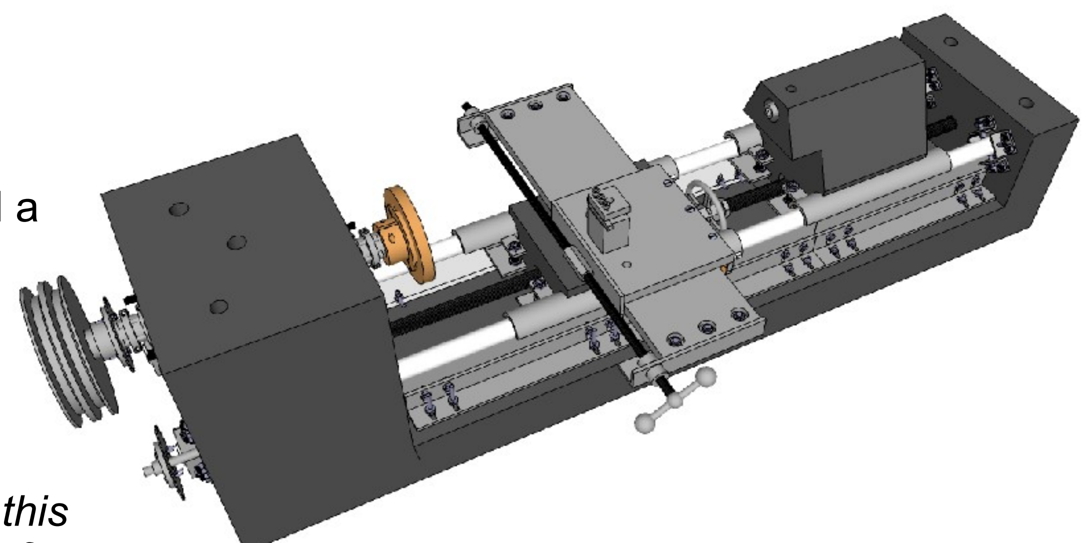
The Multimachine Open Source Concrete Lathe Project

The basic machine tool, the basis for any manufacturing or industrial production

An almost free metal lathe, drill and milling machine

- Accurate, and scalable to almost any size
- The technology used has been proven for almost 100 years
- Easily made from scrap, steel bar and concrete mix
- Built with common hand tools, a drill and a few small welds
- Simple screw cutting without gears
- Easily converted to drilling and milling

Anyone is welcome to translate and sell this .pdf in the Developing World. Contact us for the free Open Office files.



Credits

Many have contributed to this project. The main players are:

Pat Delany | Design | rigmatch@yahoo.com 903-723-0980

Shannon DeWolfe | Research

David LeVine | Research

Tyler Disney | 3D Models and Drawings | flowxrg.com

Many more resources can be found at the following sites (including Sketchup files):

http://flowxrg.com/concrete-lathe-project-start-here/

http://vimeo.com/27493189

http://flowxrgdotcom.files.wordpress.com/2011/07/new-method-of-building-lathes.pdf

http://TinyURL.com/6dmdaub

Support at http://groups.yahoo.com/group/multimachine/

Dedication

To my wife, Clarissa, without whose help this would not have been possible.

Our efforts are also dedicated to

Jeffry D. Lohr

and

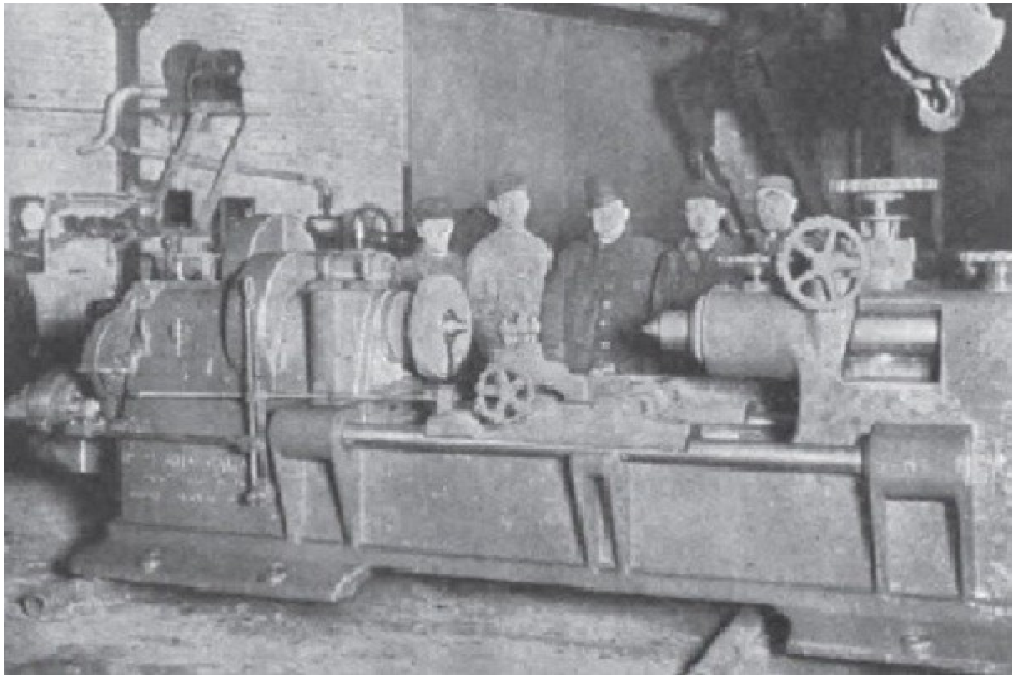
Abubakar Abdulai

Founders of the Moringa School of Trades, Moringa Community, Cape Coast, Ghana, W. Africa

(if you ever have an extra few bucks, this is a good place to send it)

Background

In 1915, lathes made from concrete were developed to quickly and cheaply produce millions of cannon shells needed for World War One. The technique was almost forgotten after the war until we re-discovered it as a way to make accurate machine tools for use in Developing Countries and in trade schools and shops everywhere.



Bottom up Development for the Developing World

Why our ten year effort to do this?

It's a way to revolutionize trades education and industrial development in the Developing World by cutting the cost of machine tools by up to 98%.

To explain this we have to start with what machine tools are.

Machine tools (principally the screw cutting metal lathe) made the Industrial Revolution possible.

They are now too expensive to have serious impact in the Developing World. Our lathe design can change this. It is an accurate, easily built, fully functioning, multipurpose tool made with long proven technology that can now be built using only cement and scrap metal.

Individuals in the developing world face huge obstacles -- and stiff competition -- as they try to start economically viable enterprises. Tools are expensive and out of reach to all but a few, making the acquisition of tools and the skills to use them one of the biggest roadblocks to development in informal economies. Those who do gain skills are often roadblocked from passing them on due to the lack of available tools -- education alone is not sufficient if people can't put their skills to work.

Imagine a different scenario.

What if the barrier to machine tools of acceptable quality were lowered?

What if you could build a metal lathe (the key tool in manufacturing almost everything) out of a few bags of concrete and scrap metal?

What if you could fill an entire machine shop or small factory with tools made from inexpensive locally available materials, skills and tools?

What if that machine shop made a business out of making more machines, populating other machine shops that made businesses out of fabricating parts for agricultural equipment, repairing auto parts, making lucrative sculpture art, or any of the myriad other niche markets in the informal economy?

What if communities with severely limited economic potential could bootstrap their fabrication and manufacturing ability to increase their industry and quality of life, without outside assistance or loans?

What if you could cut training time from years to just a few weeks?

These are the sort of “what if’s” that motivate our Open Source lathe project.

Our answers to all this may be in the Lucien Yeomans "secret" that was almost lost.

What he did (and we do) is extremely simple. It is well known that concrete shrinks as it sets up. This is not important when you pour your sidewalk but this shrinkage would force a concrete machine tool out of alignment as the concrete casting dried. He solved this by casting a concrete frame or "bed" with oversize cavities where the parts would normally go and letting the concrete season and shrink. He would then align the metal parts and hold them in place by pouring a non-shrinking, low temperature metal alloy over them. He could build a 10 ton lathe in as little as 7.5 hours when other companies took up to 6 months. His machines were used to manufacture millions of highly accurate cannon shells in WW 1 and this ultimately brought Yeomans the nation's highest engineering award, the Franklin prize. Sadly, once the war was over his machines were scrapped and his idea almost forgotten.

The type-metal that he used ninety five years ago is no longer available but we can use the non-shrinking cement grout commonly used by tile workers.

We use this technique or a small variation for:

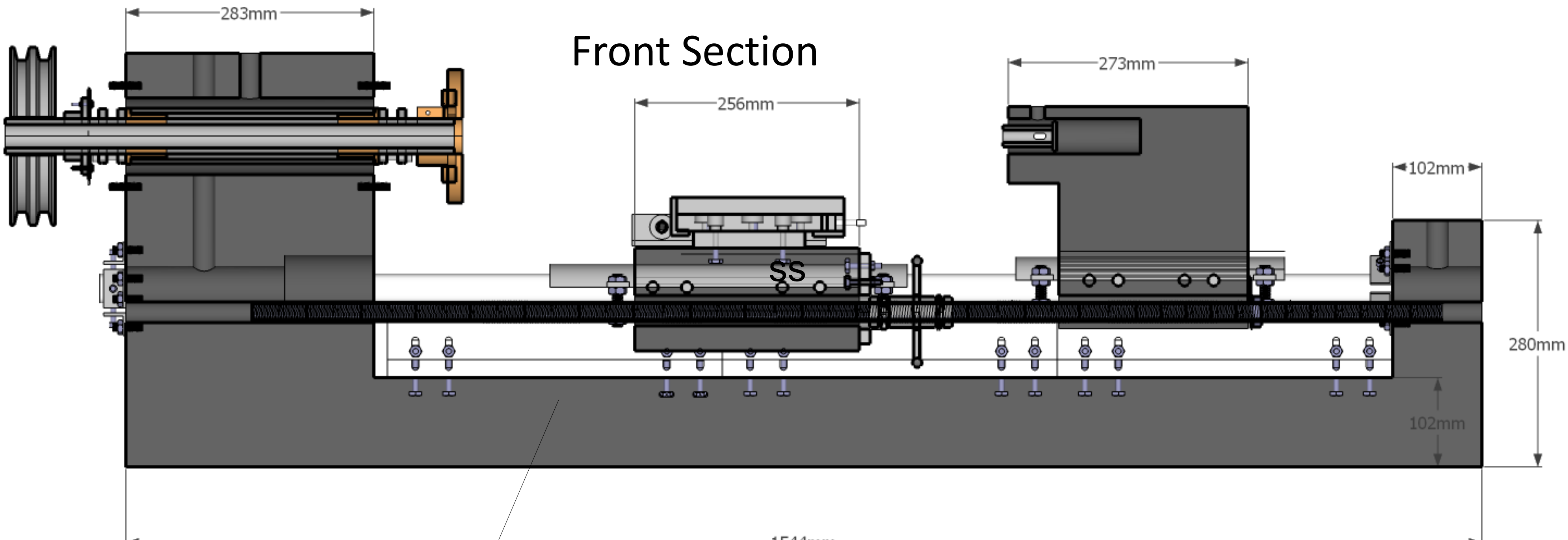
- Fitting the ways to the bed
- Fitting the "shoes" to the ways and the carriage and then grouting them together
- Fitting the cross slide to the carriage
- Fitting the tail stock to the ways
- Fitting the Morse Taper socket in the tail stock
- Fitting the spindle cartridge to the headstock
- Fitting the thread follower spindle cartridge in the head stock

Our lathe, more than most other kinds of machines, can be used to build, repair and upgrade itself

The lathe can be used to repair most of its own parts. Every part of the lathe can be replaced as parts wear or as improvements are needed.

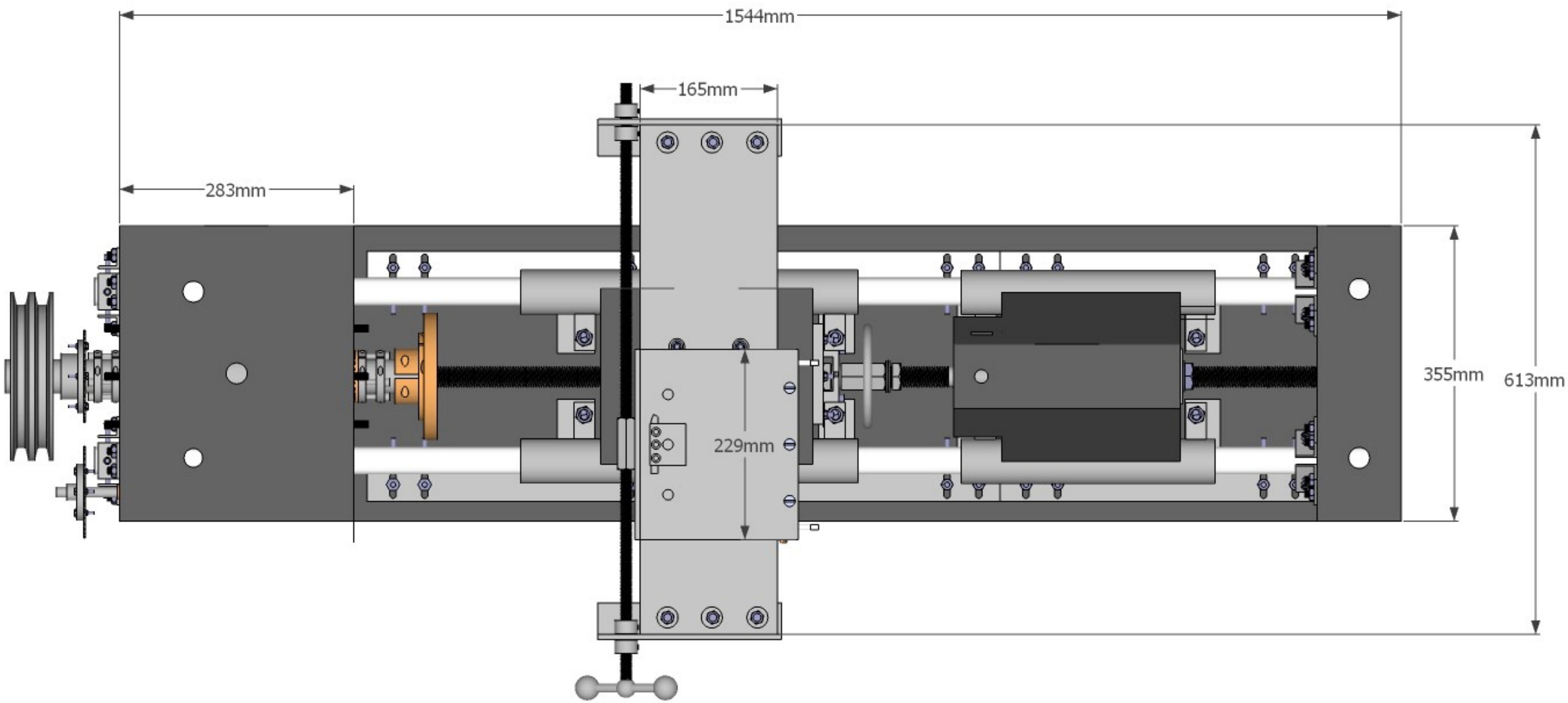
- The bushing type spindle can be replaced by a ball or roller bearing type.
- The carriage can be swapped out with special milling or boring carriages.
- A compound slide can be added to the cross slide.
- The box type cross slide can be replaced by a dovetail type machined on the lathe itself.
- Change gear type threading could replace the simple “thread follower” type.
- Steady and follow rests can be added.
- The tailstock can be replaced by a turret type.
- In case of excess wear, the ways can be rotated to the unworn side. The ways could even be replaced by sawing them off, pulling out the stubs from their greased sheet metal liners and chiseling out the weaker non-shrinking grout from the concrete bed/frame.

The guiding principles of this project are simplicity, economy and ease of of construction.

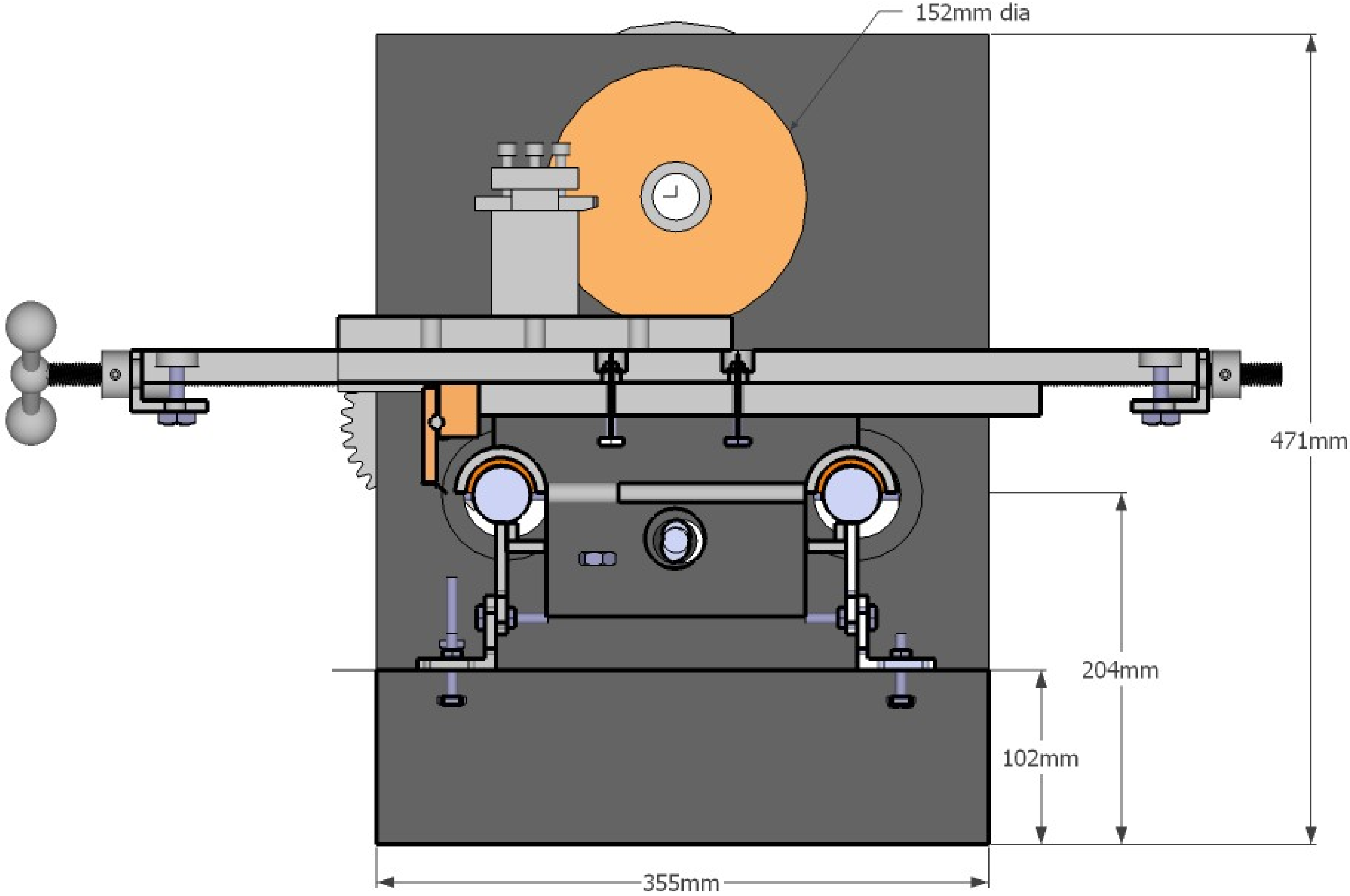


The “bed” or base of a short version could be 100mm thick but a regular length version like this should be 150mm thick.

Top View



Side Section



Ready to build one?

In this version the component size is similar to a typical 250kg. 225mm swing lathe but actually has the capacity to mount a grinder that be used to re-surface 300mm diameter clutches and brakes. It was specifically designed to be transportable so it could be taken to Maker Faires and could also be used in rural areas of Developing Countries.

A better choice for many would have ways 300mm between centers and a 400mm swing. Other parts could be scaled up accordingly and would add little to the total cost. The lathe would be even easier to build since the carriage parts would be even less crowded together.

Our goal, not the best tool, but one that will work with reasonable accuracy and that can be built by a skilled mechanic using common tools and at the <u>absolute lowest cost.</u>

Materials and tools needed to build a 300mm screw cutting lathe that would fit on a workbench.

A desktop lathe half this size could also be built. Our optimal “shop size” lathe would have ways 300mm (center) apart, swing 100mm and would weigh at least a thousand pounds.

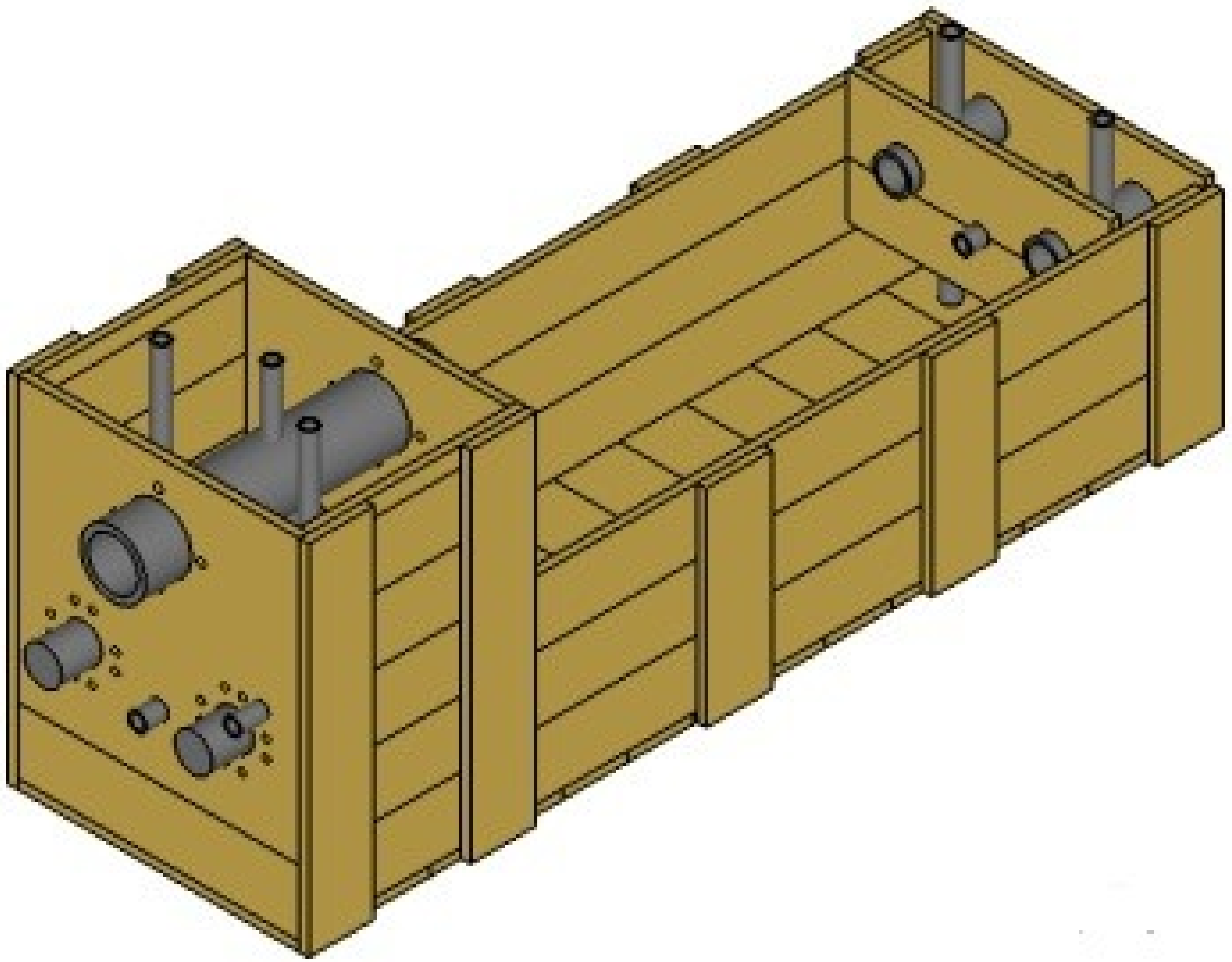
A lathe the size of a railroad car could be built using the same basic design.

- (2) 40mm x 1.5 meter (approx) very straight steel rods or pipes (scrap hydraulic cylinder piston rods?)
- Steel bar, .18 mm x 150mm x 600mm.Trucks often have double layered frames and pieces of this might be used if they are separated and then lapped together. Some change in our designs will be necessary if you do this but then, except for concrete, the whole machine could be built entirely from scrap metal.
- A discarded hydraulic cylinder with a 37 mm/1.5” piston rod. Larger would be better.
- An auto wheel hub if no metal or wood lathe is available to machine aluminum castings you make.
- Concrete mix
- 8 very simple, aluminum/piston metal castings (You do need to learn the art of simple aluminum casting to build a really low cost machine).
- Wood, scrap steel, bolts and nuts (almost nut and bolt free construction is also possible).
- Basic carpenter's and mechanic's tools, an inexpensive dial indicator will be very helpful but alternatives can be made.

