Machinist's Clamps

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A handy tool in a shop is a machinist's clamp (also called a toolmaker's clamp or a parallel clamp). The picture below shows one made from brass on the left and a commercial version (Starrett 161B) on the right. The Starrett clamps are case-hardened to stand up to long use and e.g. being bumped with a file or clamped in vise jaws. However, one clamp will cost over $50. That's pretty expensive because these are things you can make yourself pretty easily -- a few dollars for material and perhaps a couple of hours of your time. They can also be made with simple tools: flat and round files, center punch, hacksaw, drill/bits, vise, hammer, and tap -- so there's really no reason you shouldn't have one if you want one and have the time (when I have the time, I find it more satisfying to make my own tools than to buy them).

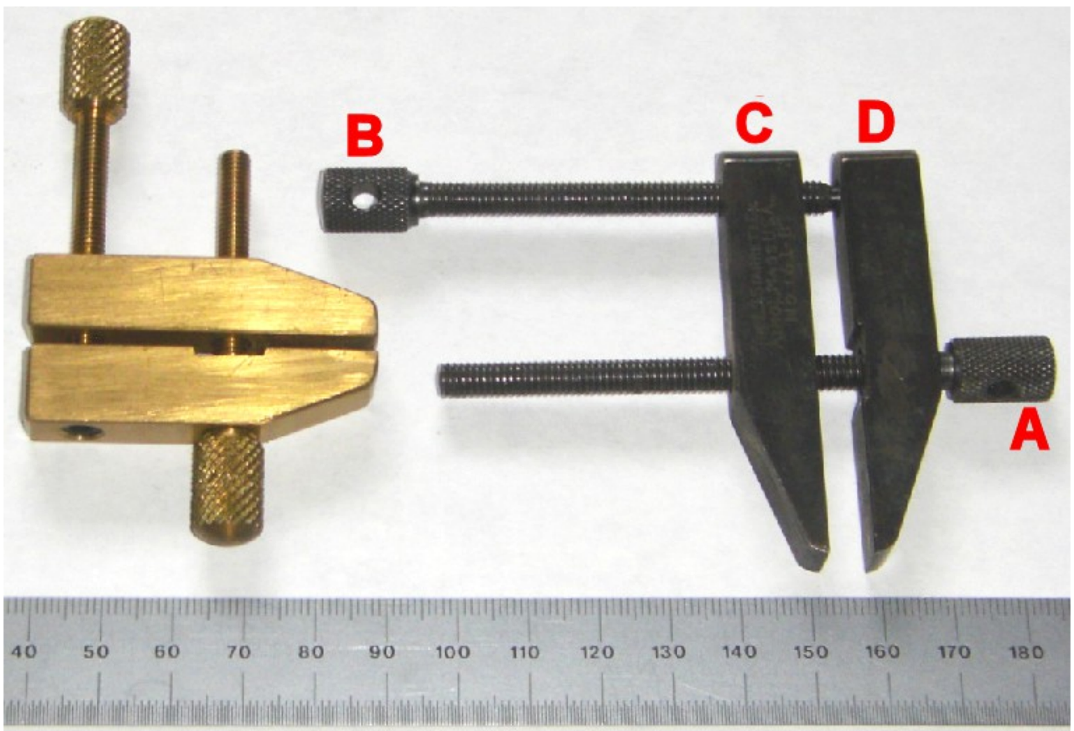


Figure 1

Here's a clamp made from 3/8" stainless steel square key stock and some brass screws machined from 3/8" bar stock:

