of a hub, work not centred in the vise, work tipping in the vise after tightening, check for gaps under parallels, work that is small and flimsy such as step pulleys, should be mounted on an angle plate instead of the vise for better support.
5. Too heavy of a feed of tool bit, feed tool bit .002" to .004", stopping feed every 6 or 7 strokes, to reduce crowning of key way.
6. Lack of cutting lubricant, for steel, bronze, sulfer base oil, for aluminum penetrating oil, fuel oil, or WD40, for cast iron, or yellow brass, no cutting lube required.

To make a Angle Plate for your shaper

An accessory the 90°angle plate, that has come in handy especially if you have to key seat a 80" dia. plus bull gear, this is, a 90° angle plate, these are used for larger jobs than the vice can hold. It can, if made with some fore thought also be a table extension to mount a dividing head or rotary table.

If your going to make only one, a good rule for size is, what ever your table width is, should be the size of the bottom and end of the angle plate. The base should have at least 4 holes to anchor it to the table, measure the table's T-slot spacing for center distance. The vertical end has a 2" to 3" wide slot starting from the top edge to the center of the plate this is to let the key seat bar pass through the angle plate. The other plate has just a shallow slot (1/4" deep) in it's centre that matches the centre T slot in the table, this shallow slot is used to align a dividing head or rotary table.

This is easy to make and will give you some shaper experience, start by cutting 3 square plates, 1" thick minimum, using the width of your table to give you the length and width of the two end plates, cut the third plate it can be ¾" thick (same size as the end plates) diagonally, these become the two gussets of the angle plate. Shape the gussets to a 90°. Hints here, "shape them together", next drill the 4 holes, give1/16" bolt clearance in both plates to match the slots of the table. Take your time in laying out the holes.

Assemble the pieces, "paying close attention to keeping it square". Tack weld and check for square, if all's ok, finish weld, AND "NOT" on the shaper table....@$#%^!!

After deburring your weldment, bolt the angle plate to the side of the table, use shims or packing to balance out the plate, "what is meant here is", to "shim the weldment so that your NOT" taking a large amount of metal off one edge of the plate and little or nothing off the other edge, you have to find a happy medium between both, bottom, and end plates, this is why close attention is given to squaring prior to welding.
Change clamp positions of plates, that's why 4 holes in "both" plates, balance out the unmachined plate, same as before but no shims this time, and machine.

Scribe a cross on the end plate, center punch, scribe a 2" or 3" circle. This is the hole I described earlier, now with a square on the machined 90°corner, scribe lines from the hole to the opposite edge of the vertical plate, do "NOT" use a torch to burn out the slot, doing that will warp your angle plate. If you have a hole saw, drill the hole, no hole saw, use 1/4" to 3/8" drill bit for the hole, drilling around the circumference.

If you have machined the gusset side of the angle plate square, you can bolt the weldment to the table side. You can now shape two grooves from the top edge of the vertical plate to the hole. Deburr and your ready for the big stuff. Some drilling and tapping maybe required on the vertical plate to clamp your work to Safely.

Well that's about it for cutting key ways in a bore.
I have described how to
1. Make roughing cutters
2. Make finishing cutters
3. Make grinding jigs to grind cutters
4. How to set up the shaper to cut key ways
5. Cutting actual key ways
6. What to watch for as you are cutting key ways.
7. Causes of Chatter and how to remedy
8. How to make an angle plate for your shaper.
9. Safety while operating a shaper.

I hope it wasn't "TOO" boring for you.