Special note:

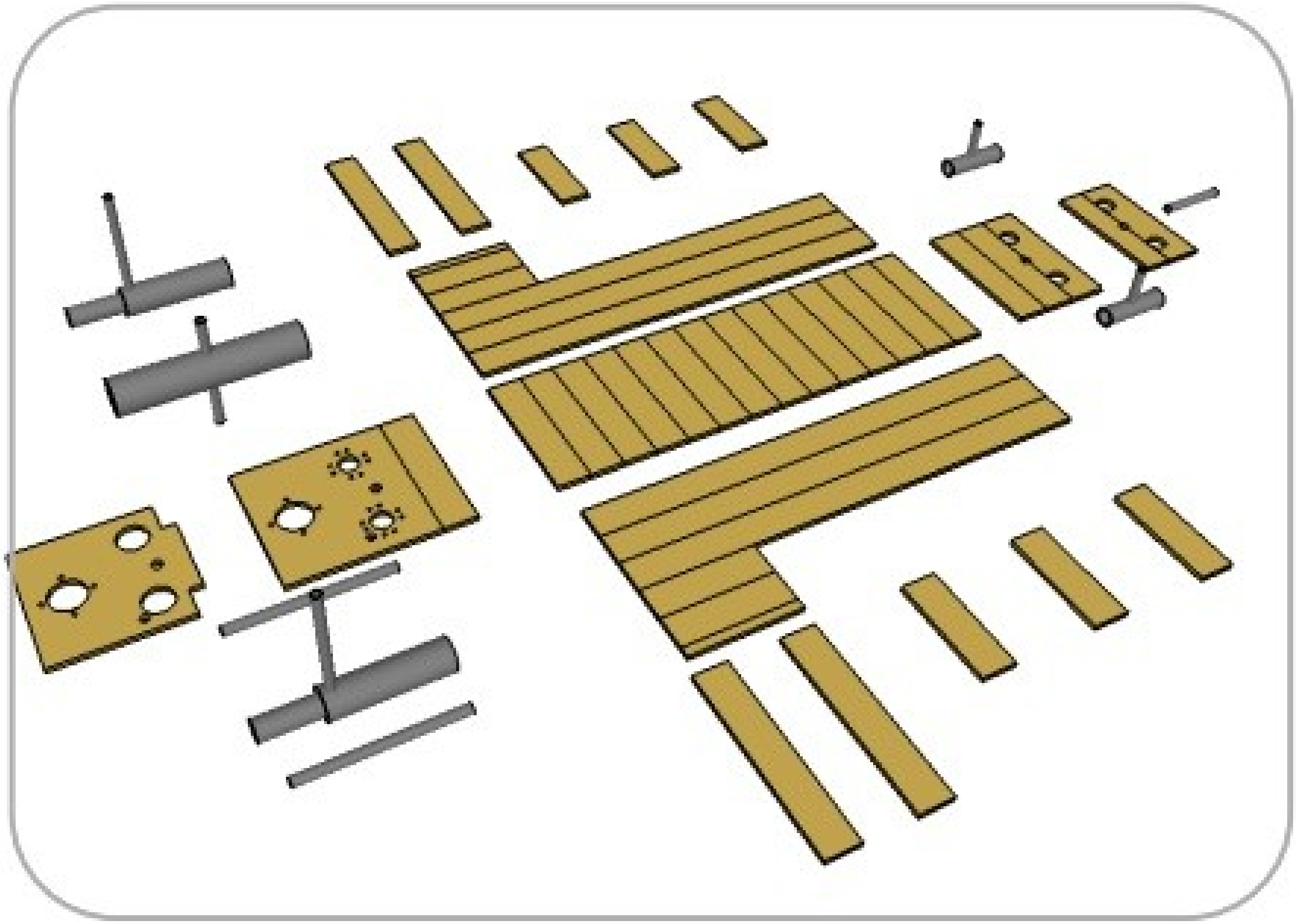
Two uncommon terms will often be found here. The “ways” are the round rods the carriage slides on. The sliding parts that ride on the ways are called “shoes”.

We start with the form for the concrete frame (lathe bed)

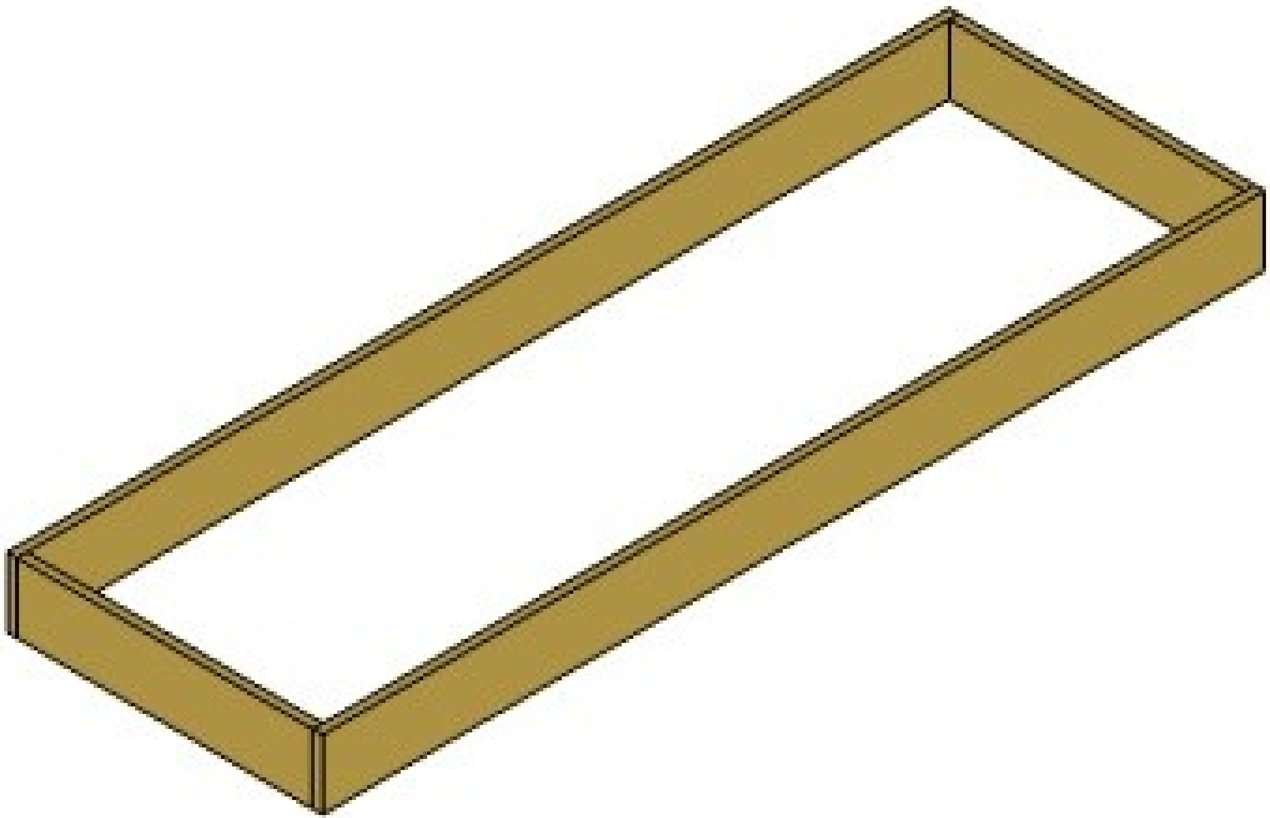


Materials can be as simple as pallet wood and cardboard or plastic tubing

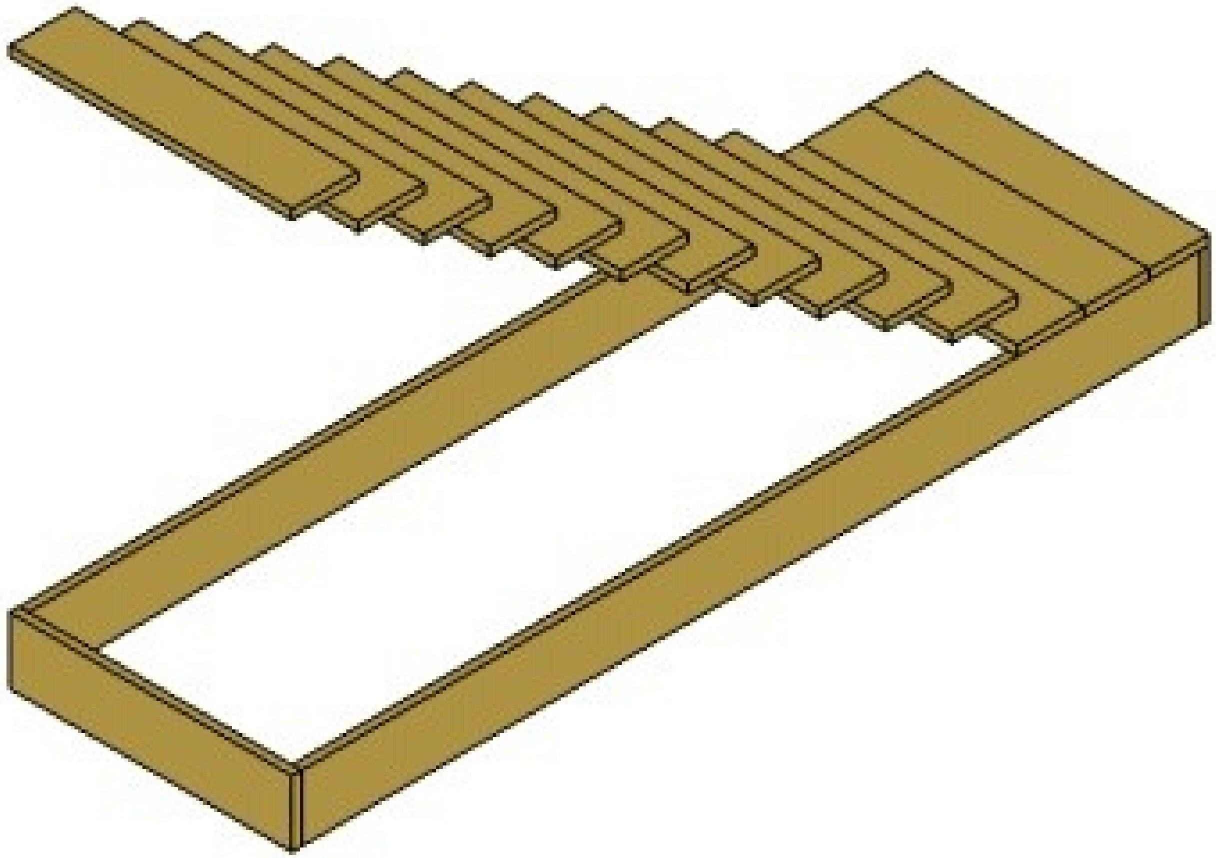
How simple it can be!