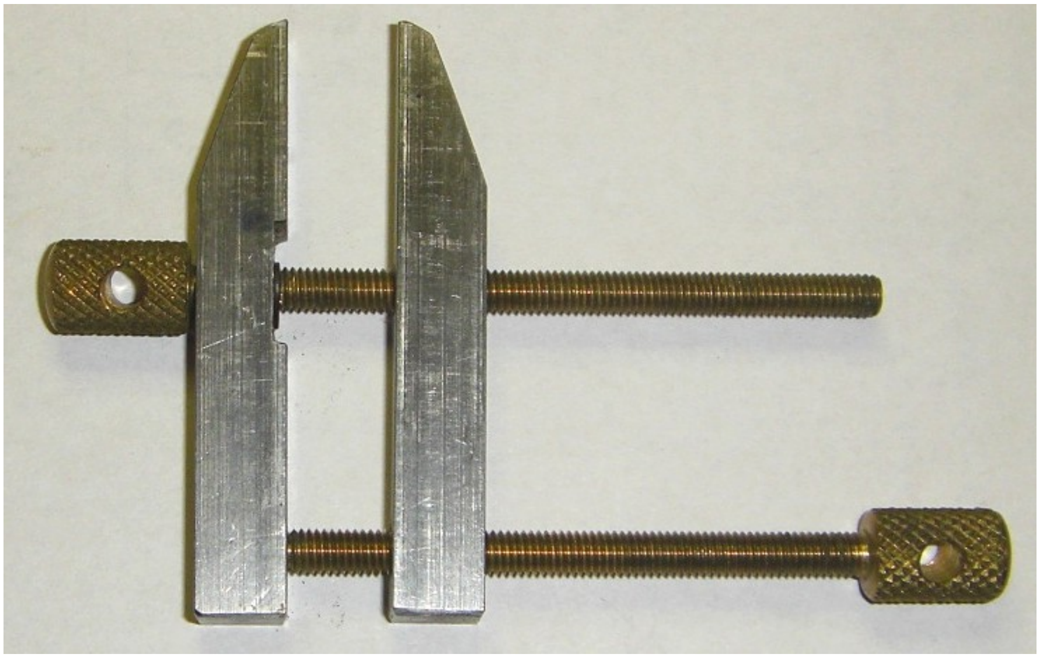
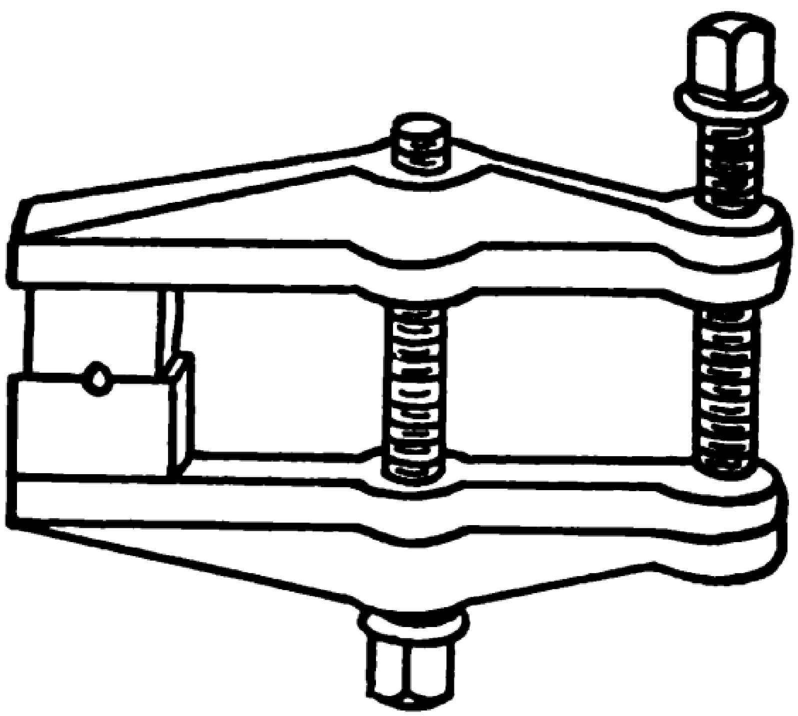


Figure 2

This clamp can be left out in the rain and I don't need to worry about it (there's a steel E-clip holding the left jaw to the clamp screw's head, but if it rusts, it's easily replaced). The jaws are 2" long, and the brass screw threads are 10-32 UNC and 2.9 inches long. Both this clamp and the Starrett 161B clamp can hold something as thin as a piece of paper or something up to 2 inches wide. The clamping depth is about 1 inch.

Machinist's clamps are designed differently and are easier to construct than the typical woodworker's clamps (which require a left-hand and right-hand thread). Both screws in the machinist's clamp are a right-hand thread. Here's a drawing of a machinist's clamp from 100 years ago [cs:11:23]:



Other than having forged jaws, it's the same as the machinist's clamps used today.

I'll include some dimensional drawings of the Starrett clamp shown in the above picture, but you can freely change the dimensions to suit the stock you have on hand or your needs (I'll also include a table of sizes from [*tmbr*] that covers a range of clamp sizes). A fabrication detail is an E-clip that holds jaw D against the right-hand end of screw A (the size-adjustment screw). This clip requires a small groove that's most easily made on a lathe. This E-clip (it's missing on the Starrett clamp in Figure 1 but visible in Figure 2) keeps jaw D stationary with respect to screw A so that you don't have to manually pull the jaws apart when opening the clamp. There are other ways to accomplish this which we'll show in the section *E-clip alternatives* below. However, I recommend using an E-clip or a retaining ring for this task, as the other methods typically involve hardware near the clamp screw head and these are things you can ding your fingers on or break a fingernail on if you're not paying attention.

Some nice fabrication features about machinist's clamps are:

1. They only use a right-hand thread. This makes them easier to make in the home shop than carpenter's clamps. In fact, the easiest way to make them is to use some threaded rod -- then you only have to tap two holes per clamp.
2. They can be made from inexpensive steel or brass key stock.
3. You can use a socket head cap screw instead of the custom screw if you wish. But this means you may need to use an Allen wrench for tightening. Or use a hex head bolt -- but then the clamp may not lay flat if the hex is wider than the stock.
   A. If you use a socket head cap screw, the whole clamp can then be made using a hacksaw, file, drill, and suitable tap (if you're willing to leave out the E-clip). It's not uncommon for people to make mini-machinist clamps with socket head cap screws.
   B. If you want to use a socket head cap screw, you can make a knurled cap for it. For cap screws that have a coined head, measure the diameter over the coining and then make the cap's hole diameter a few thousandths of an inch (about 0.08 mm) less. Then the cap can be pressed onto the cap screw in the vise and it will form itself around the coining, meaning it won't move (make the cap out of a soft metal like brass, aluminum, or copper). For a metric cap screw that doesn't have the coining, file some light marks and then use a thread-locking compound (e.g., Loctite). Or, lightly ding up the surface with a prick punch so it presses into the cap and stays put.
      1) You can also buy thumbscrew heads for cap screws; Shear-Loc is one brand name (check to see if your local hardware store stocks them). But if you have a lathe, it's more fun to make your own rather than making a trip to a store.
      2) If you make a knurled cap for a socket head cap screw, consider drilling a hole through the cap so that you can also apply an Allen wrench to the cap screw to tighten it if you wish.
4. The E-clip/retaining ring is optional, but you'll probably want it for convenience.
5. If you don't have a lathe, you can still make the screw head from a suitable piece of bar stock material. Cut off a piece, file the ends, drill a hole in the end and the cross hole for the tommy bar, then attach it to some threaded rod for the screw using a spring pin (your local hardware store should have the threaded rod and spring pins). If you don't have a spring pin, you can make a pin from some brass welding rod or copper wire. Peen the ends to lock it in place or ding the pin's surface with a prick punch or cold chisel (see *Part A: size-adjusting screw* below). Welding, brazing or soldering can be used too. If you're patient, you can lightly dimple the surface of the screw head with a center or prick punch in a number of places and this will work as a substitute for knurling for gripping.

You may be able to find cheap machinist clamps sold on the web, either new or used. Also try less expensive places like PEC or Grizzly. However, these clamps don't sell very often and I've seen a number of places that sold clamps quit offering them over the years. Us home shop machinists often take pleasure in making our own tools -- it lets us practice our hobby and we wind up with something we can use. Thus, if you want some of these, I suggest you make them. It won't take long and you'll use them the rest of your life.

These machinist's clamps don't replace other clamps in the shop such as C-clamps. However, once you get some practice in using machinist's clamps and learn how to tighten them properly, you'll see how useful they are. See the *Uses* section for how to use these clamps.

Design

If you have access to Guy Lautard's *Machinist Bedside Reader* books [*tmbr*], in Volume 1, page 149 he gives the measured sizes of a number of different machinist clamps; the intent was to give you enough information to make your own (these sizes are given in the *Range of sizes* section below). In this section, I'll give some drawings using the dimensions of the Starrett clamp. But there's nothing critical about the dimensions -- make things to fit your tastes or the stock you have on hand. The only design concern is to ensure that the holes through the clamp body be small enough in relation to the material thickness that the clamps don't fail in use by breaking at the holes. For example, you wouldn't use a 9 mm hole through 10 mm wide stock.