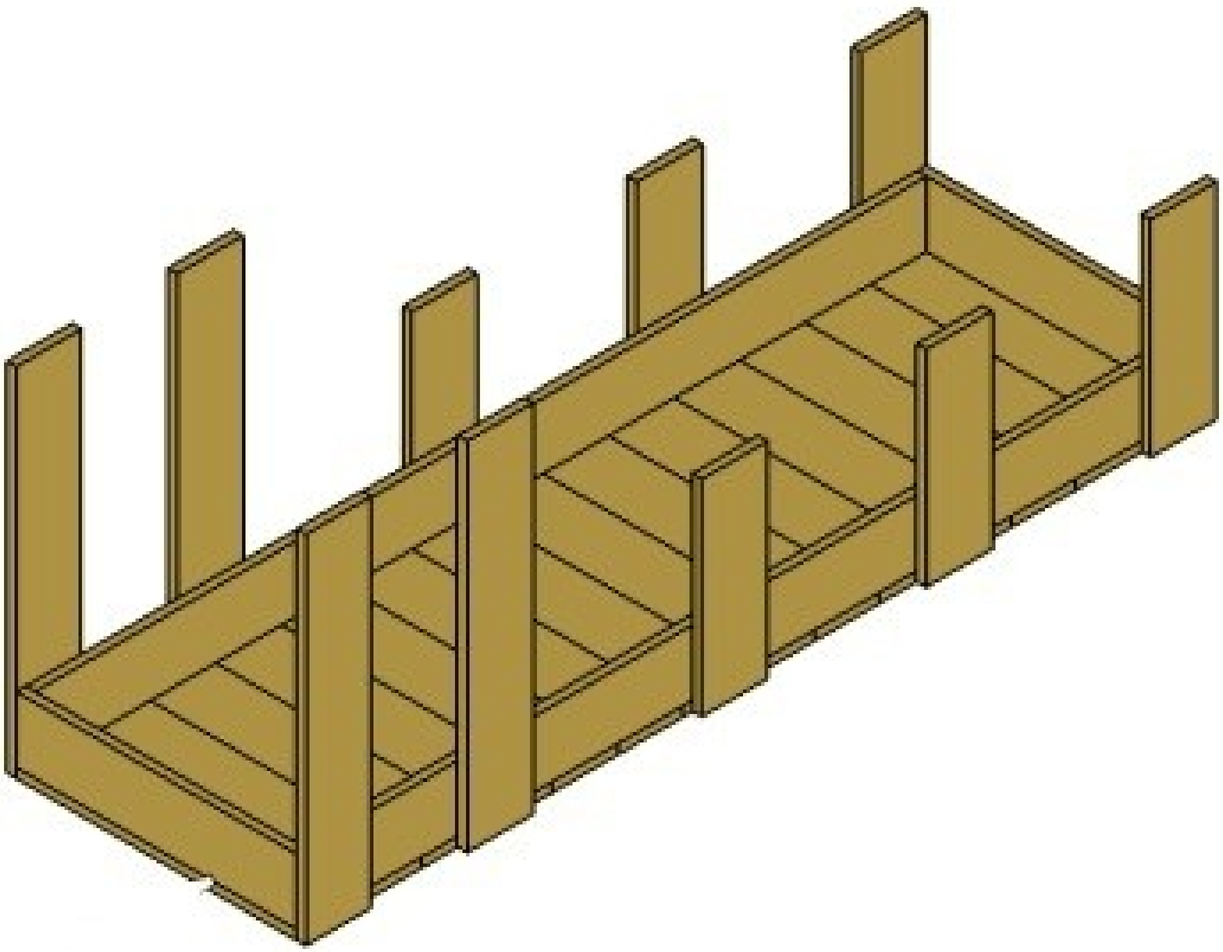
Start with a simple box



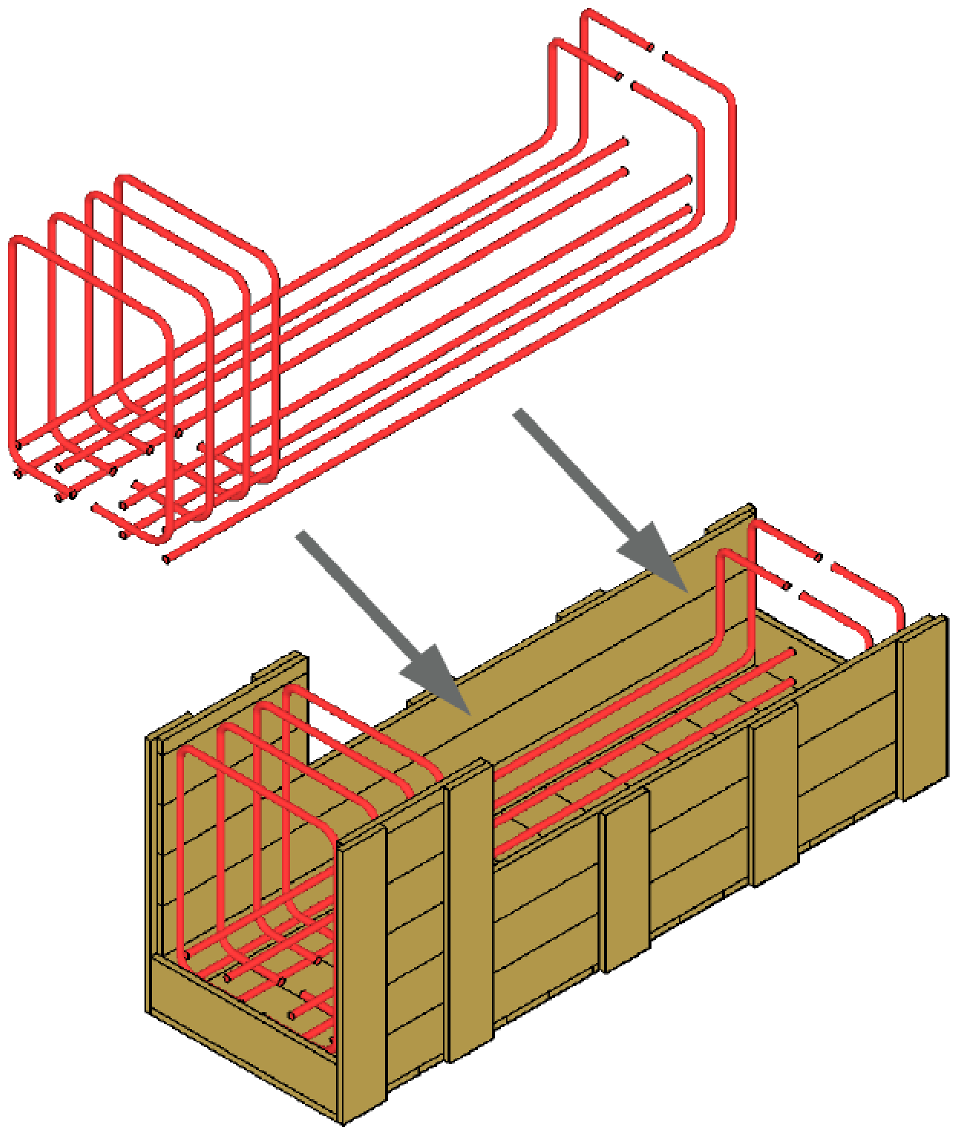
Close up the base



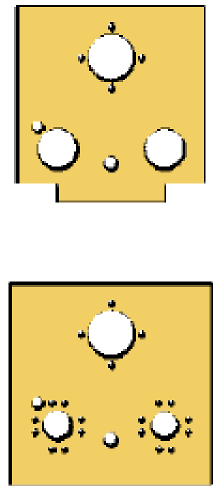
Add the sides

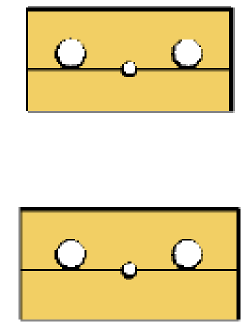


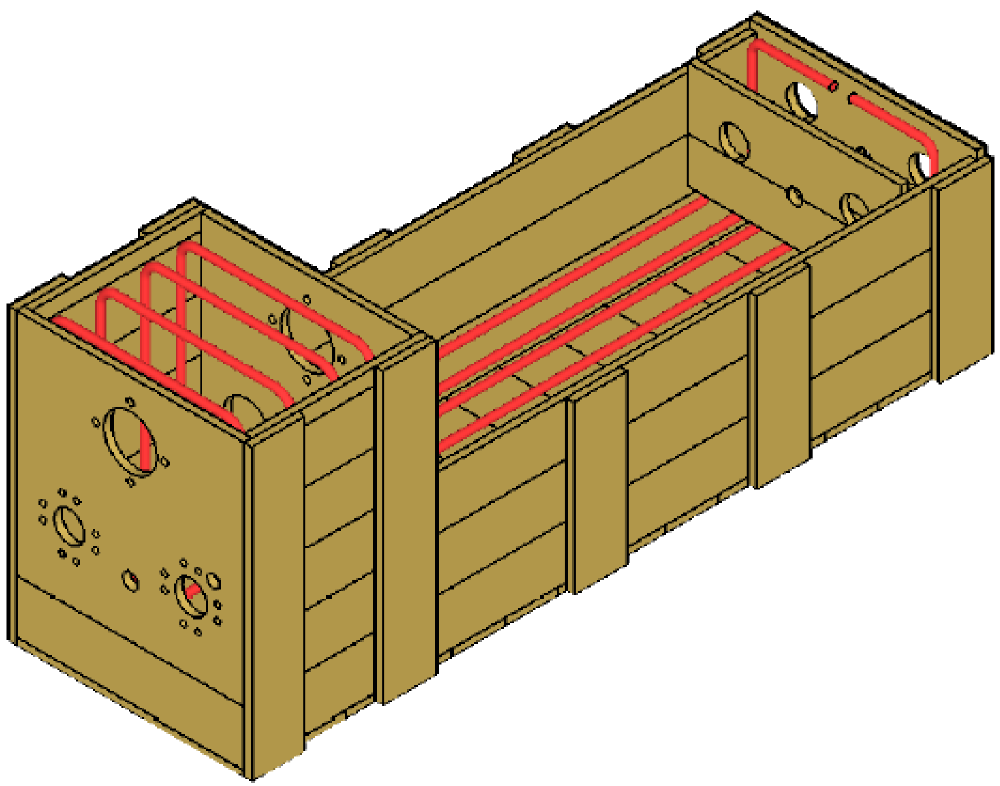
Add structural rebar



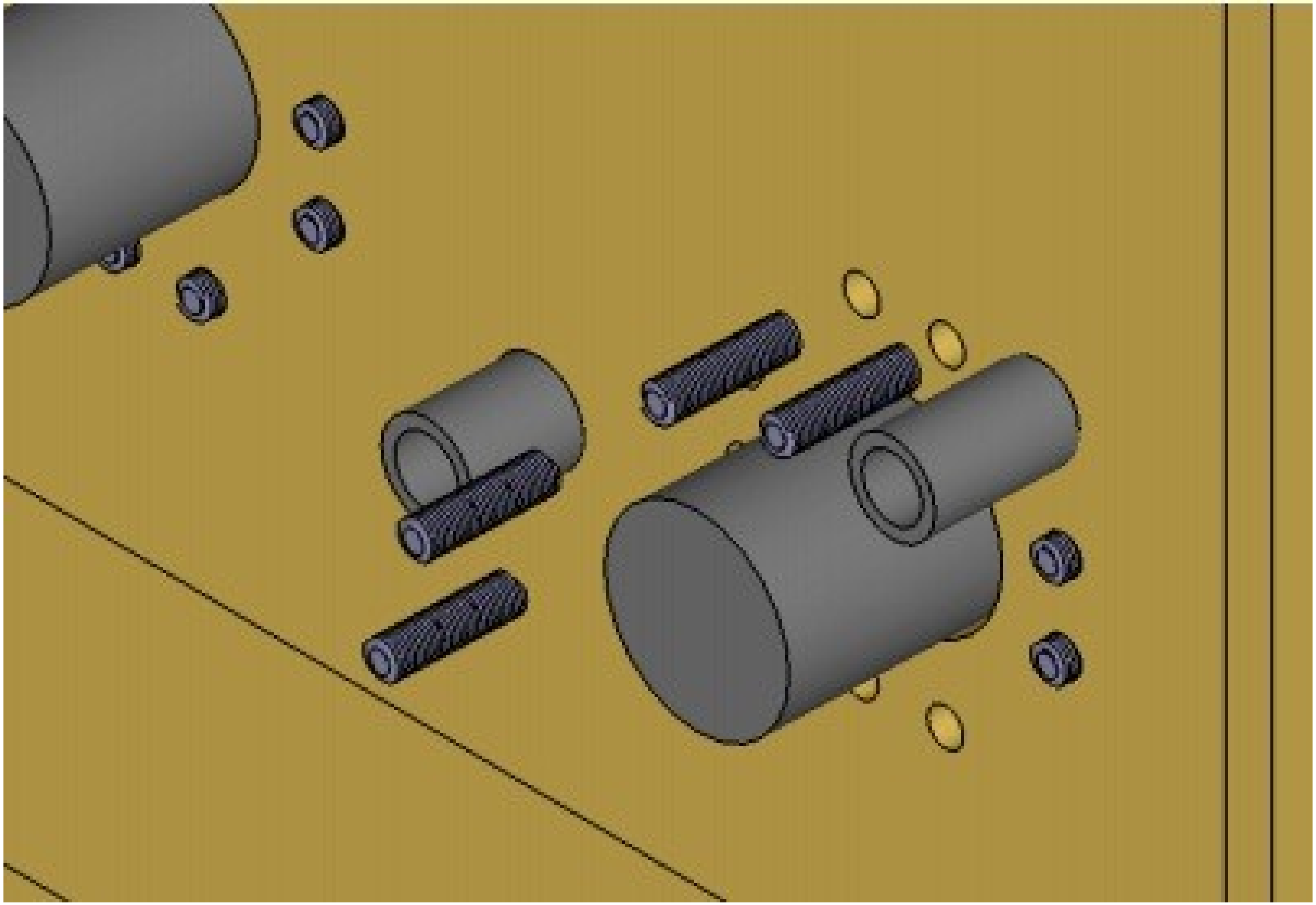
Close up the ends



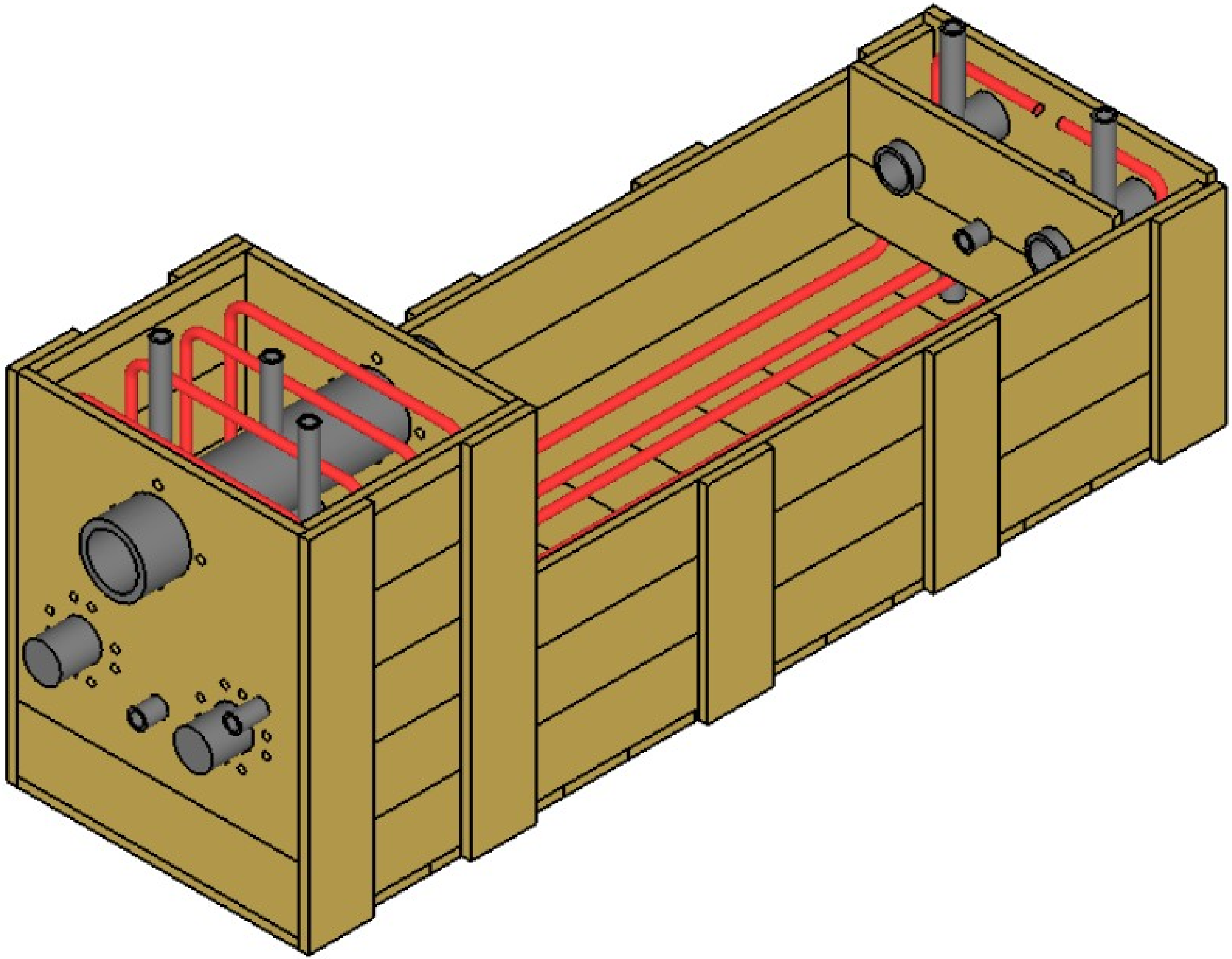




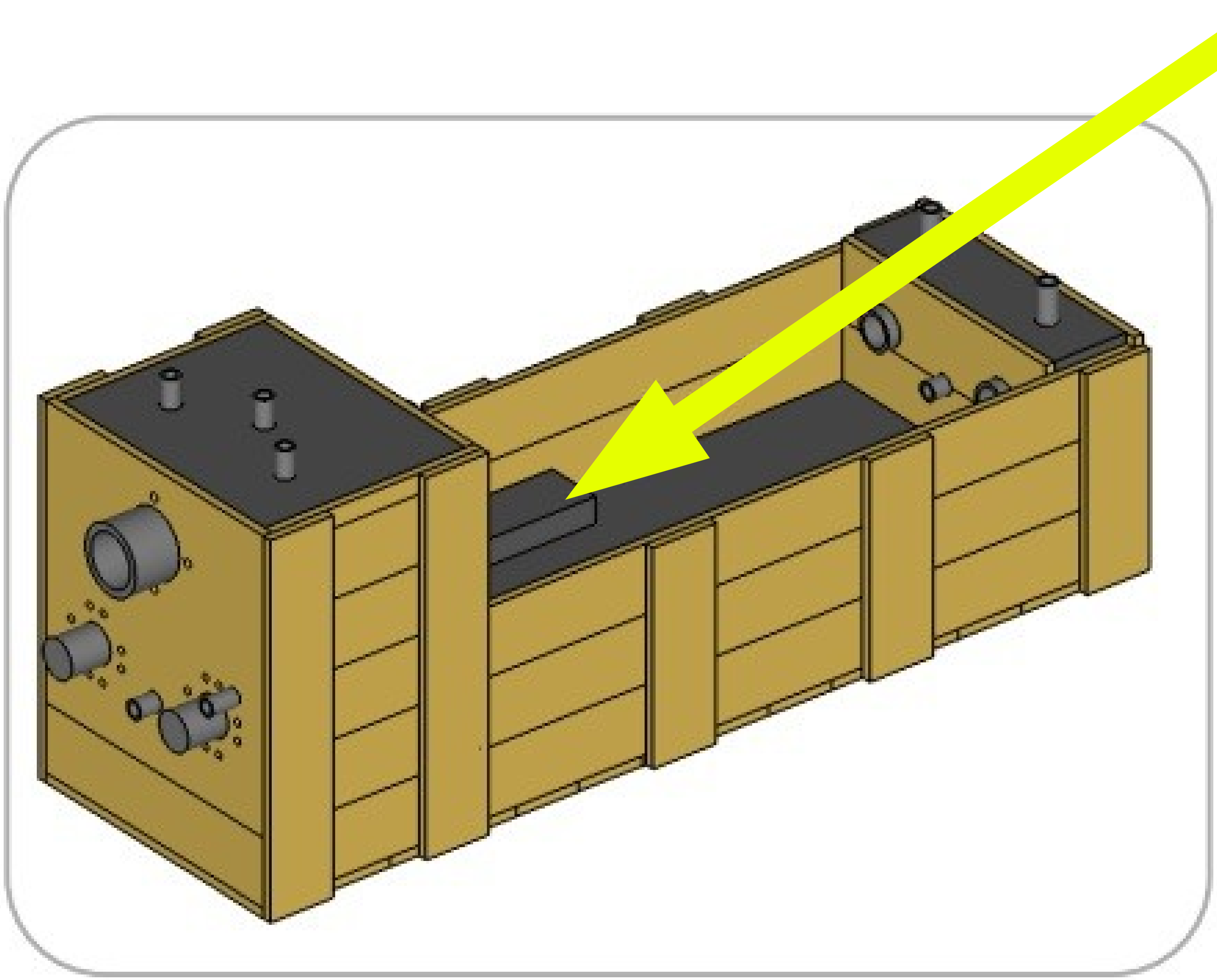
Detail of inserted plastic tubes and the bolts



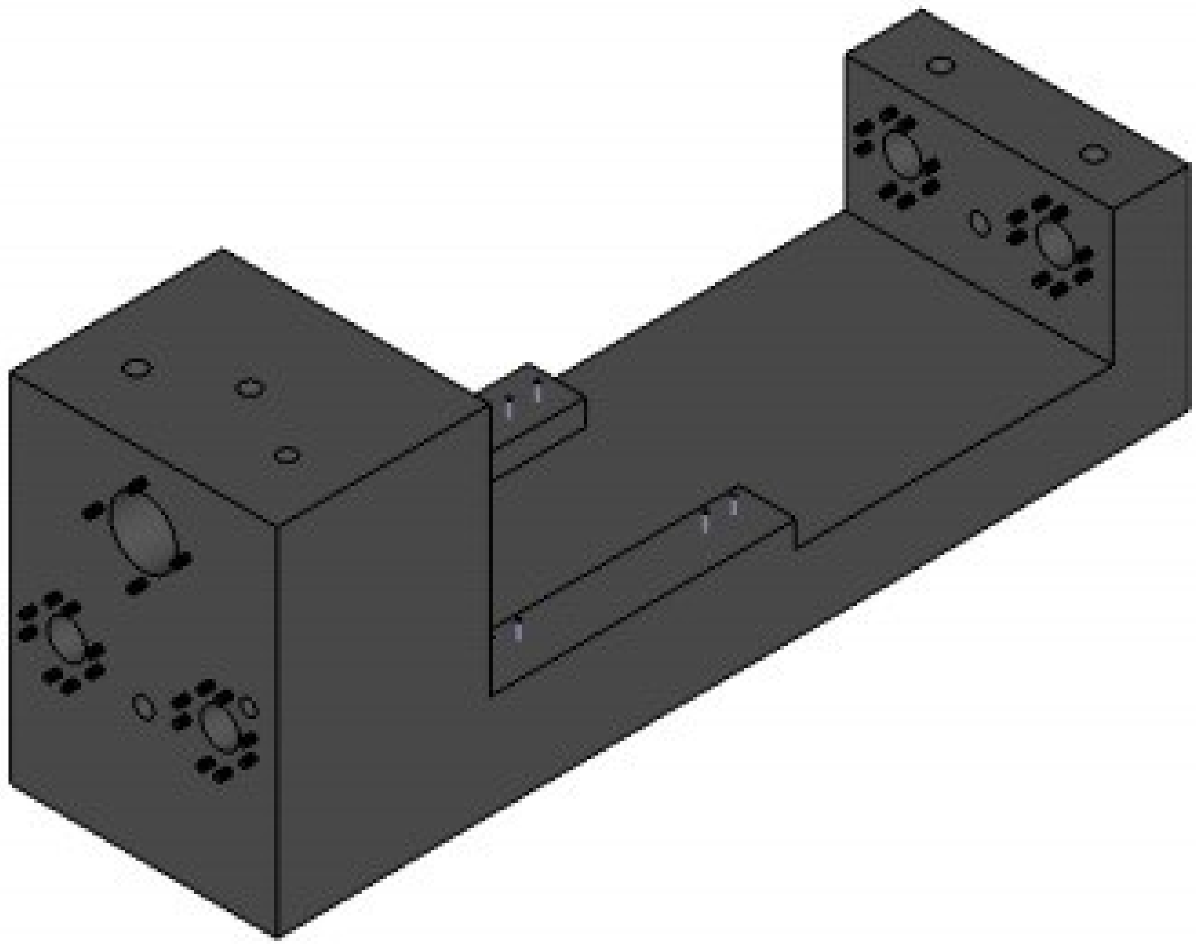
The form with added hardware



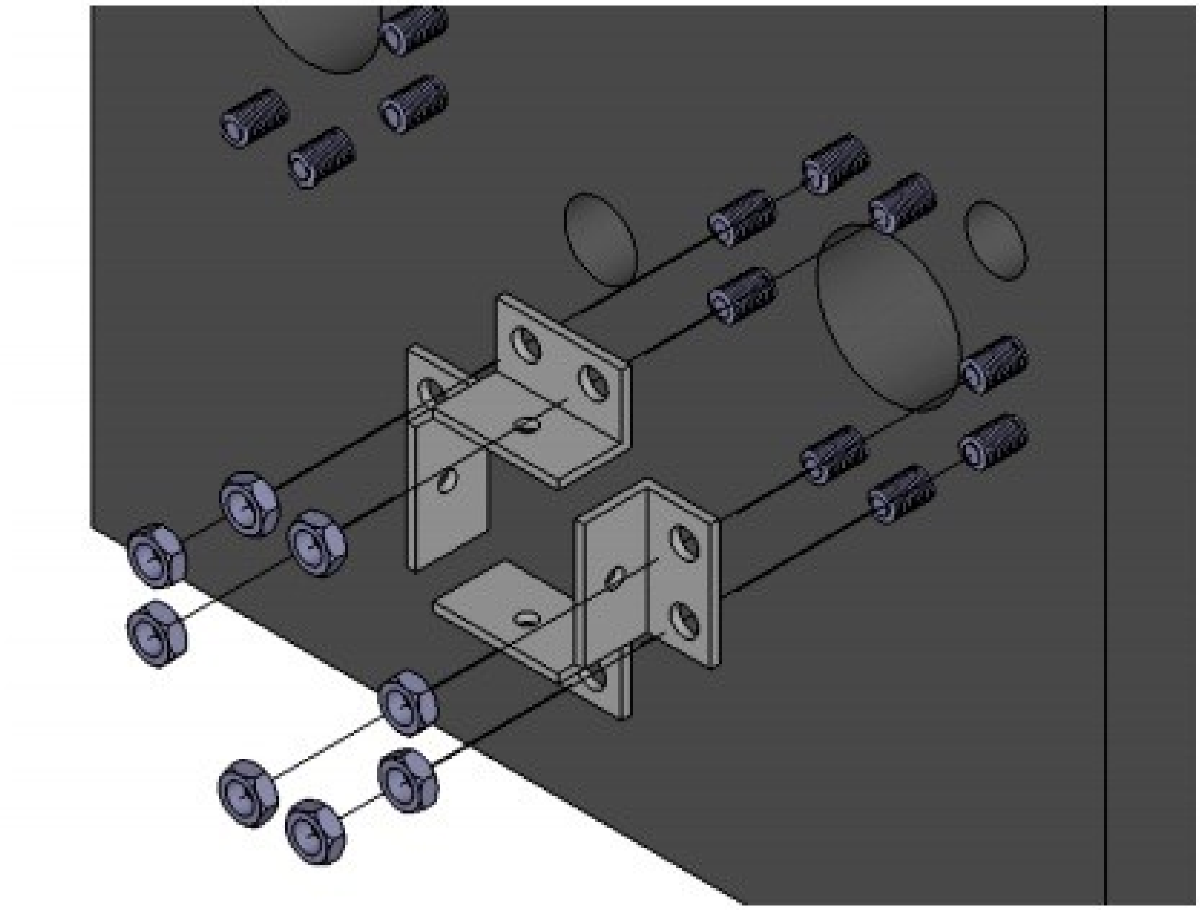
Pour the concrete, add pieces of form here, embed the way stabilizer bolts and then add the concrete needed here. The way stabilizer base shown here should actually extend the full length of the bed except for a gap that will be used as a coolant drain and to remove chips.



The concrete lathe “bed”



Bolt on the way adjusters. If necessary the adjusters could be replaced with hardwood wedges but accurate way adjustments will be much more difficult.



The Ways

The ways are the most critical component of an accurate lathe. Selection of the steel and accurate alignment is all important.Yeomans' used specially ground and hardened round bars that would be too expensive for our machines.

These are among our possible sources:

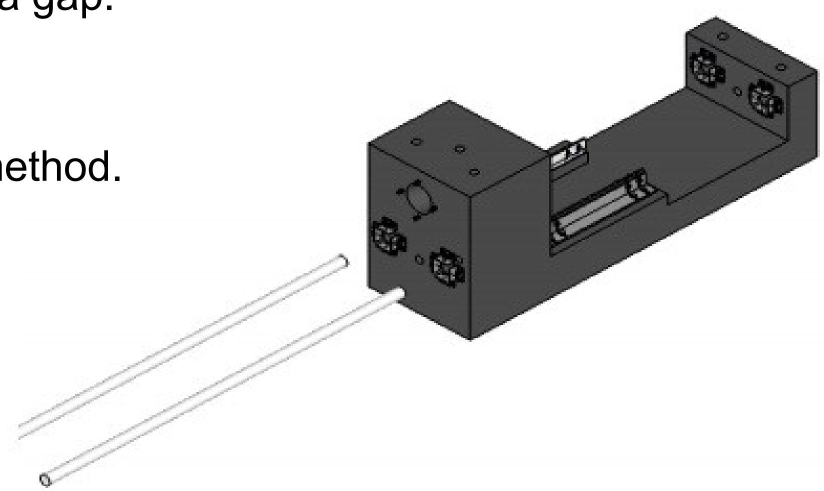
Pipe or round bar that may not be truly round or straight . Pipe should be made more rigid by filling with non- shrinking grout. If your budget allows for machining in a lathe then do it but don't expect perfect results because many lathes will be too worn to machine the way to the exact size over it's entire length.

Hydraulic piston rods come in a great variety, imperial US, metric, straight, bent, chrome plated, rusty etc. You will need 2 the same size.

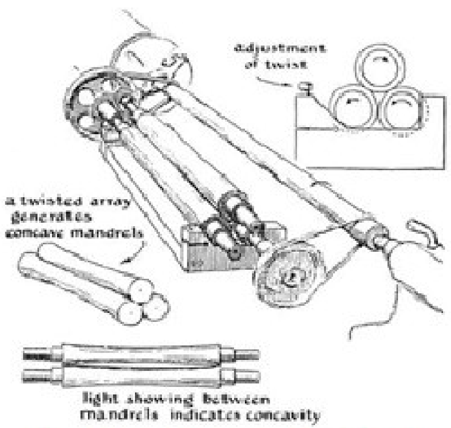
Used or new pipe, piston rods or drive shaft sections must checked for straightness. The best way to do this is to put the 2 pieces side by side, rotate one while pressed against the other and use a feeler gauge or bright light from behind to check for a gap.

Fortunately there is a way to (slowly)

repair inaccurate ways using the "3 rounds" method.



The “3 rounds” method, from an early Scientific American magazine



A primitive method of generating straight mandrels

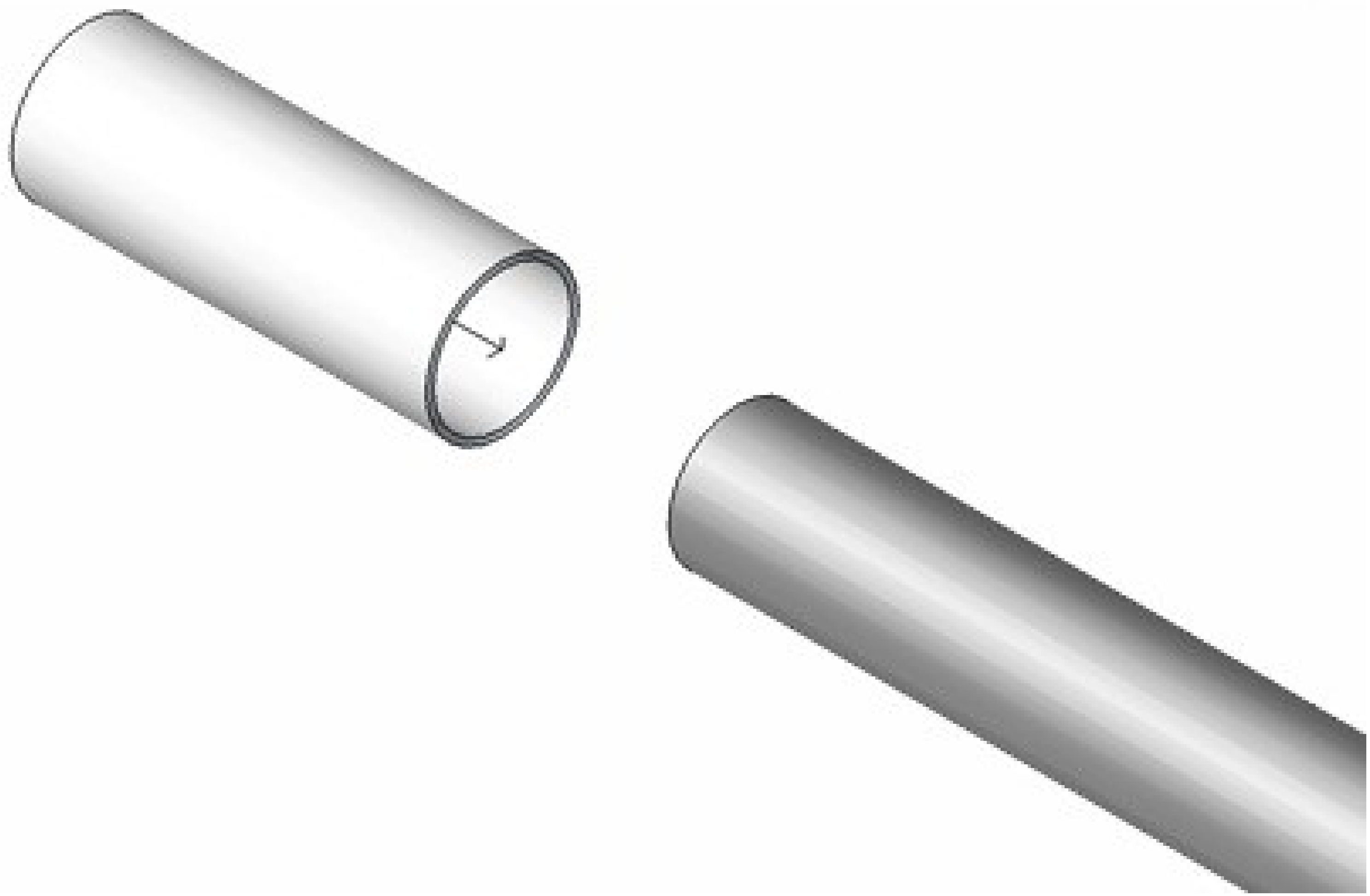
"It occurred to me that the necessary straightness could be generated by the primitive method of wet-grinding three mandrels together in a manner analogous to the making of three flats. This time-honored method depends on the fact that if any three surfaces make perfect contact when tried in all possible combinations, all must be plane. In the case of mandrels, the method has the attractive feature that the three can be ground together in one continuous operation. The method will not assure roundness, but this is not a requirement of the ways. The sketch to the left shows the setup.

"It is apparent that two cylinders can lie in contact with each other along their whole length if one is barrel-shaped and the other spool-shaped. A third cylinder could not lie in contact with this pair, however. In the grinding setup it would abrade the center of the barrel-shaped member and the ends of the other. If an array of three stacked cylinders is twisted slightly, a fit is possible if all taper from the ends to thinner waists in the middle. This condition can be tested by holding two cylinders in contact up to the light. If a position can be found where light can be observed between them, then the mandrels are concave and the array was twisted during grinding. A slight adjustment of the end bearings of the grinding fixture will correct the matter.

"A few evenings of grinding produced quite acceptable cylinders. The design of the bedplate and bearings of the grinding fixture is apparent in the illustration. By making the pulleys of the two lower mandrels of different sizes, I was able to get each of the three mandrels to grind on the others when they turned. The upper mandrel runs free, and grinding pressure is supplied by its weight. The assembly is belted to a rod chucked between centers in the lathe as shown. The mandrels are identical. Symmetry can therefore be maintained by exchanging and reversing the individual pieces frequently during the grinding operation.

Way Installation

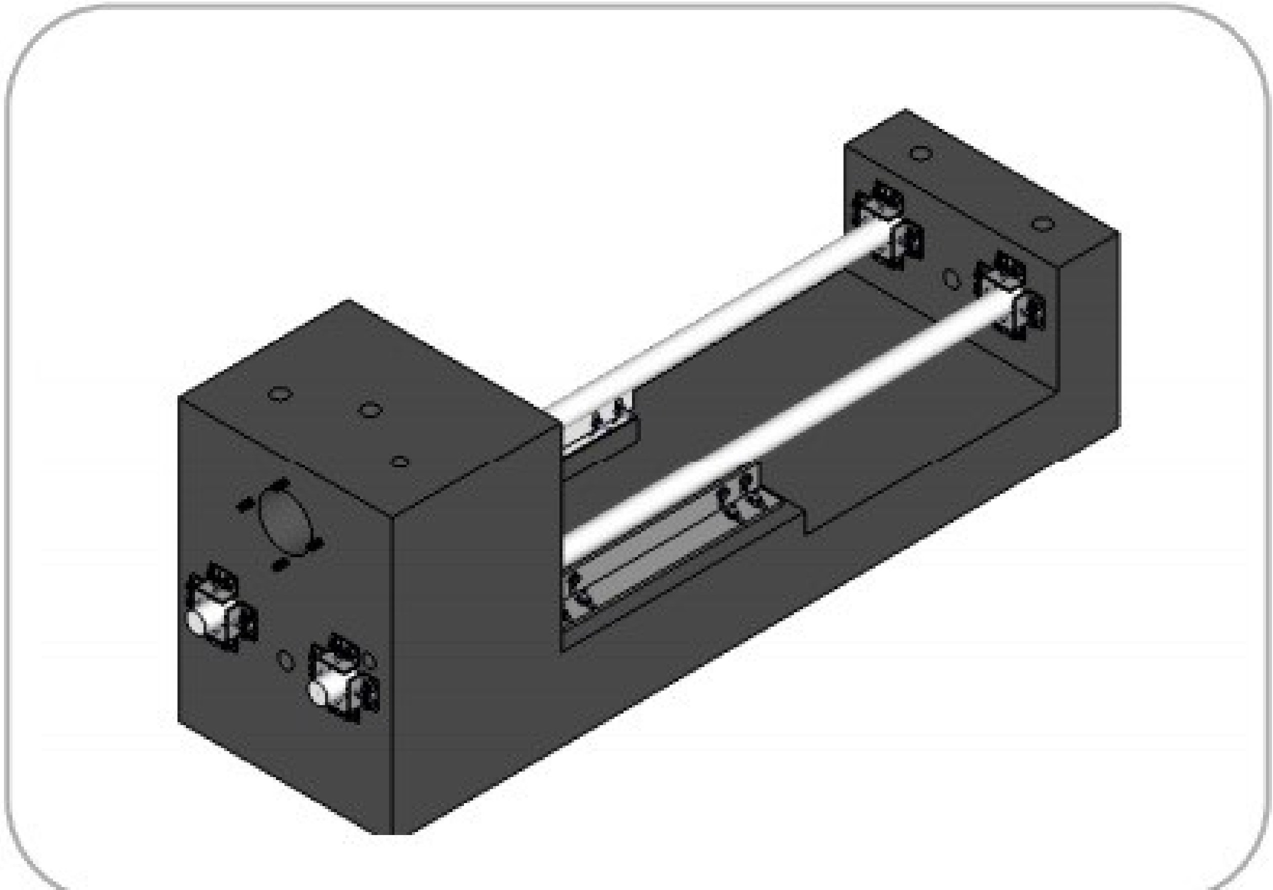
The way ends are tightly wrapped in greased sheet metal so that they can later be rotated to unworn areas if necessary. The sheet metal should kept in place by wire or hose clamps.