High-level thoughts

There are two basic designs of machinist clamps. The first design has the tapped holes for the clamp screws on the same piece (the tapped holes are in the blue piece):

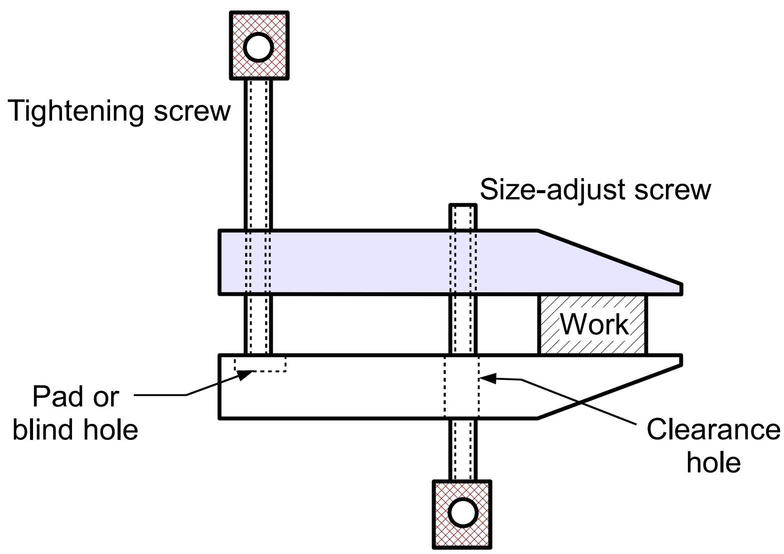
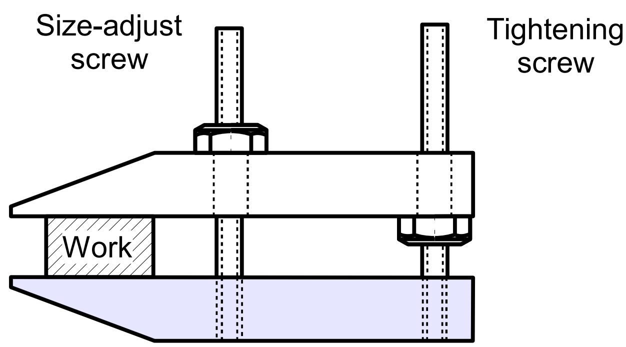


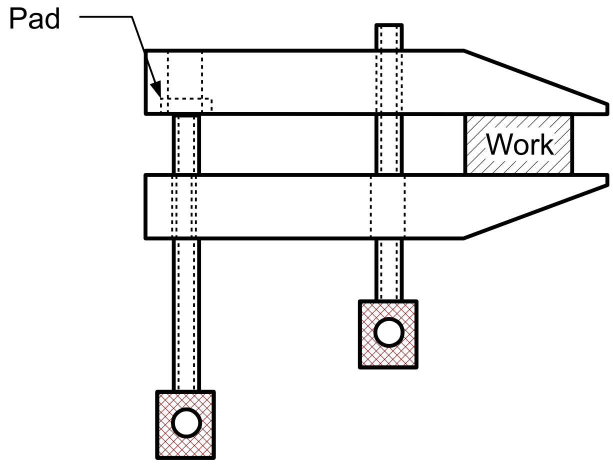
Figure 3

This is the conventional design of most commercial machinist's clamps. If instead of the pad or blind hole a through-hole is used, we have the screws-on-one-side design:



If you have a milling machine with a clamping kit, this screws-on-one-side design could be useful with the studs, nuts, and step blocks from the kit.

Another design is to make the jaws have one clearance hole and one threaded hole:



This means the screws will be on the same side if you use a pad. If not, it's a similar configuration to an adjustable lathe dog, but it won't have the clamping capabilities of the typical parallel clamp because the tightening screw doesn't force the jaws apart, which is the key behavioral characteristic of a machinist's clamp, regardless of the detailed design.

Important: **The latter two designs don't let you easily adjust the jaws' spacing quickly**. The first design in Figure 3 lets you hold one screw and rotate the other one, turning the whole clamp body and quickly adjusting the opening. I use this quick-adjust feature constantly, so I always use the first design.