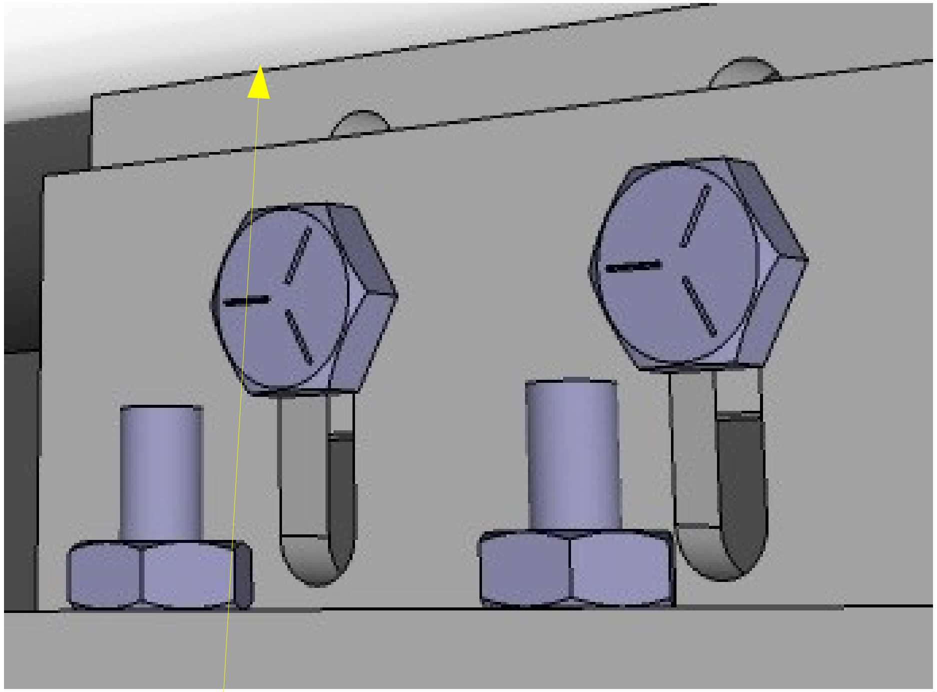
Way Installation

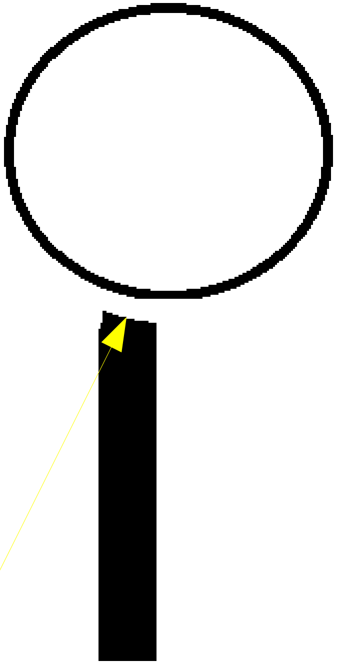
Insert the ways and lightly clamp in place.

The supports under the ways are made from angle iron and steel bar. A longer lathe (recommended) should have full length way support. Round lathe ways can both sag and vibrate but a rigid support like this is a simple cure. After the machine is complete, the adjustment devices could be removed and used to build another lathe.



Ways support





Start with a square edged way support and once the lathe is running, use a flycutter to machine a heavier (1/2”, 12mmor larger) bar to fit the radius of the way. The inner edge of the support bar should be at the center of the way. Heavier supports could be especially useful near the chuck where the heaviest cuts will most likely be made.

Ways alignment

Great care must be taken in aligning the ways but the process is actually quite simple.

- **A machinist type level will make alignment much easier (this is a Grizzley.com $62 model, a great bargain) but you can do without one if necessary.**
- **Use a carpenters level to set the ways as level as possible.**
- **Use a spacer between the ways to accurately set the separation between the ways. This spacer must be kept level, at the center and at exact right angles to the ways. Build a bracket to hold the spacer in a consistent position. Use a dial indicator here if you have one. Consider the thickness of a thin piece of paper as an accuracy goal.**
- **Use a thick, square piece of plate glass laid across the ways to check (with a feeler gauge) for even contact on all 4 corners. Rotate the glass and check again (the glass plate may not be perfectly flat) . Move the glass plate from one end to the other of the ways to make certain everything is correct.**
- **Adjust the way supports for even contact.**

- **Move the glass along the ways and test with a ball bearing to make sure it stays in the center of the glass when the glass is lightly tapped.**
- **This whole alignment process may take days but is well worth the effort because lathe accuracy will depend on it.**

STOP!

Time to put brain in gear!

Study every detail carefully before you try to build a machine. Machine tools should be built by people paying infinite attention to detail. Using scrap material is no excuse for sloppy thought and workmanship.

The carriage.

There are a lot of pieces of steel stuck in and around a relatively small chunk of concrete and it is important to understand just what they do and why it was done this way.

You will see that a relatively small increase in lathe size (especially carriage and tailstock length)will make a better and easier to build machine.

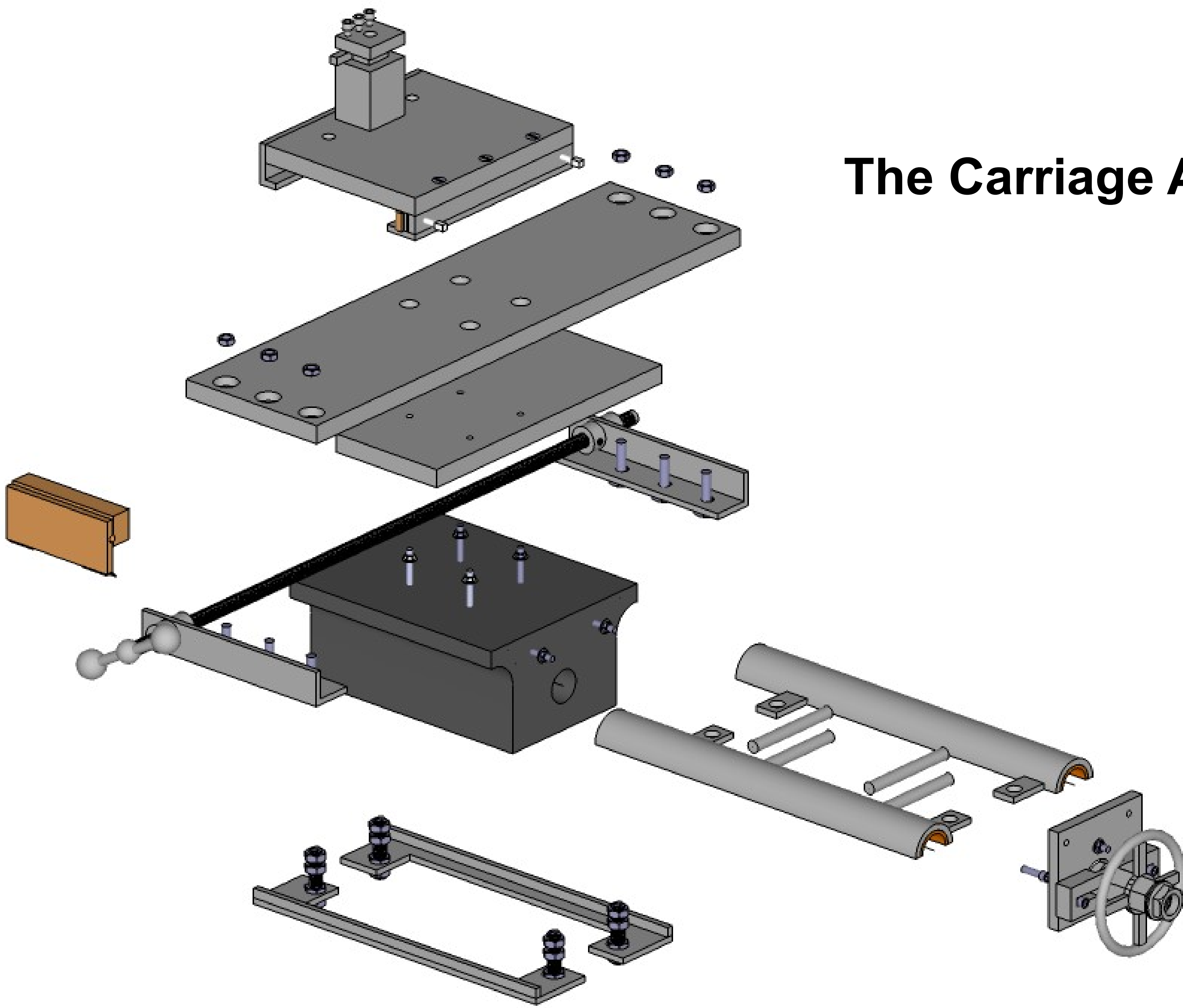
There also 3 important design features that even experienced peoplele will probably not be familiar with since as far as I know, they are unique to this machine.

(1) The method used to attach the "shoes" to the carriage that make it "self-aligned"

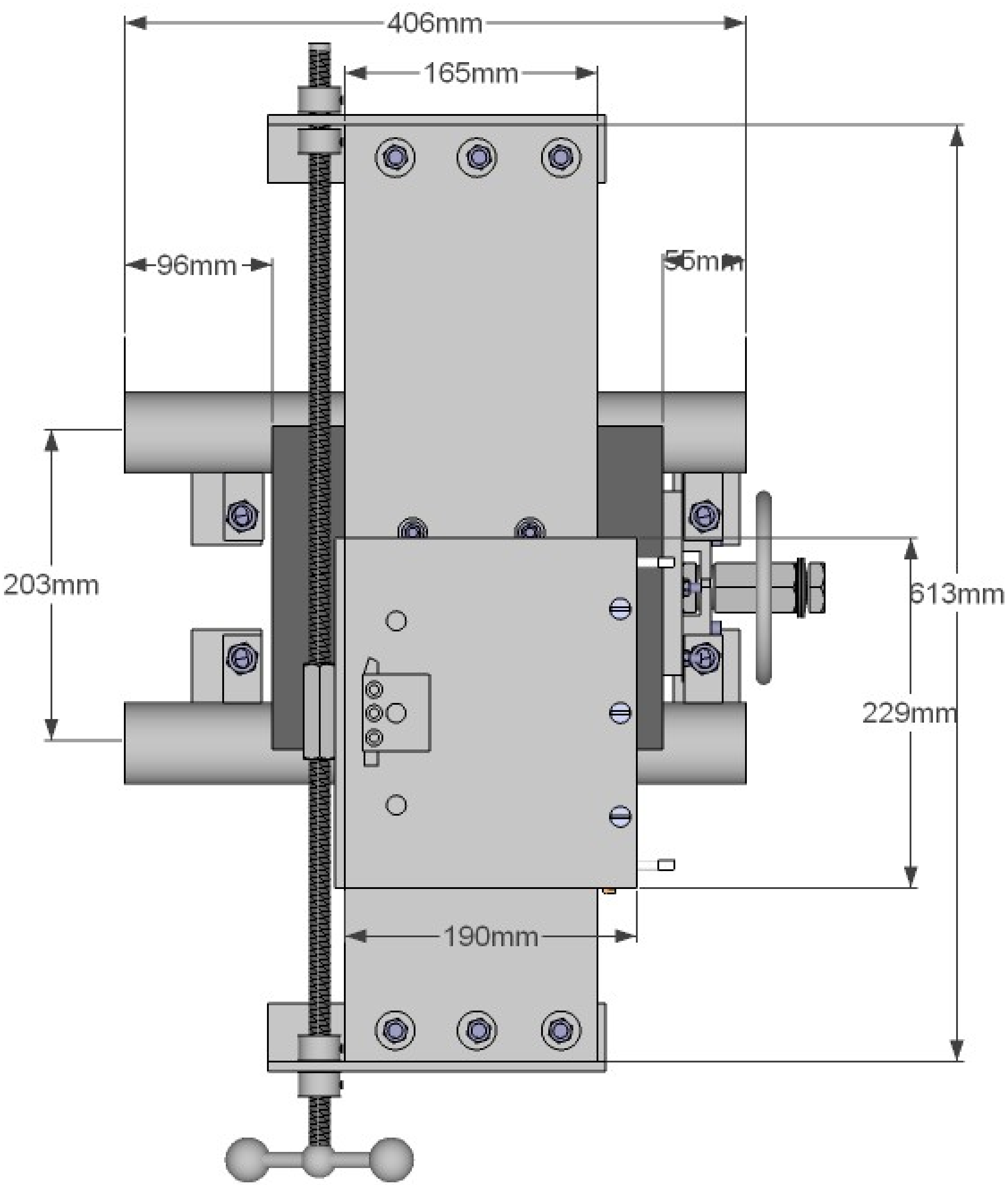
(2) Off center ways support that leaves room for the clamps needed to hold a relatively light weight carriage down. <u>Carriage weight alone is usually sufficient for a larger lathe.</u>

(3) Thread follower threading device (a few pages below)

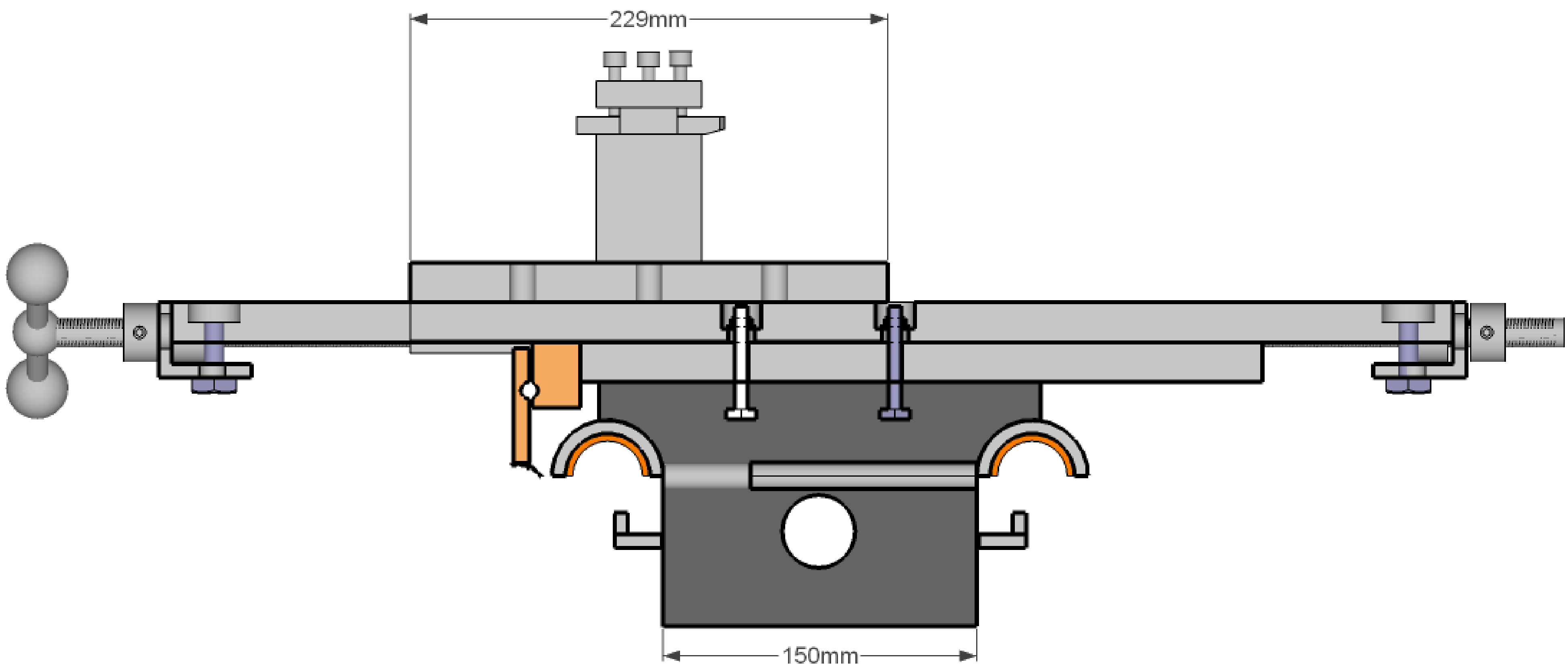
The Carriage Assembly



The Carriage Assembly

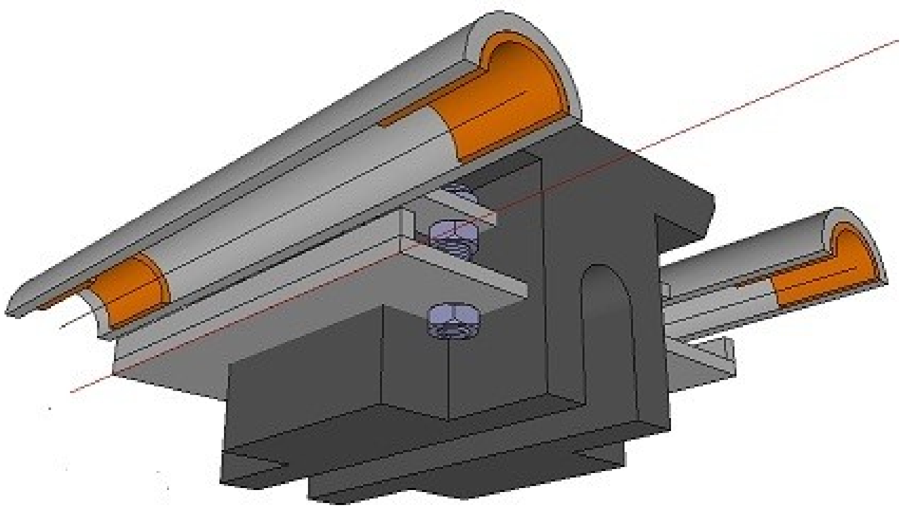


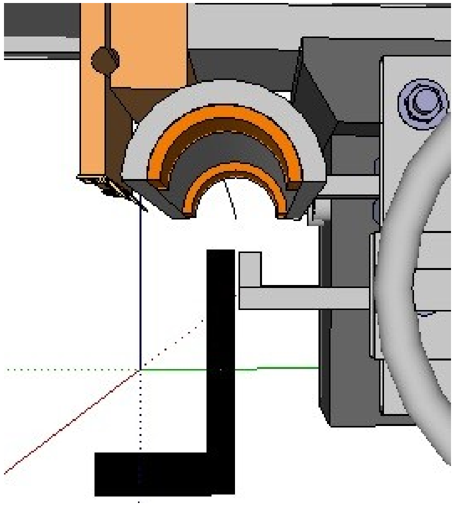
The Carriage Assembly



The Carriage

The carriage is, in effect, pre-aligned. The two shoes are first leveled and then firmly clamped to the ways. They are *__not__* mechanically connected until concrete is poured into the form so that it connects the shoes on each side. Any slight distortion from concrete shrinkage can be adjusted for by putting shims between the shoe and the bushings. The bushings should then be lightly epoxied in place.





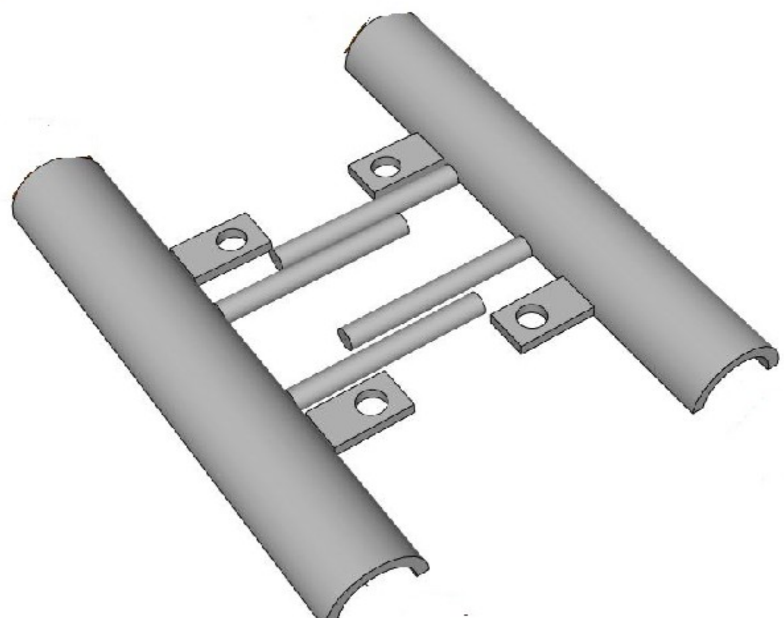
Two unique design features are shown above, the shoes connected only by concrete and also, the round ways are supported by a bar that is slightly off center so that there is room for a carriage clamping device. Since a flat surface can only contact a round surface in a very small area, we take advantage of this fact by using just the edges of two flat surfaces to support the ways and to hold the carriage in place. Normally, cutting forces tend to press the carriage downwards but occasionally the clamps will be very necessary.

The carriage frame and "shoes"

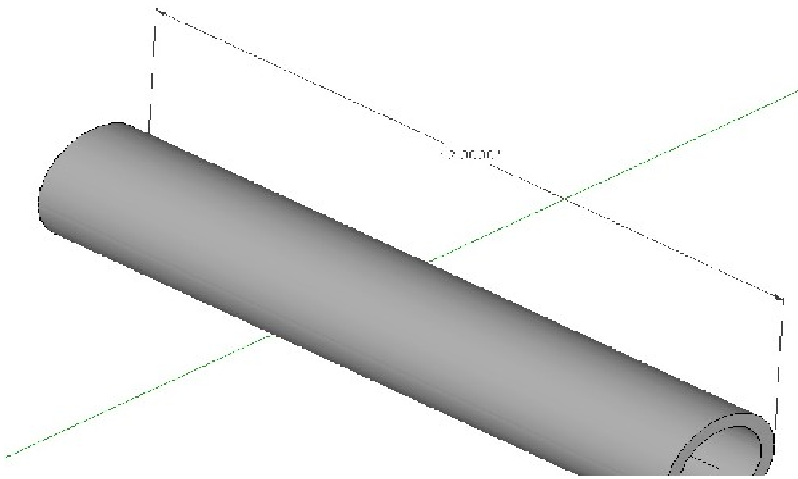
The shoes are split pieces of <u>*heavy wall pipe*</u>. The inside diameter of the pipe should be about 12mm to 25mm larger than the outside diameter of the way. The bushings will take up this space and could be made from cast iron, bronze or piston metal alloy. The holes in the tabs are used to mount the clamps that contact the bottom of the ways. These holes should be at least 12mm (1/2"). The welded on cross bars (made from re-bar?) should be large enough to have enough contact area so that they will not flex. The placement of the drilled tabs and pieces of re-bar are going to depend on the size of lathe you choose to build. Adding a foot to the bed length will allow both a longer carriage and a longer tail stock base. A longer carriage and tailstock will let you spread out the tabs and re-bar. The re-bar should be covered by at least an inch of concrete at the side. The concrete should have a fiber additive mixed in. The larger carriage will make construction easier, the carriage heavier and less likely to vibrate and cause the dreaded "chatter".

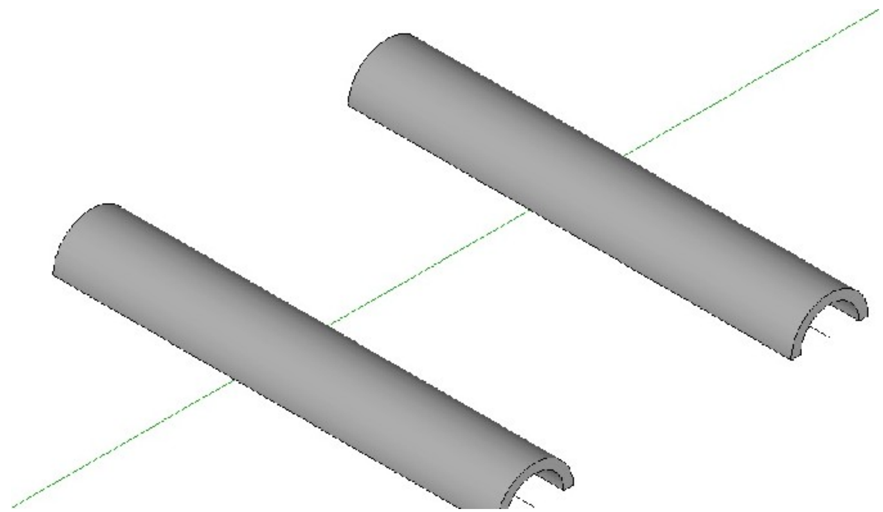
There will be a trade-off in that the lathe will larger, heavier and harder to transport..

Note that parts are not welded over the part of the shoe covering the bushings so weld distortion will not affect alignment.



The carriage shoes





<u>The width of the carriage is determined by the space between the shoes And that is determined by the diameter of the pipe used for the shoes and the distance between the ways.</u>

The pipe can be split with a hacksaw or an angle grinder with a cutoff disk.

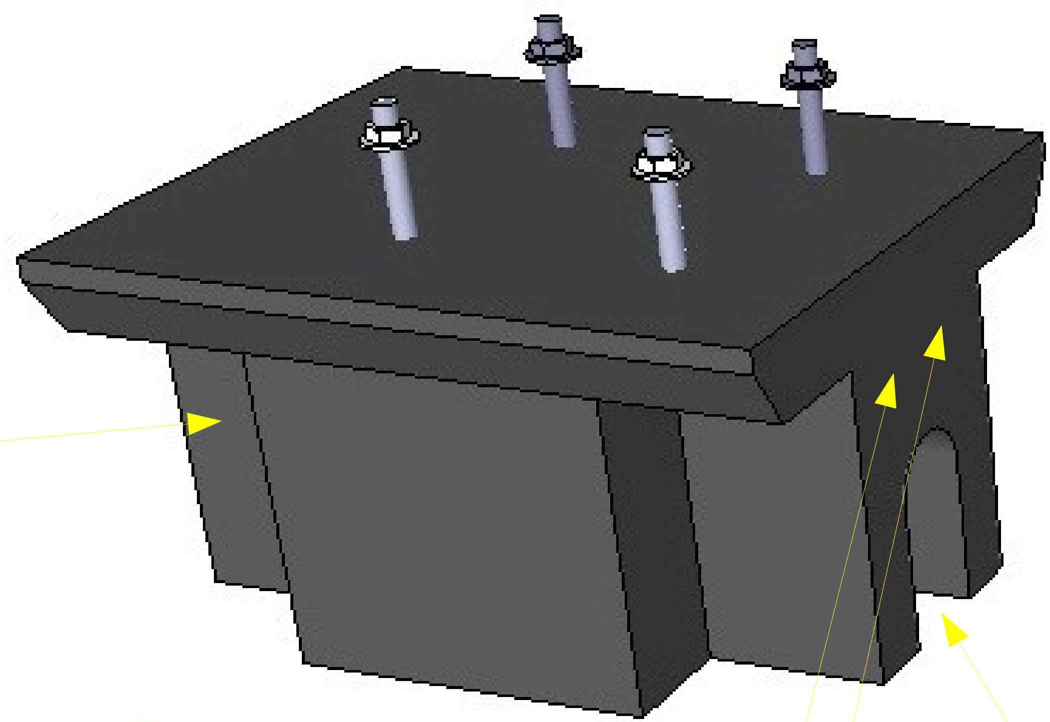
The length of the shoe should be between 1.5 and 2 times the distance between the way centers. The headstock has over sized cavities so that long shoes can slide inside if this proves necessary to keep the optimal carriage length/width ratio. Just extend the shoes past the clamp mounting tabs and adjust the length of the grouted areas in the headstock so that the longer shoes will slide inside the headstock.

The carriage concrete base

To make the shape of the concrete more clear, it is shown without the embedded shoes. This carriage design can be dropped over the lead screw so that it is easy to replace it with a different or specialized (milling for example) carriage. Four threaded rods are used to mount the base of the cross slide. These must be of very good quality steel that is firmly anchored in the concrete. Engine head studs would be a good choice here. They should be cut to the proper length and welded to bars that will anchor them in the concrete. Counter-bore the 3/4” thick cross slide base plate then cut the studs and nuts off flush with the base.

On a small lathe, great care will have to be taken to fit the steel parts that come from 3 directions! This was the only big problem In scaling the Yeomans lathe down 95%!

The notches in the concrete are for the clamp assemblies, those and the space for the lead screw and are made by inserting wooden blocks in the simple box like form. The clamp tabs could be moved farther out And these notches would not be needed.



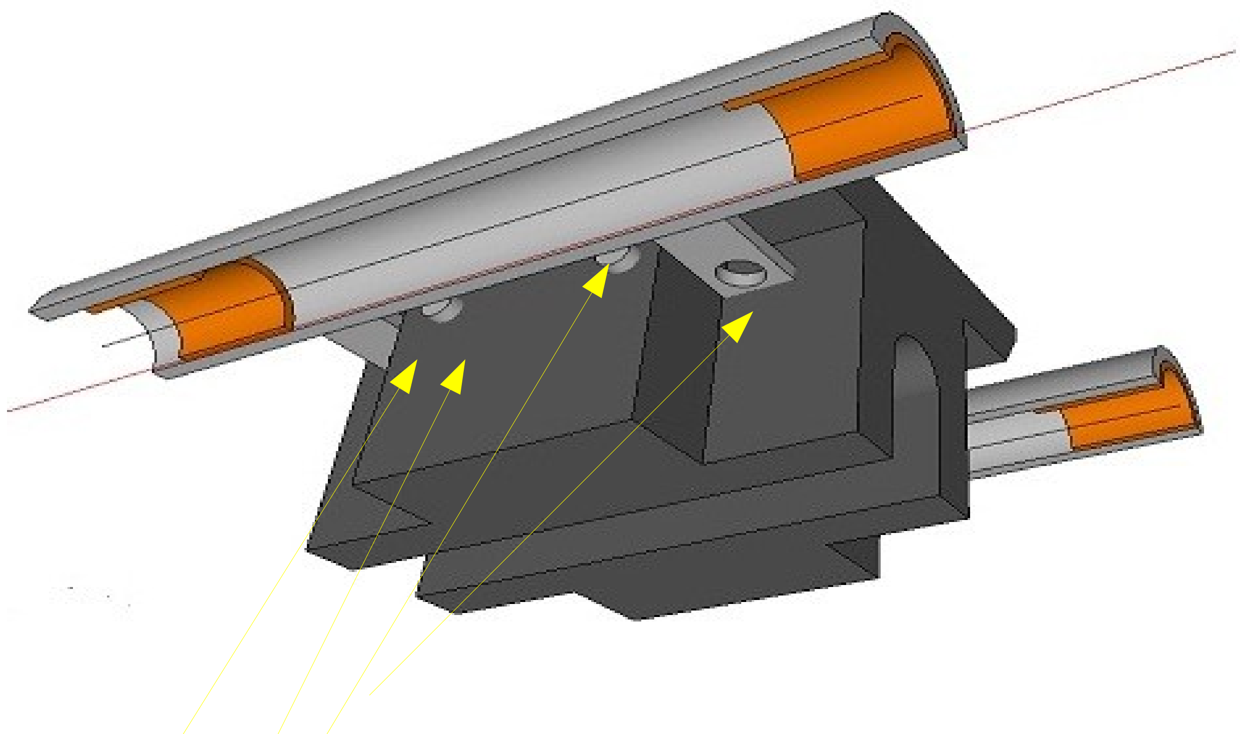
Two cored holes here for the bolts are to connect the hand-wheel back plate and the optional milling attachment. A third bolt for the milling attachment can be fitted below the lead screw. Shown is a “drop-on” type carriage.

The carriage shown without the under the way clamps.

It is shown as it would be cast between the carriage shoes. Alignment is automatic because the separate shoes are firmly clamped to the ways before the concrete is poured. Note the bushings at the ends of the shoes. They fill the gap between the shoes and the ways and can be made from piston metal castings. The bushings are lightly epoxied in once the carriage is checked for proper adjustment.

Note: the latest version of the lathe has a longer carriage so that parts will not be crowded and construction will be much easier.

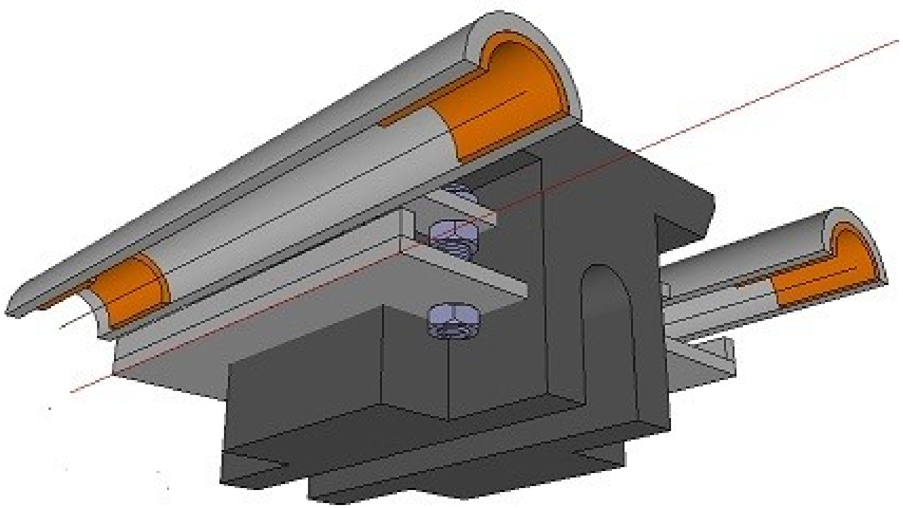
The re-bar rods should placed well in from any edge of the concrete. Read a concrete countertop construction book for more information on using concrete.

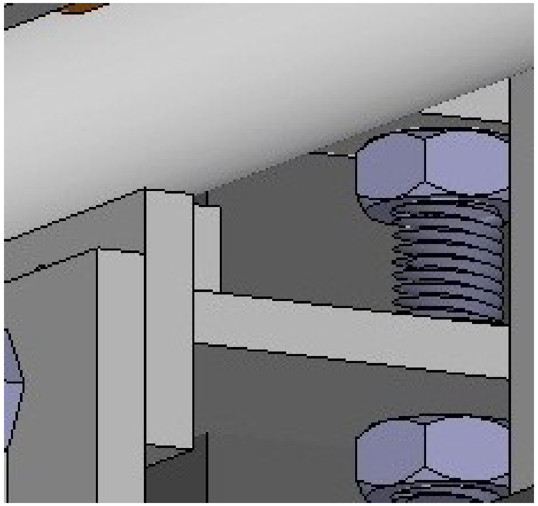


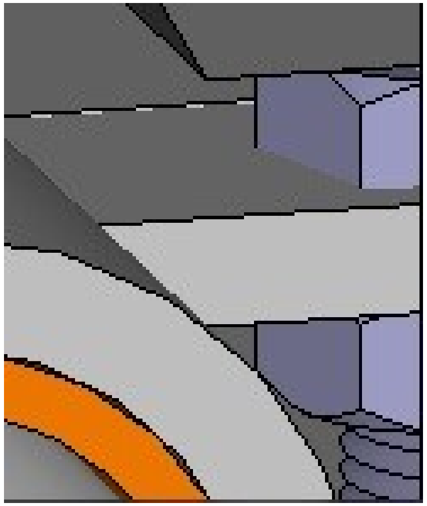
The form will have to be made so that it can be removed from around these points

Clamping devices

Clamps are bolted to the square tabs that are welded to the sides of the shoes. Normally cutting forces are downwards and clamps would not be necessary but occasionally things will go very wrong and these safety devices will be needed.





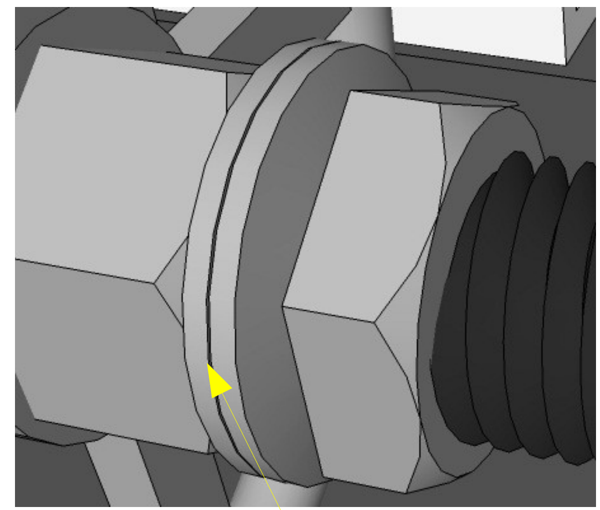


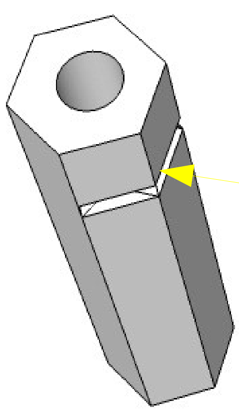
The main lead screw

A piece of threaded rod that does not rotate. The carriage and the tailstock are moved forward by turning nuts that move along the screw. The lead screw is secured by nuts at the foot (end) of the lathe. The carriage and tail stock are both the "drop on" type that is easily removed and replaced. The size of the lead screw could be anything between 18mm and 25mm for this 300mm swing version of the lathe.

Backlash can be compensated for by adding 2 opposed spring (Belleville) washers and an extra nut.

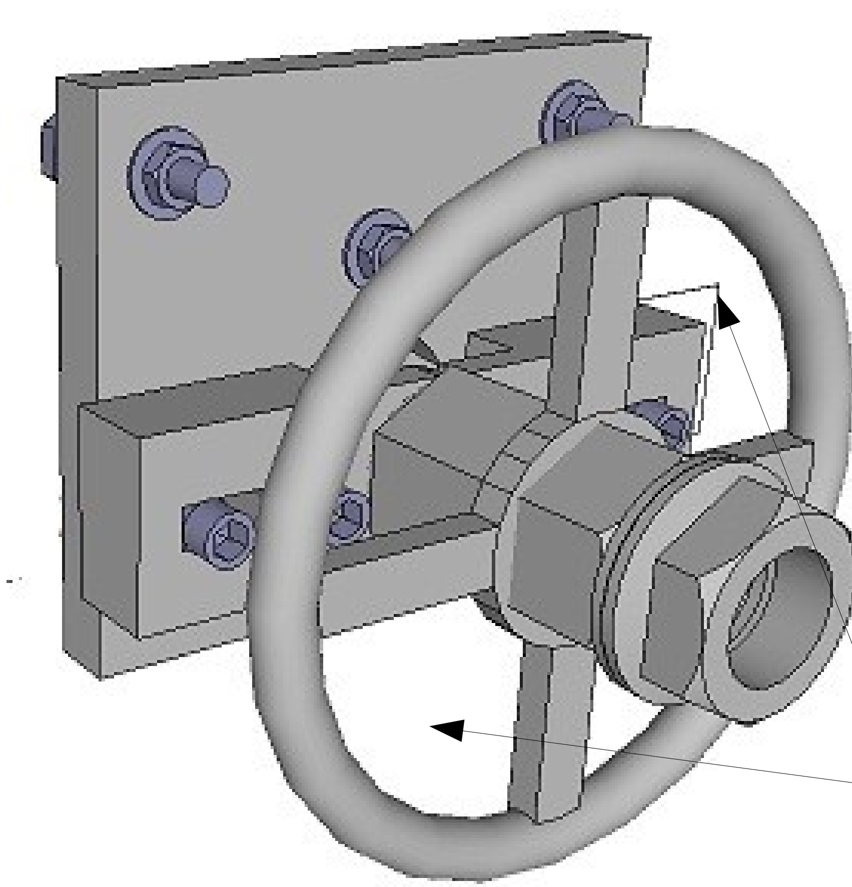
The most common lead screw source is the all-thread rods found in metal shops and hardware stores. Commercial all-thread screws with a black finish seem to be of a higher quality. Cross slide lead screws can also come from auto seat adjusters and auto jacks.

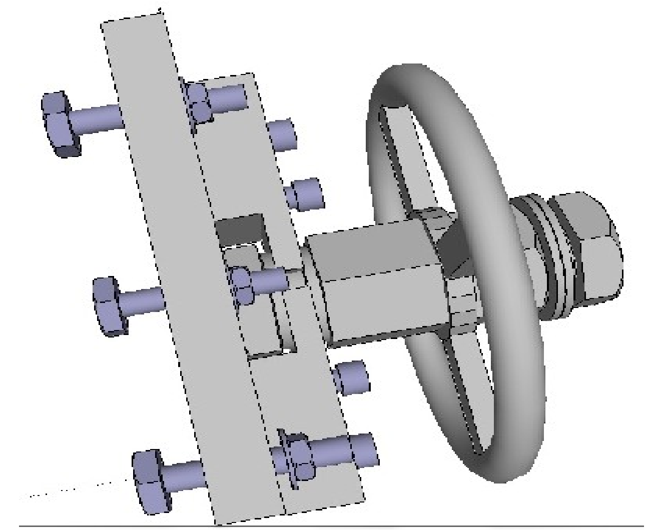




Many sizes of spring washers washers are often used on cars but larger ones may be more difficult to find. An alternate way of reducing backlash is to cut a long coupling nut two thirds of the way through and then bending the nut slightly closed.

This carriage mechanism is quite simple. Unlike most lathes that have complex "aprons" with many parts, this one just has 5 simple parts that can be built using just a drill, hacksaw and file. The handwheel can be replaced by a bicycle sprocket that later can be linked to another sprocket in an easier to reach location. Or, to get the lathe up and running in a hurry (so it can make it's own parts), just make the mounting plate, add a nut that can be turned by a wrench to move the carriage forward and heavy springs to pull it back. The clamp parts, grooved nut and handwheel adapter could be easily made at this stage.





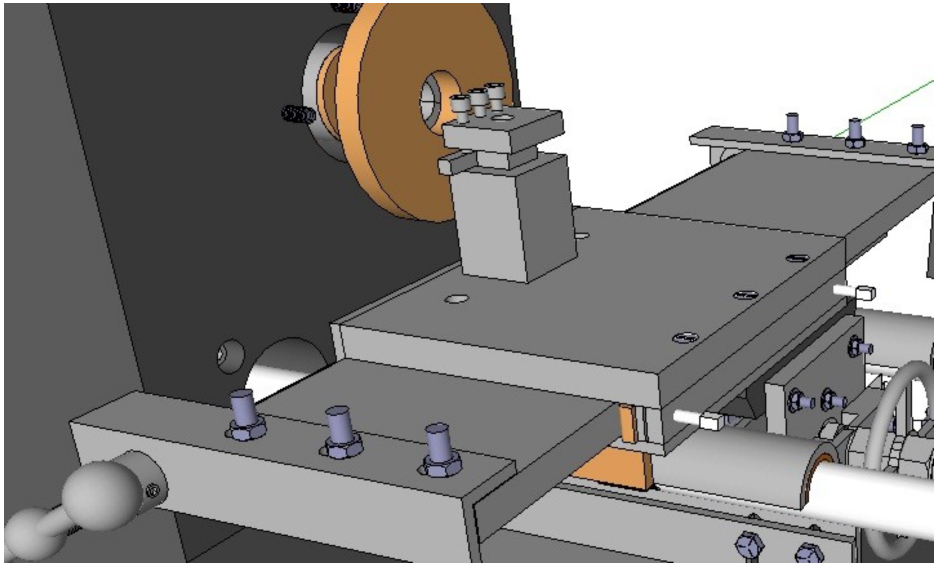
If a milling attachment is going to be added, the base can be made longer so that a bolt can go below the leadscrew and connect to it and bottom of the milling slide base.

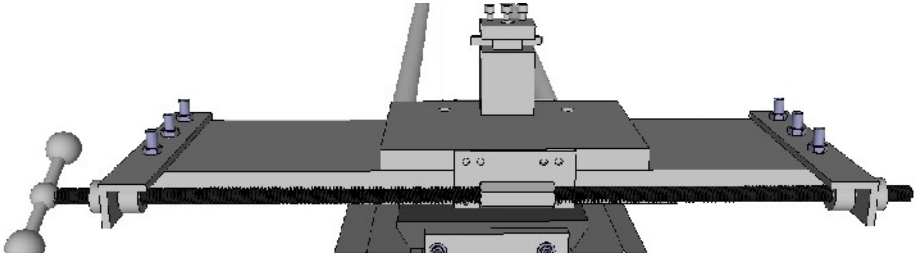
One side of the clamps (above) can be shimmed to reduce backlash in the carriage hand wheel clamp device. The coupling nut could have a larger grooved hub pressed over It to make a larger clamp contact area.

Cross slide,

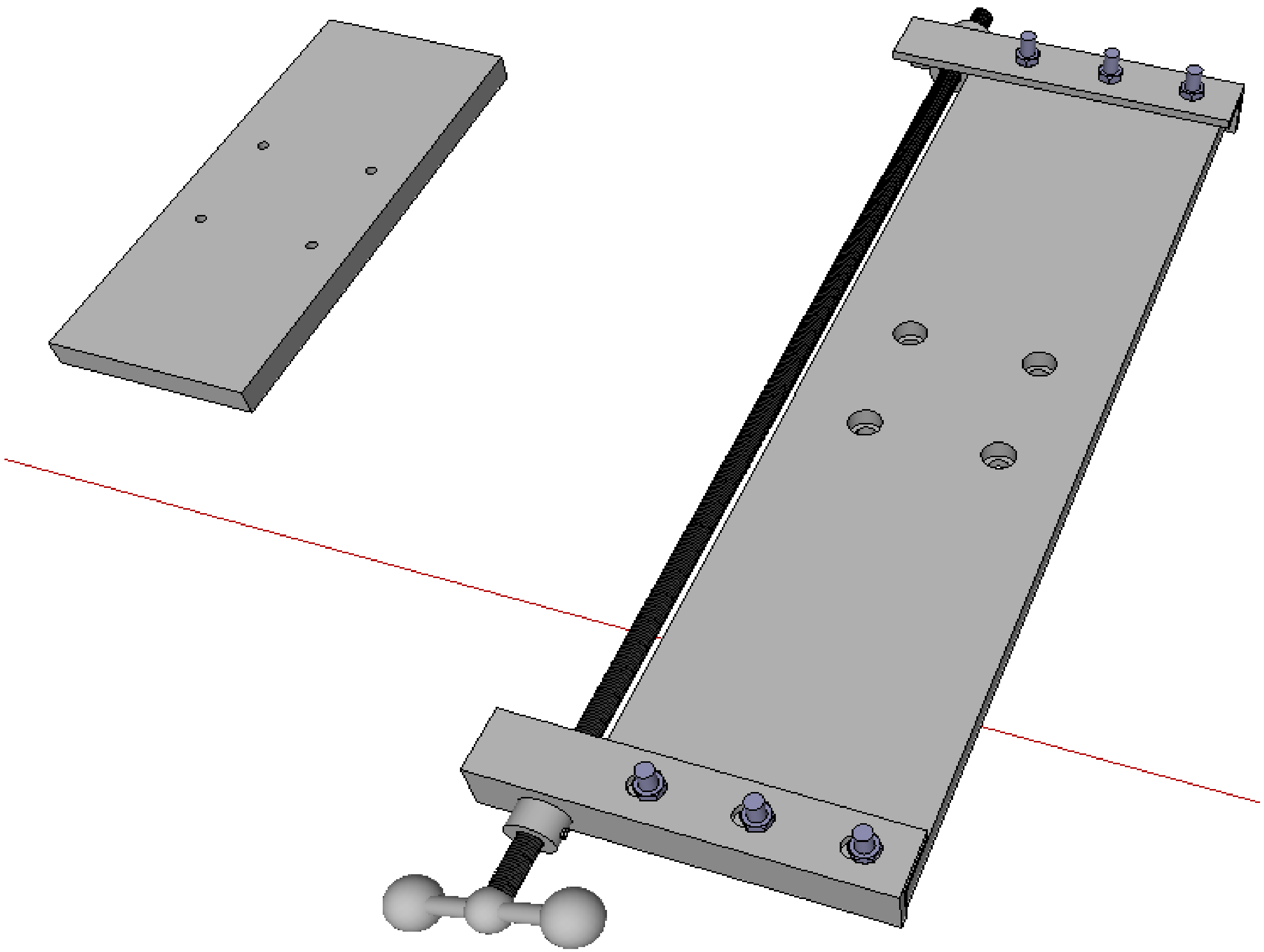
A simple bolted plate assembly. The side pieces (clamps) could even be temporarily tack welded on and "gently" aligned with a hammer. It should be later refined by replacing the welded camps with adjustable clamps as shown below.

Cross slide size? Even though the rest of the lathe will probably be from scrap materials, A piece of steel for the cross slide may have to be purchased. It should be at least 150mm wide and 18mm thick. It should be at least 375mm long and the base about 250mmlong.





The basic cross slide base, a compound or second slide can be added to the top and used for cutting tapers. The lead screw can be in the position shown where it would be susceptible to cuttings or on the trailing edge where it would be farther from the center of cutting forces. A toss up.



Getting the slide parts (or other stuff) flat

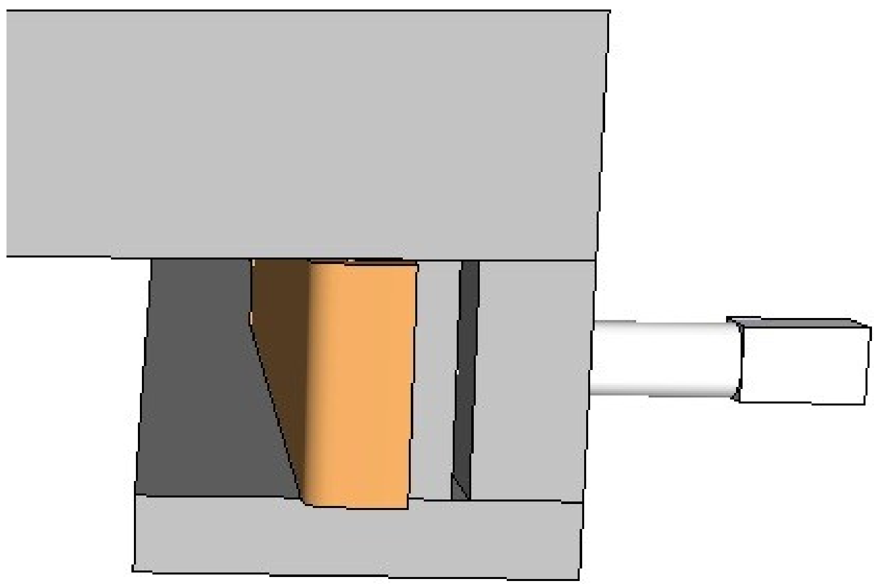
When grinding an optical (or other kind of flat), three disks are used, let's call them "A", "B" and "C". Put "A" on "B" with some fine grinding compound. Grind until a frosted finish is seen on both surfaces., now do the same with "B" on "C", now repeat with "C" on "A" until the surfaces have 100% contact, repeat until it takes little (or no) work to get 100% contacting all three combinations. The surfaces will be very flat. It works on steel as well as on glass. How does it work? A on B results in a spherical surface, B on C results in a less spherical (closer to flat) surface, C on A results in a closer to flat surface after grinding. Each pass results in flatter spheres (if A is concave. B is convex and C is concave.) When A and C are ground to each other, they the high points first, now either A or C is concave and the other is convex. Grinding both against B results in the flats being averaged. Eventually they are flat enough. Gravestones and monuments are often VERY flat. They are good layout tables!