Starrett clamp design

One of the design features of these clamps is that the knurled screw heads are smaller in diameter than the thickness of the jaws. This allows the clamp to e.g. lay on its side or let you clamp it in a vise[1]. **You probably want this feature**. However, sometimes you need to clamp something harder than you can get by turning the knurled portion with your fingers, so the hole in the handle is used with e.g. a drill bit to increase the turning torque (sometimes called a tommy bar). I use the lay-flat feature a lot, so all the clamps that I've made have that feature. The Starrett design puts holes in both the size-adjusting screw (part A) and the clamping screw (part B). I've never needed the hole in the size-adjusting screw, so you can leave it out if you wish.

One advantage of Starrett's case hardening is that you can bump the clamp with a file and not remove material. As filing isn't done as much as it was 50-100 years ago, this isn't a much-needed feature anymore. If you make your clamps from some key stock, you can knock out new some pieces in under an hour using a hack saw, file, tap, and drill press. In fact, you might prefer the unhardened steel or brass in case you run a cutter into the clamp. I've been using shop-made clamps for decades and I've never needed them to be hardened.

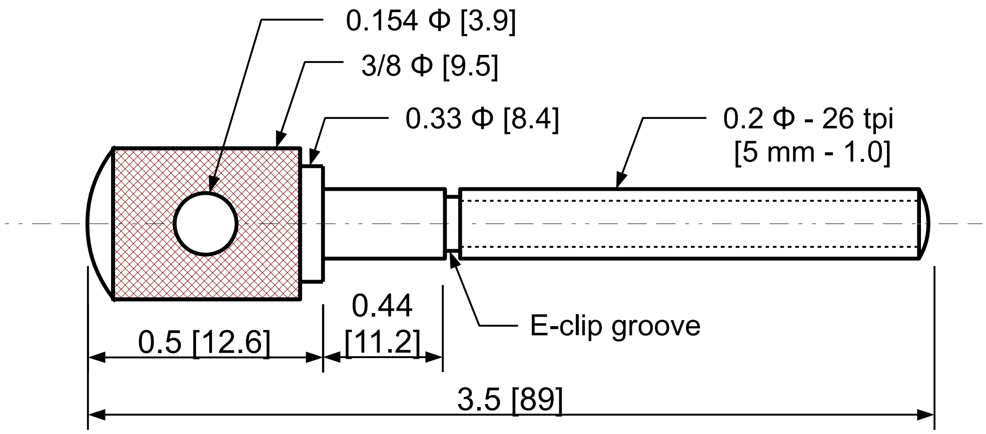
I've given the dimensions of the Starrett clamp in inches because it's pretty clear that these were designed by folks who used fractional inches (they were probably designed in the late 1800's). In the drawings, I've put the nominal metric equivalent in mm in square brackets.

Part A: size-adjusting screw

There are some dimensions left out because they are up to the machinist's judgment. For example, the groove dimensions will depend on the E-clip or retaining ring you use. For one of my Starrett clamps, the E-clip always falls off after a while (leading me to believe the groove wasn't machined correctly). The clamp is still usable, so you can leave out the E-clip if you wish (but you may have to manually separate the jaws to open them up). I consider the clip a mandatory part of the design and never leave it out. For larger clamps, I'll sometimes machine a washer for the clip to bear against,

1 An advantage of Starrett's case hardened clamps is that the vise jaws won't leave marks in the clamp.

as the hole size might be a bit large.



I use a 10-32 screw thread when I make clamps this size and machine the screw from a chunk of 3/8" brass bar stock (I start the thread straight by single-pointing it, then do the rest with a die). You'll want to turn the 3/8" knurled diameter down a bit if you're using 3/8" square stock and you want the lay-flat design -- knurling will increase the diameter about 0.01 to 0.015 inches, so you'd want to start perhaps 0.04 inches (1 mm) under the nominal 3/8 size.