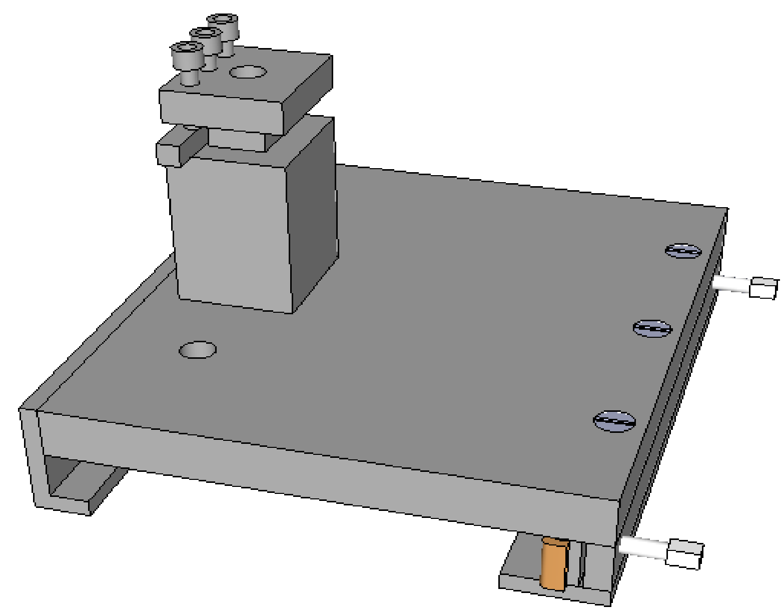
The plate edges are also important since the clamps are screwed to them. Edges of hot rolled steel plate are not flat and this has to be corrected since clamp parts are screwed to them. Carefully file the edges flat while constantly checking with a square. Keep flipping plates over and end for end while checking them side by side until you get them filed to identical widths, parallel sides and with flat edges.

Dave LeVine

This simple cross slide and adjustment device is easily made but requires steel bar of 3 different widths and these may be difficult to find in Developing World conditions. The adjuster is made by sawing a slot in a piece of steel keystock and then drilling and tapping the outer piece so that the setscrew can slightly bend the inner piece to adjust clearance between cross slide pieces. The brass liner is optional.

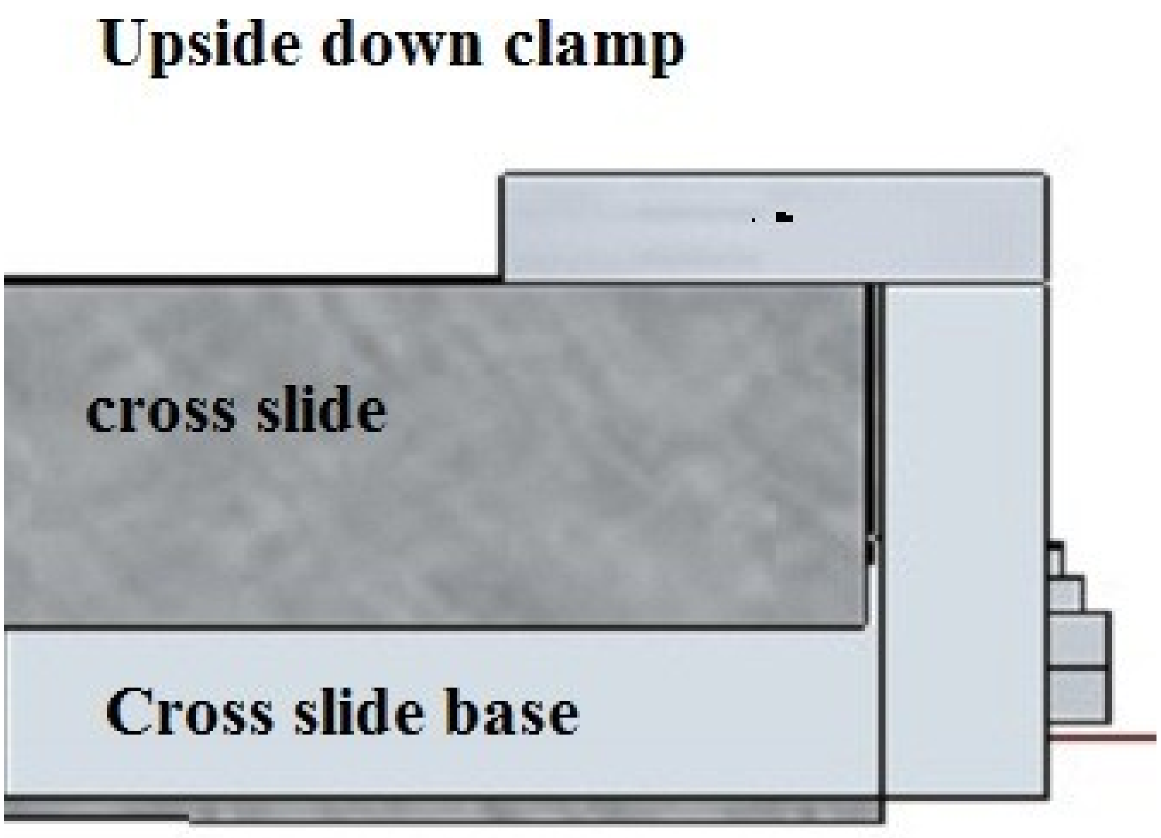
The slide should be 1.5 to 2 times as long as it is wide to prevent “cocking”.





Another way to build machine slides is to invert the clamp. This lets you build the cross slide assembly using just two pieces of steel of the the same width. This may be more economical and in some areas might be the only way practical. The disadvantage is that metal particles from machining may get between the clamp and the slide. Leather wipers attached to the edges of the top pieces of the clamp should help with this. Wear could be adjusted for by judicious filing or adding a thin shim. A common way to build something like this fit it a little too tight and add very thin shims to make things move smoothly. The shims can be removed as the parts wear in and play develops. Another difficulty with inverted clamps is that an additional “compound” slide is made harder to mount because of the more narrow mounting surface.

A temporary, light duty clamp could be made from carefully fitted angle iron.



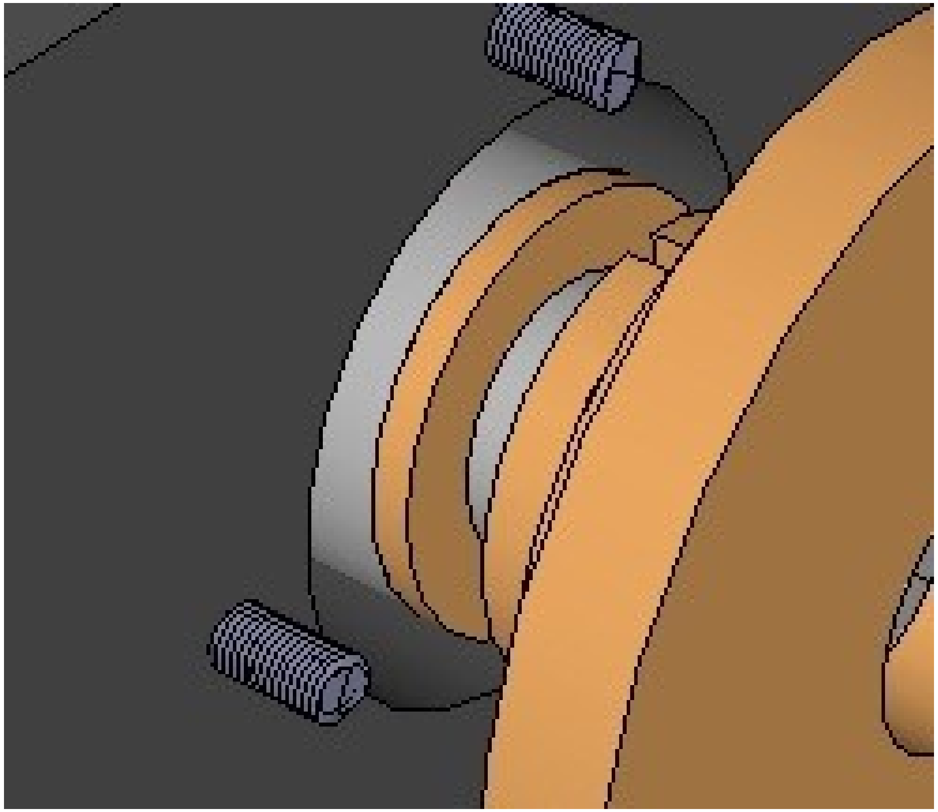
Cross slide alignment

Use the dial test indicator to measure from the end of the spindle to the top and the edge of the cross slide is it is moved from one end to the other. Be certain that the spindle does not turn as you do this.

A "temporary" lathe

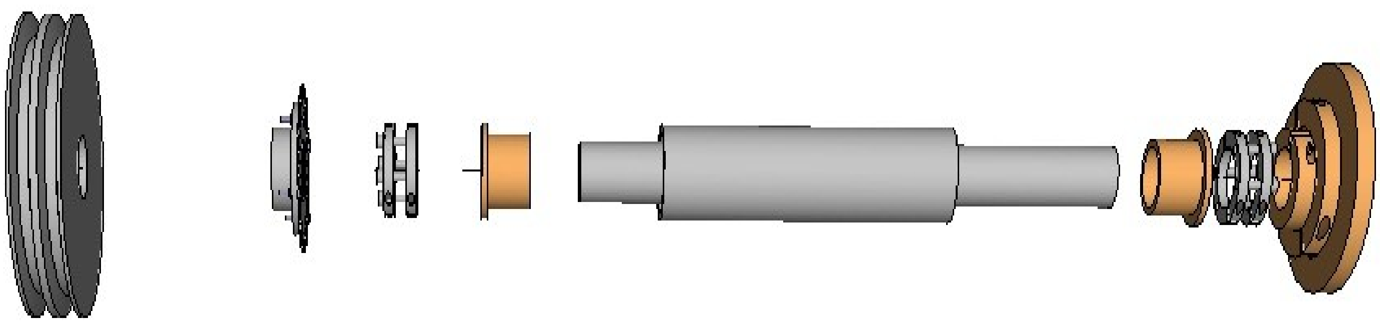
can be used for machining the piston metal spindle bushings, chuck and pulley mounts and thread follower parts. It can be made by making a wooden adapter to bolt a wheel hub to the head stock and then bolting a hard wood or metal faceplate to the wheel studs. A "V" belt drive could use the brake drum as a pulley. The bushing castings can be clamped to the face plate in different ways that will be shown in the "chuck" section (below).

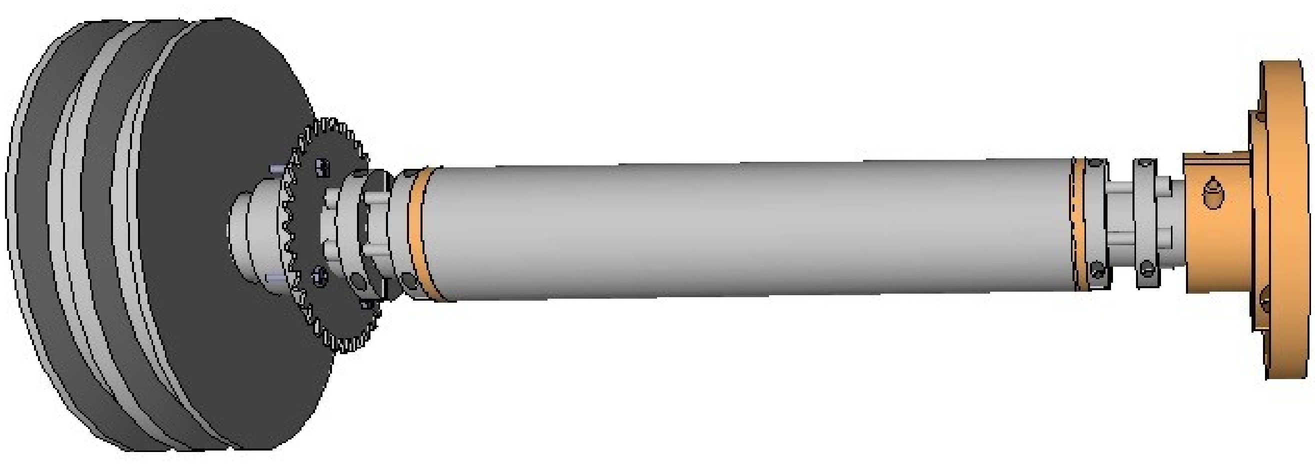
The carriage and cross slide should be finished first so that they can be used to machine spindle parts.



The spindle

The outer part of the spindle cartridge can be made from a piece of pipe (like the outer part of a hydraulic cylinder), bushings you cast yourself out of piston metal, a thrust device to keep the spindle from moving back and forth and a hollow or solid spindle (like the piston rod of a hydraulic cylinder). The whole assembly is first aligned in the headstock and then (naturally) locked in place by pouring in non-shrinking grout. The outer tube protects the spindle and bushings from the concrete. If the outer tube is large enough, the bushings can later be replaced with ball or roller bearing adapters so that a higher speed spindle can replace the initial slower speed bushing type spindle. Adjusters are shown here but the front adjuster could be replaced with a steel washer between the bushing and the chuck backplate and the rear adjuster replaced with a simple steel collar that could be moved in order to eliminate end play. The hub for the thread follower could even be used (along with a steel washer) to control spindle end play until a better adjuster could be built.

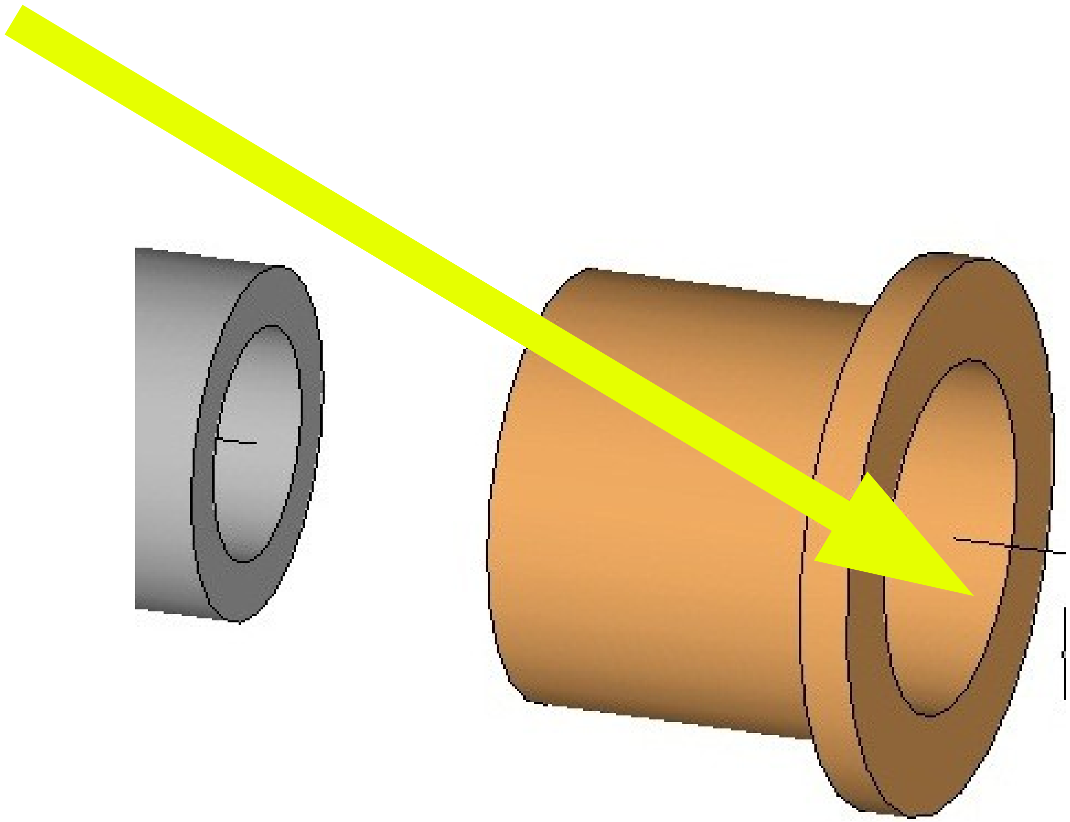




Spindle lubrication

On the main and thread follower spindle bushings, cut an “O” ring groove here.

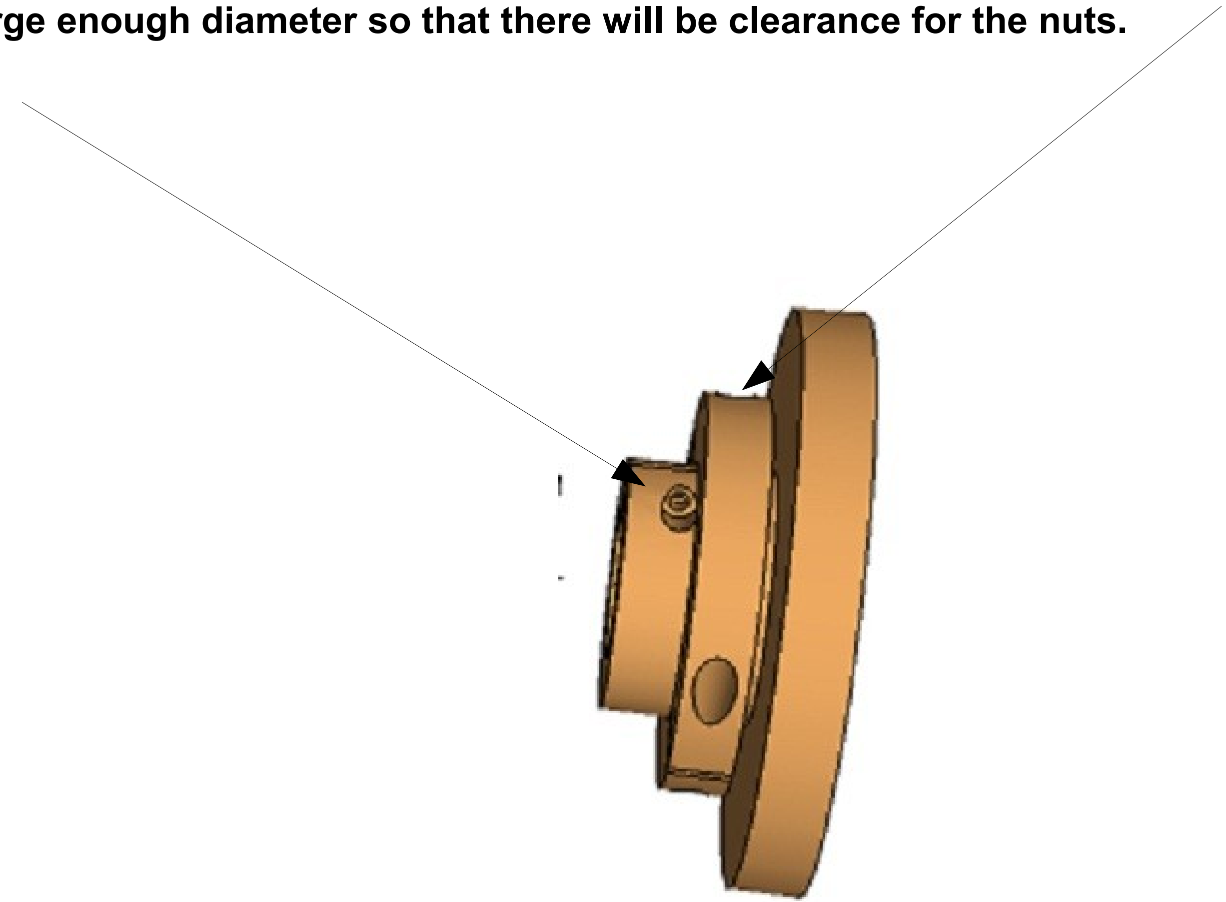
Drill and tap the cartridges for a 90 degree fitting for an oil line and grout the oil line in place with the spindke.



The chuck back plate (mount)

Seemingly simple but if you have to buy one, it could cost more than the lathe itself!

If you make your own, the two most common choices may be either a piece of cast iron that could be turned down to size or to make one from an aluminum casting. A cast aluminum back plate should have two clamp bolts and *nuts* (not tapped) on each side and an added steel safety collar. The hub will have to have a large enough diameter so that there will be clearance for the nuts.

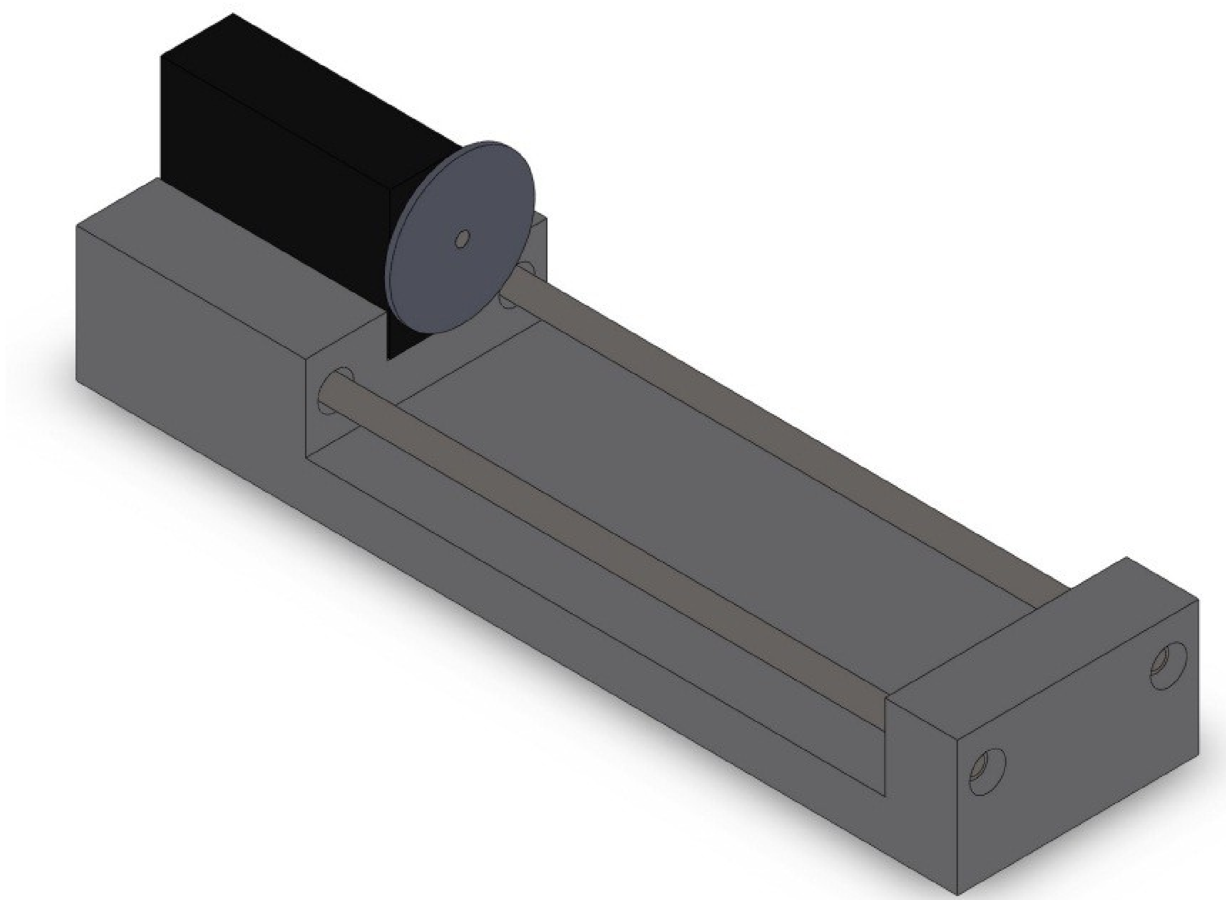


Spindle alignment

Slide the spindle so at least 8” sticks out the front of the headstock then use a dial test indicator to measure to the spindle to both sides and the center of the carriage as it is moved forward and backward. After the spindle has been accurately aligned then pour in the grout to lock it in place. This makes the spindle parallel to the ways which is all important.

The headstock, spindle and flywheel/faceplate assembly

can be as simple as an inverted engine block, crank and flywheel that has had the main bearing inserts carefully drilled and the main bearing caps drilled and tapped for grease fittings. A lathe with a 600mm to 900mm(or larger) swing could be easily made this way. Just remember that the largest Yeomans shell making lathe weighed 9000 Kg so scale accordingly!
An engine block headstock should probably kept at under 200 rpm since bearing inserts were meant to be used with a pressurized oil system. Grease every few hours at first until you make sure the bearings do not overheat.



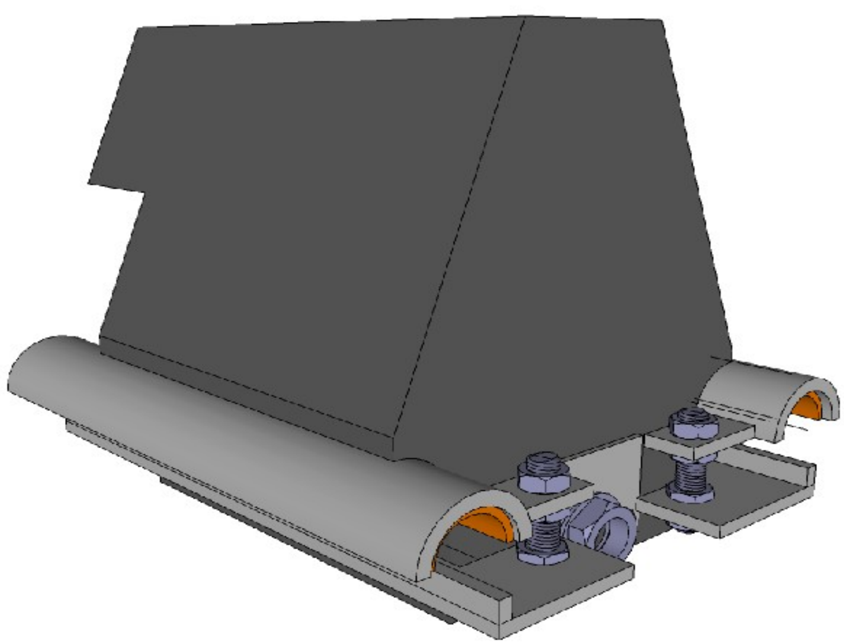
Tailstock

It has a Morse Taper (2 or 3) socket that is grouted in after alignment. The tailstock is held in place in the same way that the carriage is. It can be moved up so it presses against the carriage to keep the carriage from being forced backwards during facing operations.

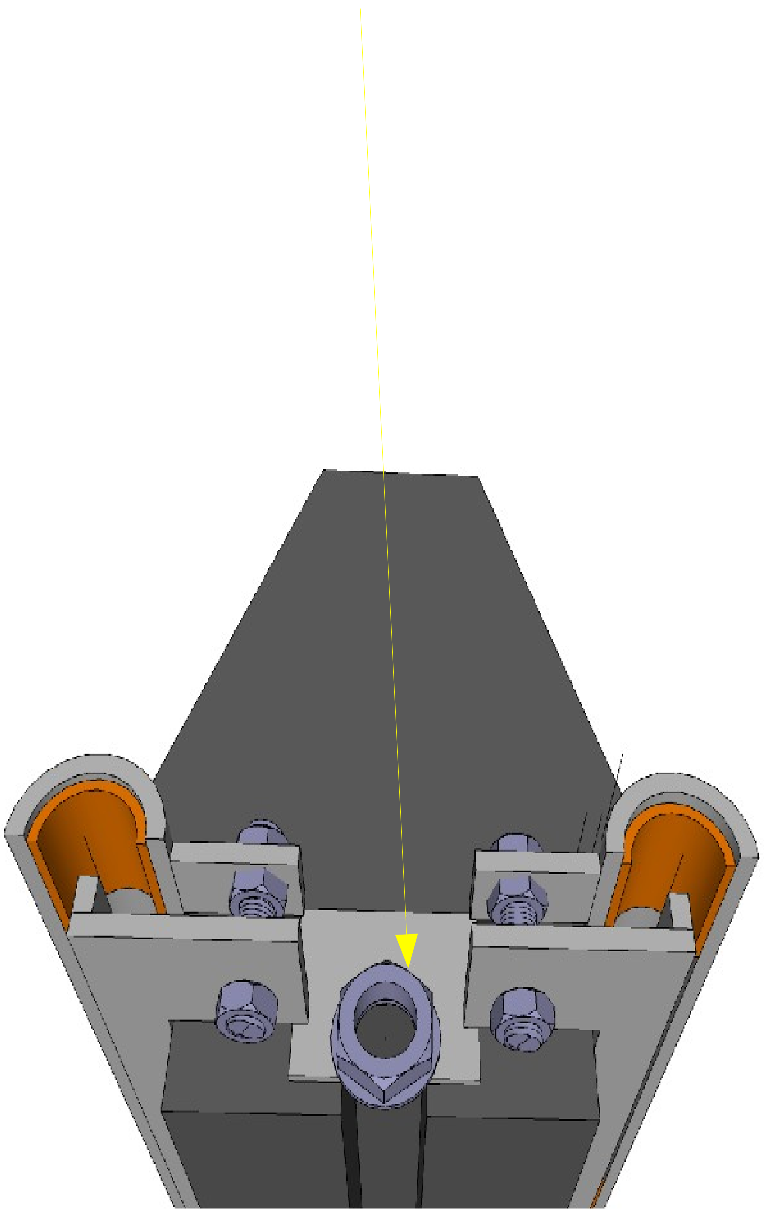
The tail stock on a lathe this small should be at least200mm long. The longer and heavier the tailstock is the better it will be.

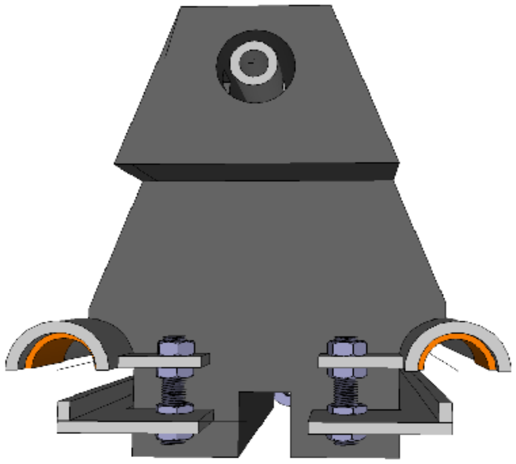
If no Morse Taper socket is available then machine a simple steel cylinder 40mmOD and . 70mm ID. Weld a piece of scrap steel on the back end or grind grooves on it to anchor it in the grout and keep it from turning. Let the front end protrude far enough (25mm) out from the grout so that set screws/taper pins can be used to retain a center or a drill chuck mount. The cylinder could be aligned and held held in place by an accurately centered 18mm(aprox)rod held in the drill chuck.

Once you have built the carriage, the concrete form for the tailstock should be easy!

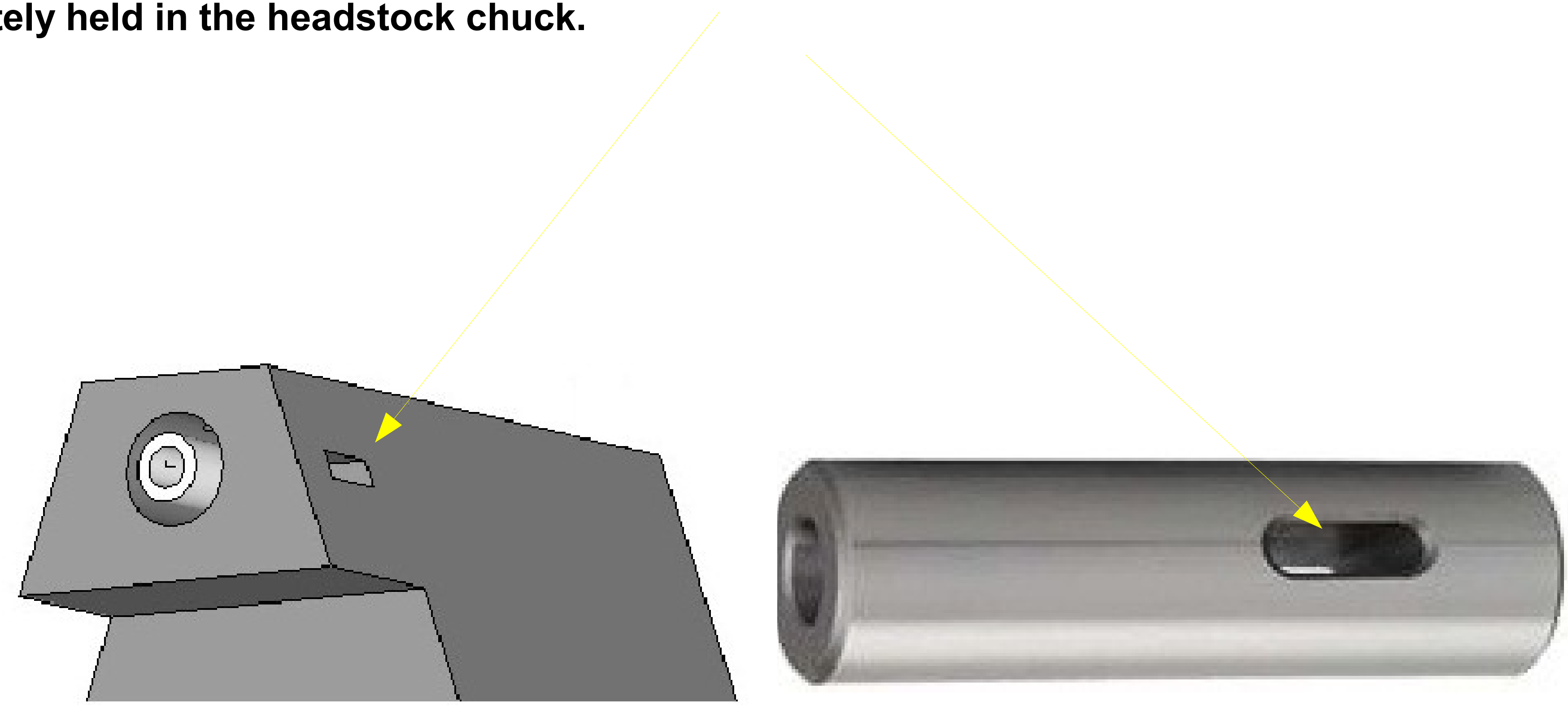


A long all-thread type coupling nut should be used (if available) to make it easier to reach.

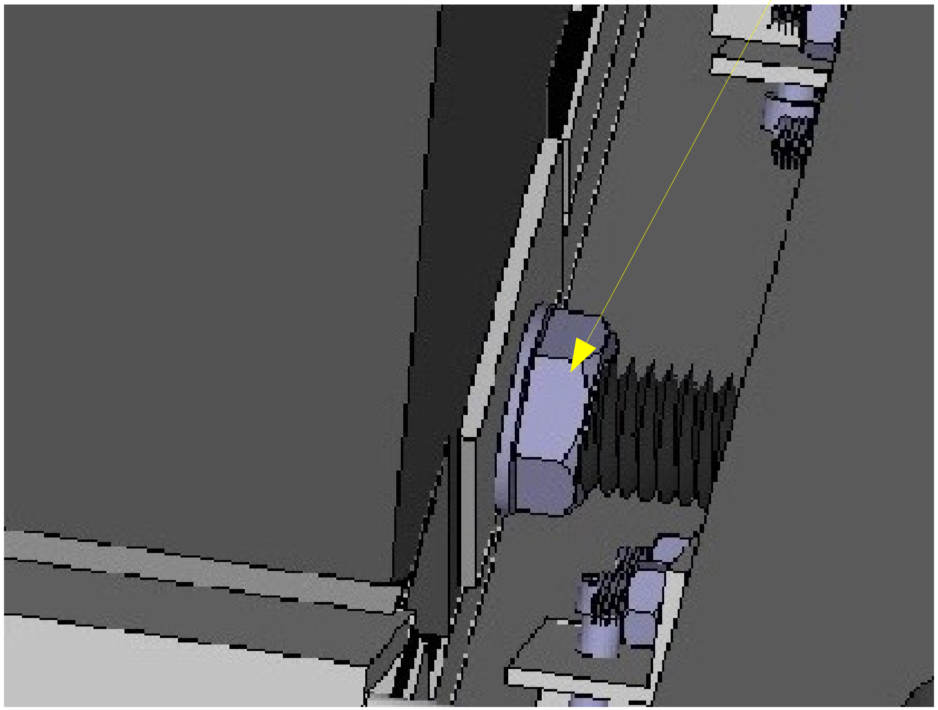


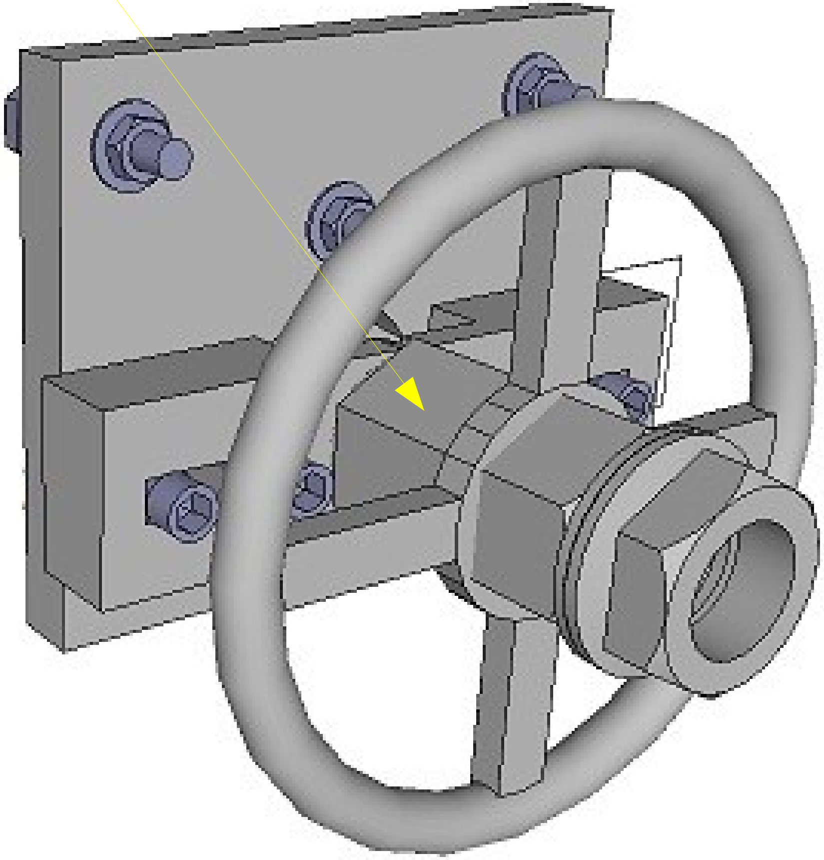


If you use a Morse Taper socket, a slot should be cast into the tailstock concrete so that a wedge could be used to knock loose a Morse Taper tool. Naturally the slots should line up! Something should be welded to the back of the MT socket or grooves cut into it so it will not turn or pull loose from the grout. Align the socket before grouting by using a Morse Taper drill accurately held in the headstock chuck.



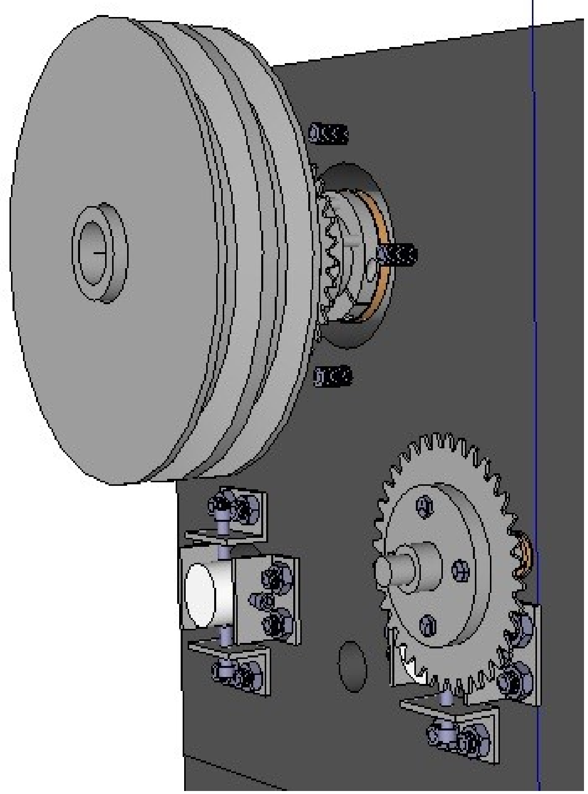
The tailstock spindle does not move, the whole tailstock is moved instead. It can be moved forward by a simple nut and washer or a carriage type hand wheel. The handwheel clamp mechanism probably won't be needed so a good compromise could be a hand wheel that is pressed over an all-thread coupling nut.





Power

One of many ways of driving the lathe. A cheaper and easier way would be to use a much larger (900mm) plywood pulley to get a single 100 rpm spindle speed. You will have to add an automotive type idler pulley to insure that the drive belt wraps around as much as the smaller pulley as possible. Also shown are the drive sprockets for the thread follower threading device. It has been my experience that multiple speed “v” belt drives that use aluminum pulleys can waste an amazing amount of power even when they are transferring little power.
An auto brake and hub unit could be bolted to the rear of the headstock so that it could provide a spindle brake, pulley surface for multiple “v” belts (like South Bend did) and a way to mount an indexing device.



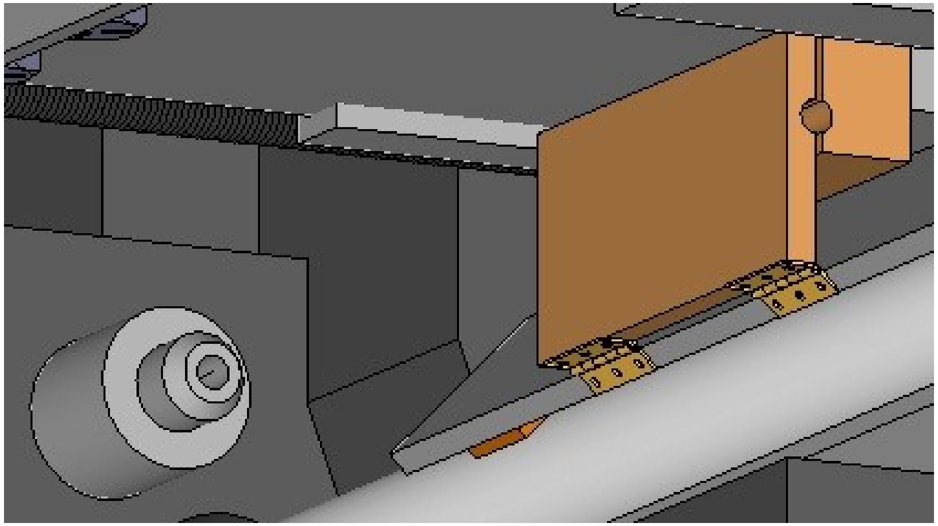
If you use a flywheel as a face plate or chuck back plate, you can drive it with a pinion from a starter motor. If you use an engine block as a headstock the you can use a gutted starter motor, driven by a flat timing belt wrapped around the starter rotor as a simple drive. It is all too easy to drive a large, self-built lathe at too high a speed to be durable or safe. *Start with slow speeds first.*

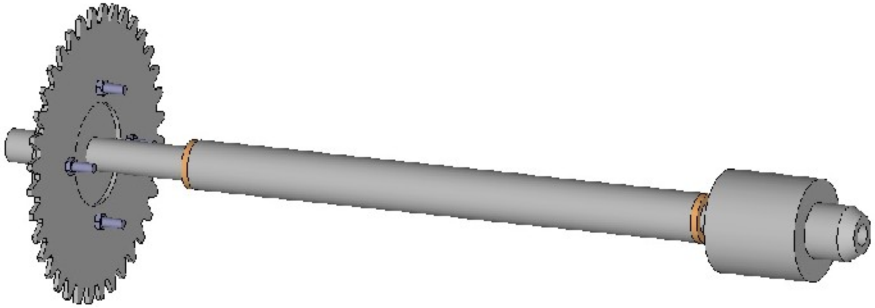
Safety is all important, always wear eye protection and always start using the machine at a speed low enough that the workpiece can be seen and not just be a blur.

The **thread follower** chuck rotates at the spindle speed and is driven by bicycle sprockets and chain. An idler should be added so that the chain could be adjusted or removed when not needed. There is a limit to bicycle chain speeds so use a motorcycle chain for speeds much over 70 RPM (which is 3 times the speed you should start threading with anyway). To cut a thread, a sample piece of threaded rod is held by the follower chuck and is manually clamped in the wooden or plastic block clamp that is attached to the carriage. This pulls the carriage at the proper speed for cutting a duplicate of the sample thread. The follower spindle cartridge is first aligned and then grouted into the headstock.(old type headstock shown).

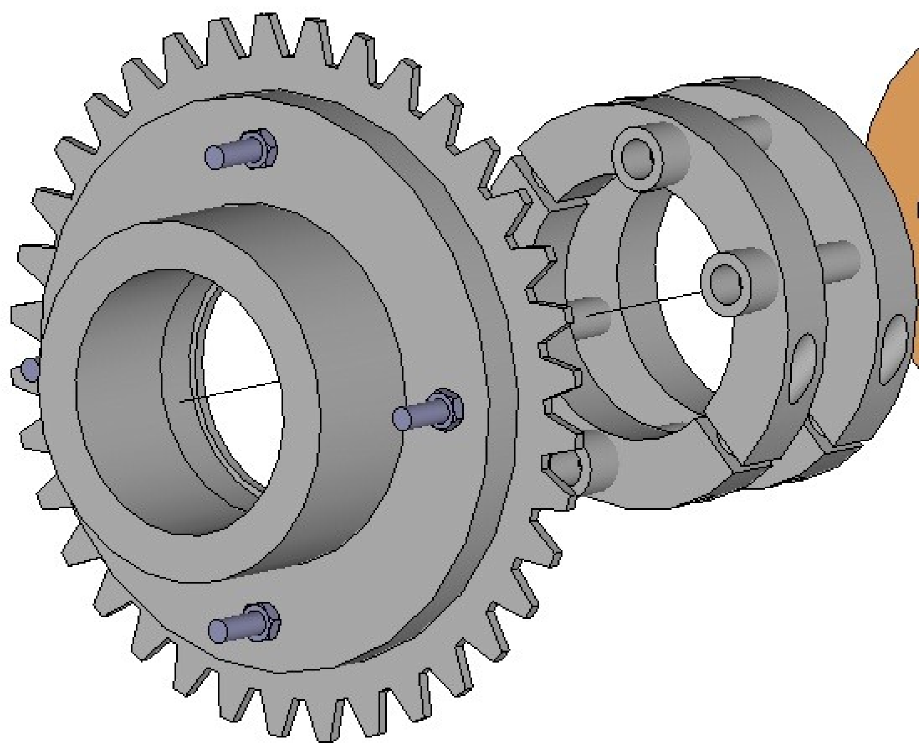
The thread that is cut could be unusually accurate because the wooden block should average out imperfections in the sampled thread.

Special note: Threading on a lathe always requires practice even if you use the best equipment. Threading usually takes multiple passes with the threading tool. Our device will require extra practice to learn how to “pick up” the existing thread on subsequent passes but this should not be too difficult because the wooden clamp can be “eased on” instead of suddenly engaged. You won't find a device like this described anywhere else but I have built and used one on the original Multimachine. It should have an oil line run to it as was described for the main spindle. Half inch water pipe is about 5/8” ID so this, 2 bushings and a piece of 12mm rod either threaded or epoxied into a discarded drill chuck should work well.





A thread follower like this is not going to work well if the sampled thread is small and the carriage heavy. A larger diameter sampling thread could be made with the proper thread count and an air cylinder with carefully adjusted air pressure could be used to help overcome carriage inertia.



A better view of the thread follower hub.

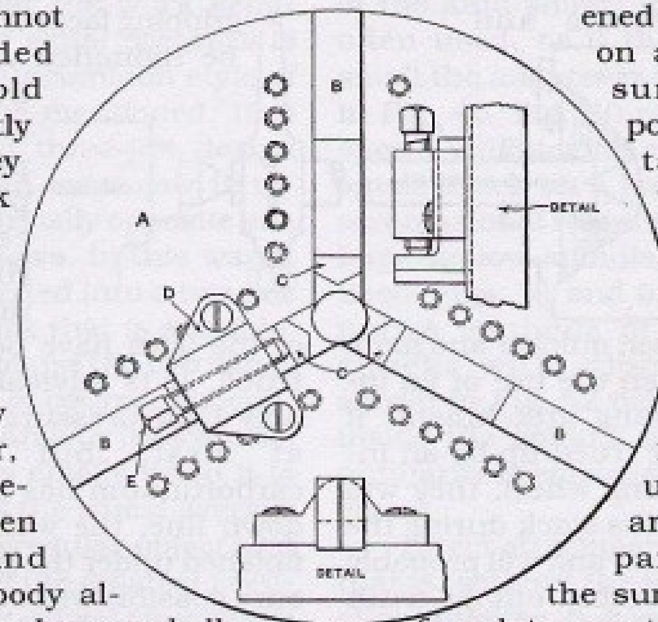
Tooling

Tooling starts with the lathe chuck. A good chuck and backplate could easily cost many times more than the rest of the lathe.

We start with this 1916 Machinery magazine plan to show that you don't have to pay a fortune.

Yours does not even have to start out as complex as this. The milled slots could be added later. The holes could be drilled by a drill motor mounted on the carriage cross slide.

The jaws of the average lathe chuck seldom have a bearing for their full length on the piece of work which they are holding, and therefore cannot be depended upon to hold work perfectly square. They may work fairly well while new if they have been perfectly fitted, but they soon wear, and the looseness between the jaws and the chuck body allows them to become bell-mouthed when tightened on a piece of work.



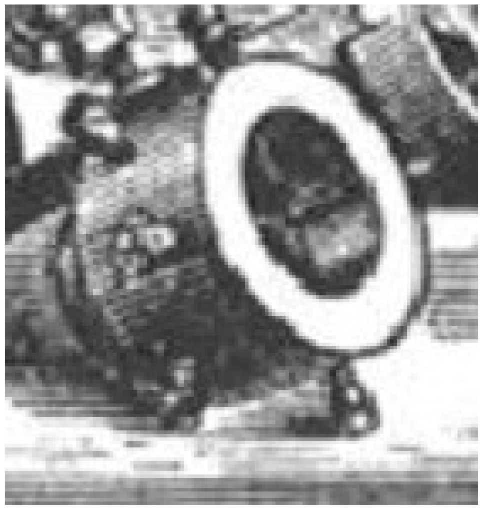
The need of a chuck which could be easily kept true led to the design shown in the accompanying illustration, which shows a set of auxiliary jaws fitted to a bench lathe faceplate. *A* is the faceplate in which have been cut the shallow grooves *B* that the jaws *C* slide in. *D* is the strap which holds the jaws in place and carries the adjusting screw *E*. The strap is held to the faceplate by screws that enter tapped holes, as indicated, spaced to allow for shifting the strap to different positions as shown.

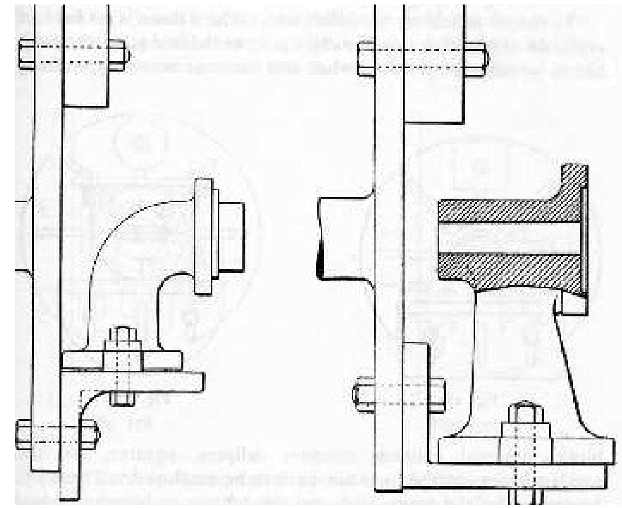
The illustration is clear enough to show the principle, but it is well to note that the chuck jaws and strap are hardened and ground on all wearing surfaces or points of contact, while the grooves in the faceplate are either scraped or ground on the surface grinder until they are perfectly parallel with the surface of the faceplate, as strap *D* must bind sufficiently on the jaws so that when the screws are drawn down tight the jaws will be a tight sliding fit. Special jaws for holding odd shaped or thin pieces can be easily made up, while any wear on the jaw faces can be remedied by regrinding on a surface grinder. While designed originally for use on a bench lathe faceplate for holding pieces that had to be turned, bored or ground accurately, there is no reason why the same principle cannot be applied to heavier work. It would prove cheaper and more accurate than the regular chucks on a large variety of work. D.B.

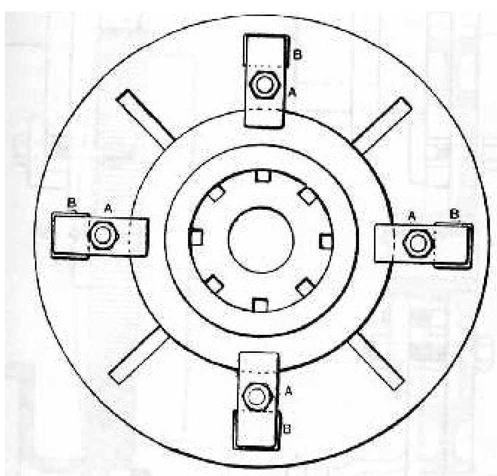
Flywheel, faceplate/chuck

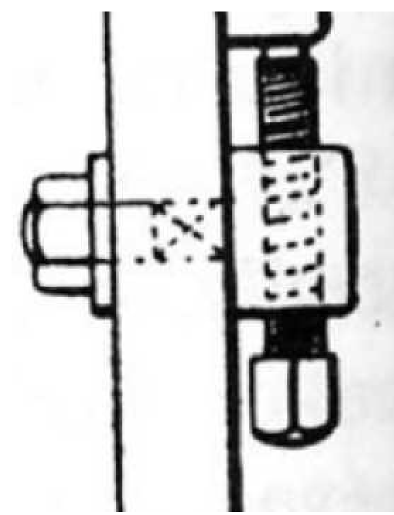
Regular 3 or 4 jaw lathe chucks may be too expensive to many in the Developing World. Fortunately an engine flywheel can be made to work. The cut out area in the center should be filled in with a round disk that is retained by countersunk flat head screws.

Inexpensive work holding devices like these can be bolted to the flywheel/faceplate and used to clamp the workpiece. The important thing to learn is how not to buy anything!



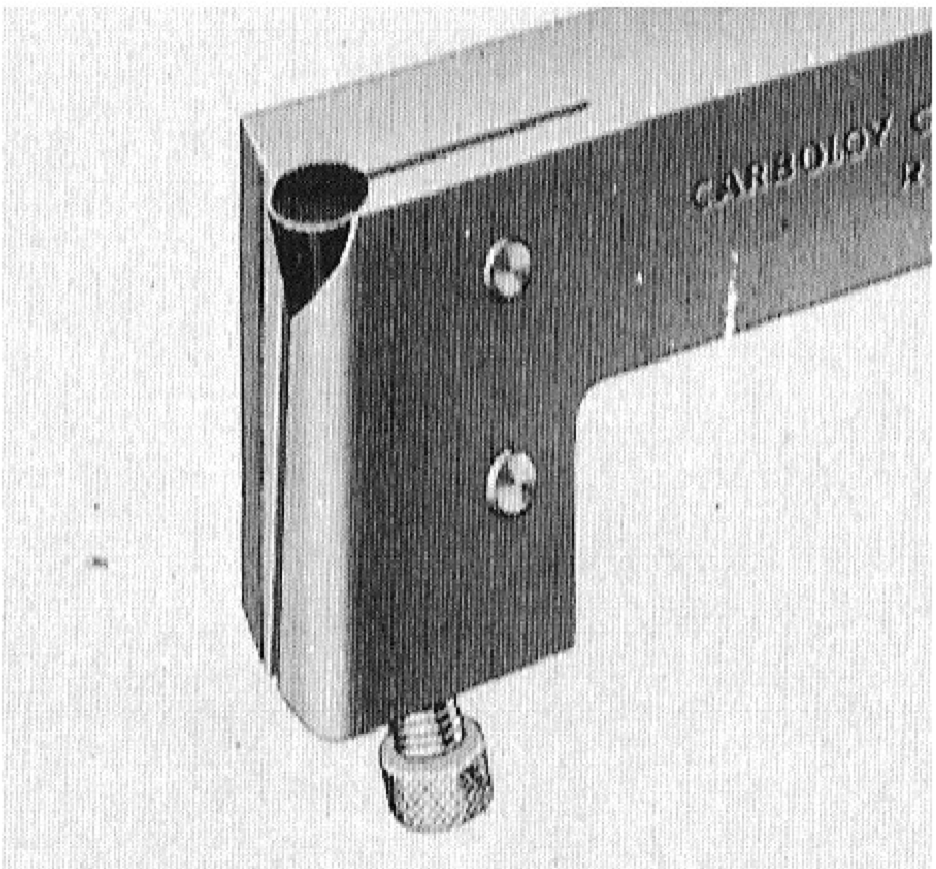






Cutting tools can also be as expensive as the entire rest of the machine but there simple and cheap alternatives such as these tangential tools made from broken drill bits or pieces of drill rod. The tool holder can be made using just a drill, hacksaw and file.

Cutting fluid can be made with 10 parts water, 1 part motor oil and enough dishwasher detergent to make them mix. Palm oil also works well.



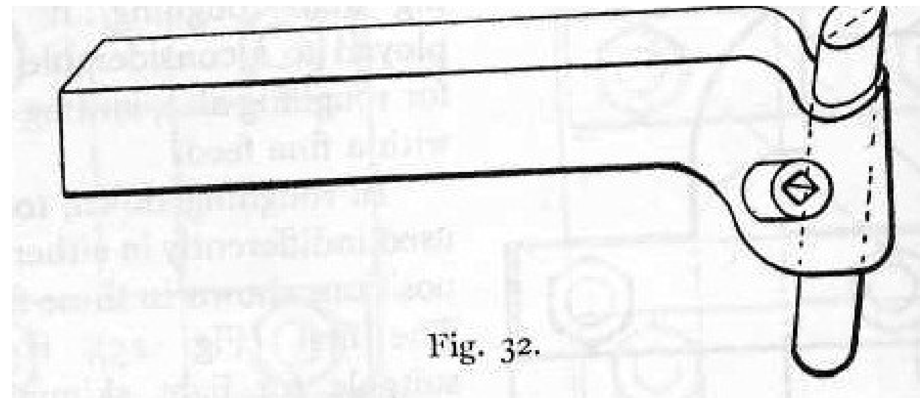
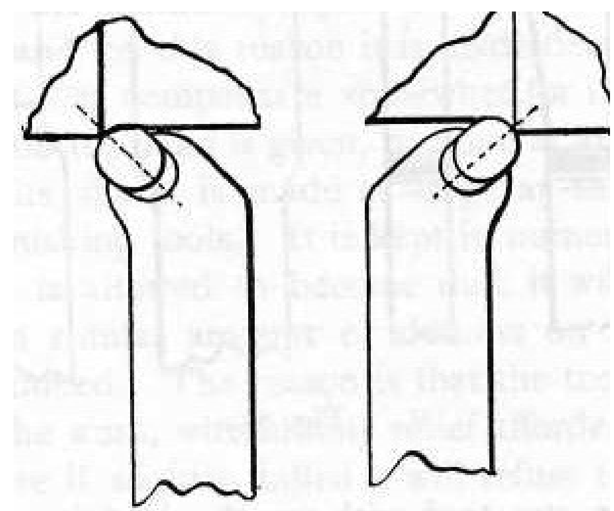
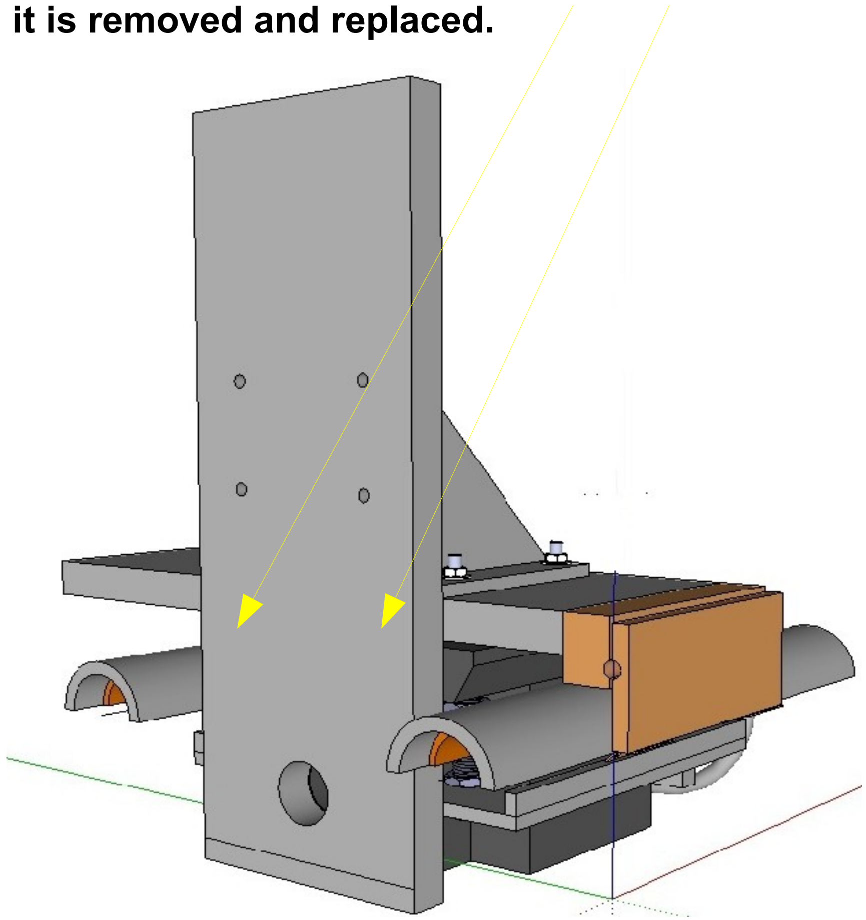


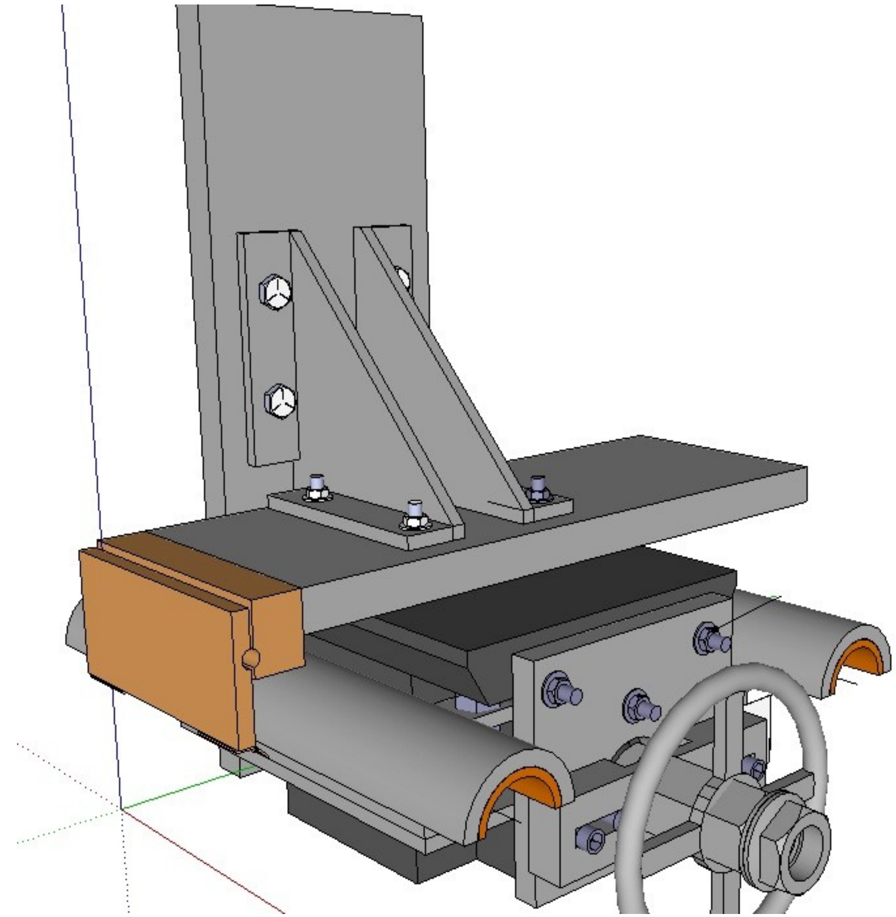
Fig. 32.



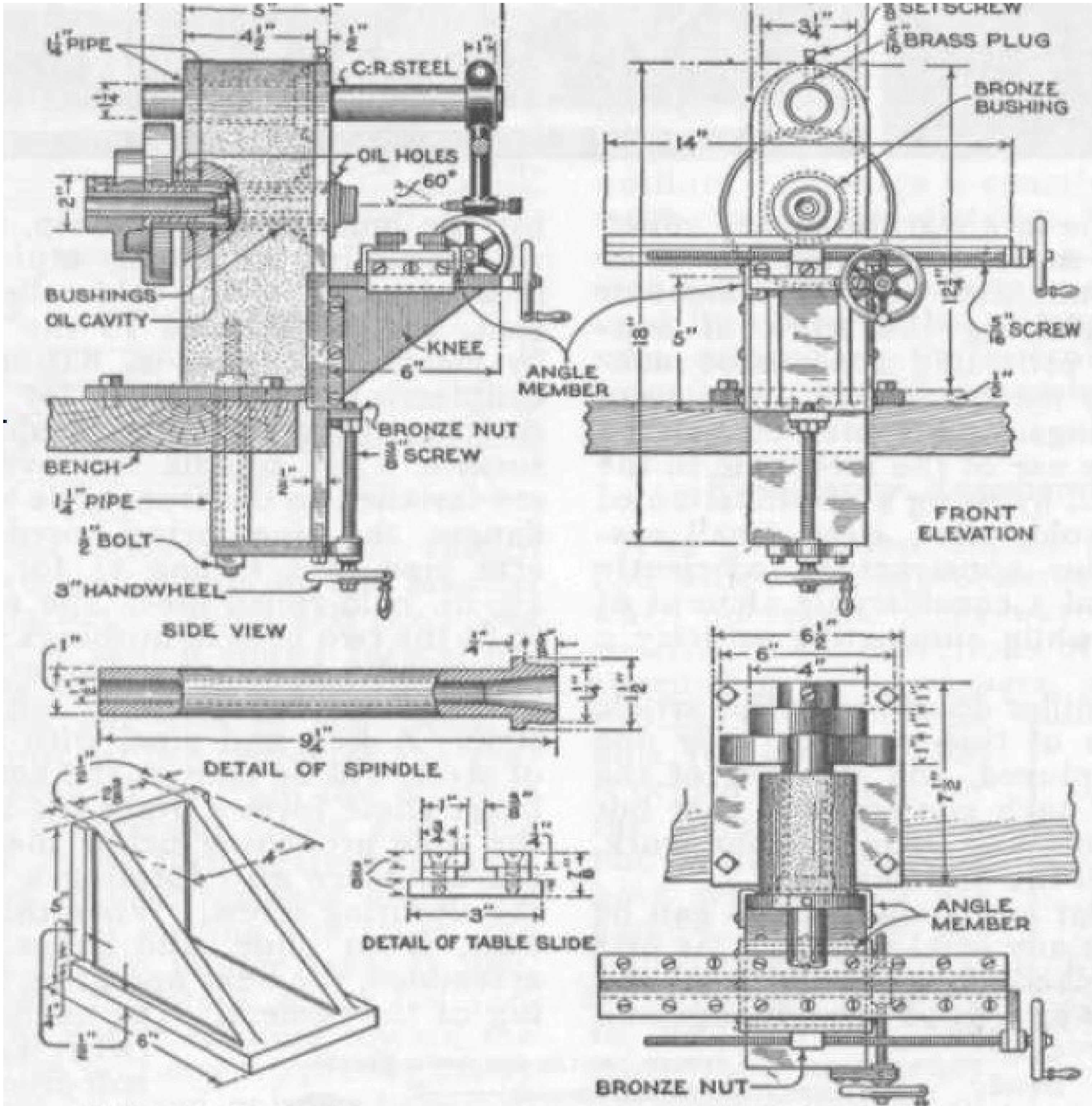
Milling and Drilling adapter bracket

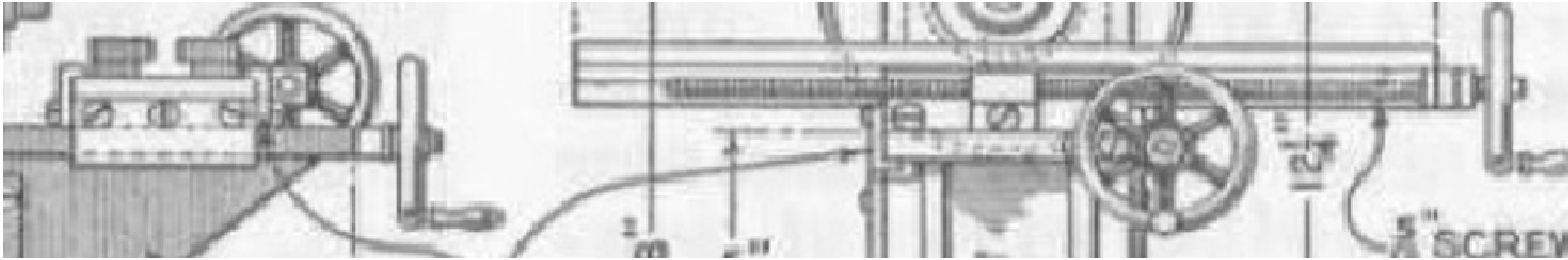
A conventional X,Y table (next page) can be bolted vertically to the front of this accessory bracket. The lead screw hole should be slotted so that it can drop on. Holes for 9 or 10mm bolts should be cast in the carriage casting so that the adapter and the handwheel mounting plate can be connected. An additional bolt can be added under the lead screw. The bottom of the vertical plate should be well greased and then aligned and grouted in to the carriage. Taper pins could be used here so that it would keep alignment when it is removed and replaced.

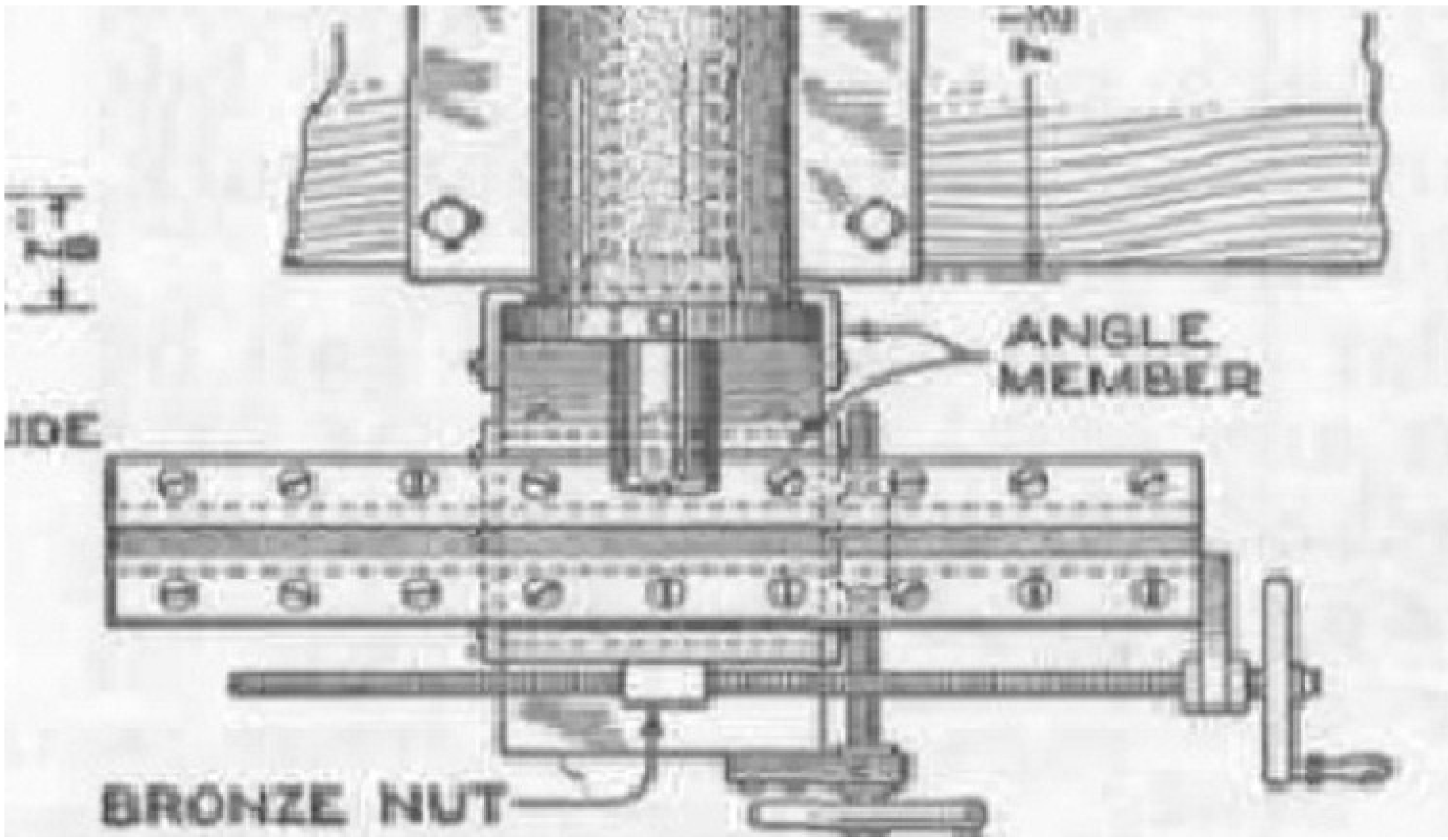




The plans were from a 1920s Popular Mechanics Magazine. It was a famous J.V. Romig design.

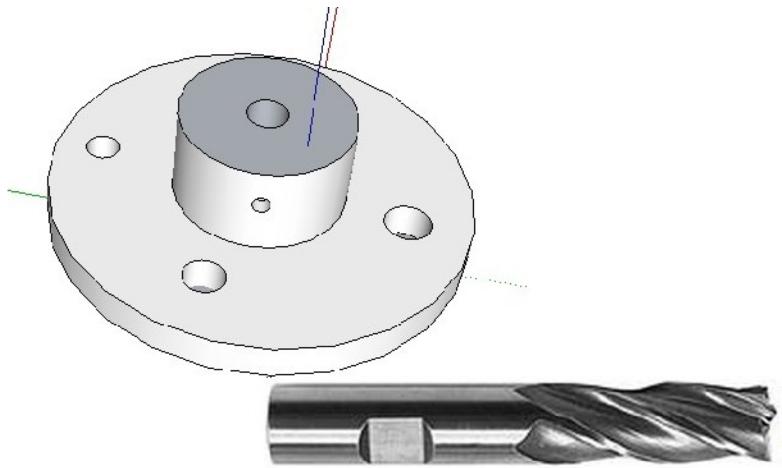

5"
4½"
½"
1¼" PIPE
C.R.STEEL
OIL HOLES
60°
BUSHINGS
OIL CAVITY
KNEE
6"
ANGLE MEMBER
BRONZE NUT
⅝" SCREW
BENCH
1¼" PIPE
½" BOLT
3" HANDWHEEL
SIDE VIEW
SETSCREW
3¼"
5/16" BRASS PLUG
BRONZE BUSHING
14"
5"
5/16" SCREW
FRONT ELEVATION
1"
9¼"
DETAIL OF SPINDLE
3"
DETAIL OF TABLE SLIDE
6½"
6"
4"
ANGLE MEMBER
BRONZE NUT

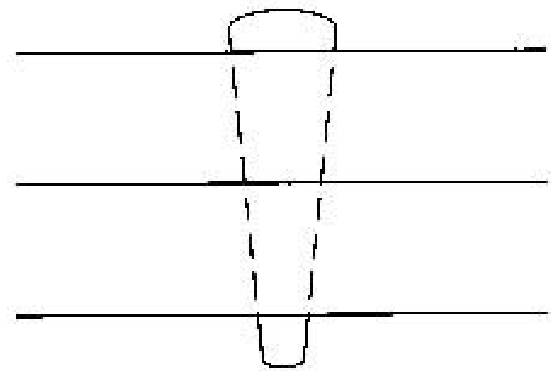




It would be a good idea to model this out of wood first to make sure it fits properly. Great care must be taken to insure proper fit of the components because the base of the slide is relatively narrow.

Something to hold the milling cutter will be needed.
A special milling spindle could be made but an easier solution would be a simple attachment like this could be made from iron or steel. The attachment should be machined in place and taper pins added so that it can be accurately replaced if it is removed. Bushings could be used to adapt to different size cutters or drill chucks.





The center part of a bushing type pulley could be turned down and pressed into the adapter (above) so that standard interchangeable bushings could be used for different size milling bits. If you do this, be sure the bushings are of a type available in small (9 or 10mm) size for the most available end mills. The spindle of a drill chuck could also be held by the adapter.

(idea from George Ewen)