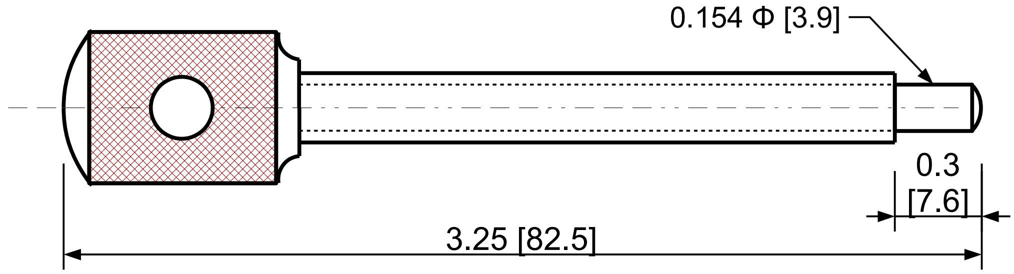
If you turn the stock on a lathe, you may want to cut the E-clip groove before you cut the thread. This will make it a little easier to index the grooving tool on the OD. I use pin gauges to measure the correct shaft size for the E-clip, then use the lathe's cross feed to make the grooving tool cut that exact depth. It's quick and reliable. It doesn't matter if the groove is a little too wide, but you want to get the diameter correct to ensure the clip stays on. For the 10-32 thread in Figure 2, I used a 3/16 inch E-clip, which required an OD of 0.147 inches. I measured the groove I cut at 0.145 inches. E-clips this size are about 0.03" thick.

> For a one-off groove like this, it doesn't make sense to grind an expensive HSS tool bit to cut the groove. Make the cutter from a short chunk of high-carbon steel (drill rod is the logical choice to stock in your shop) and file it to shape and harden/temper it. You'll find that such tools work well for the occasional groove.
>
> Another method is to grind a chunk of a broken hacksaw blade, which will give you a "cutoff" tool around 0.03 inches wide (but it's probably soft steel and won't stand up to lots of use). Other folks cut out cutoff tools out of old carbide-tipped circular saw blades with an angle grinder.

Harold Hall [*hh*] shows his clamps with substantially finer threads. The benefit is higher clamping forces at the expense of slower adjustment.

Part B: clamp screw

Note that there's a radius on the end of this part rather than a square shoulder (Starrett probably uses this to distinguish the parts). Only the dimensions that are different from part A are shown.



Coining in the lathe

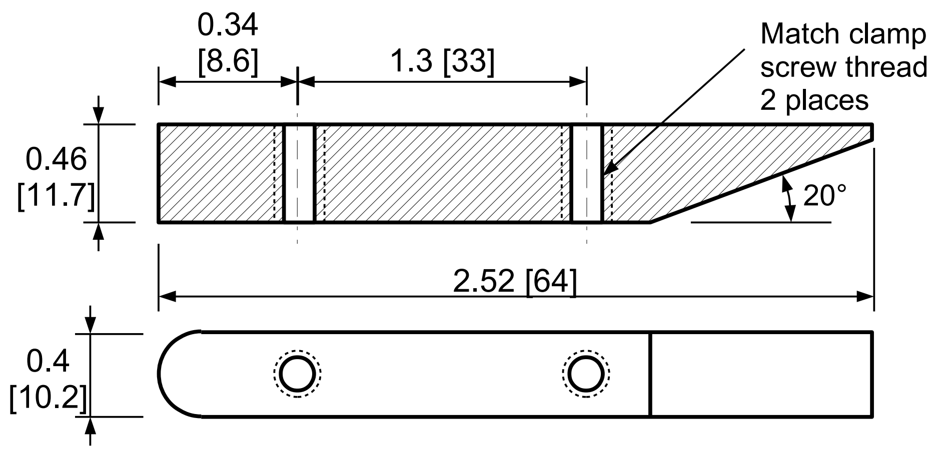
If you look at Harold Hall's clamps [*hh*], he made the screws without knurls. This is fine, but if you have a lathe and you don't have a knurling tool, you can still put coining on the edge -- and this works nearly as well as a knurl (you can also buy coining wheels that fit a knurling tool). Clamp a threading tool rotated 90° from its usual position about its longitudinal axis and drag it along the surface to be coined with the lathe's longitudinal feed (I usually feed towards the tailstock). This manually cuts a groove (rules and dials are scribed in a similar fashion). Rotate the spindle a fixed amount and repeat.

If you want something to help you index the spindle, lay out the desired number of cuts you want to make on a strip of paper and then wrap the paper around the spindle (the distance between each of n marks will be $\pi d/n$ where d is the spindle diameter you wrap around). Use a magnet to hold a piece of wire as an index pointer so you can see where to rotate the spindle next. It's fast, simple, and more than accurate enough for this task. A file can get rid of the burrs, but you might decide they're worth keeping. Get rid of the sharp edges with a motorized wire brush.

Another method of producing a knurl from two files and a vise comes from a Feb 1921 *Popular Mechanics*, page 288 (look it up on Google books), but it can be challenging to do unless you have another person helping.

Part C: jaw

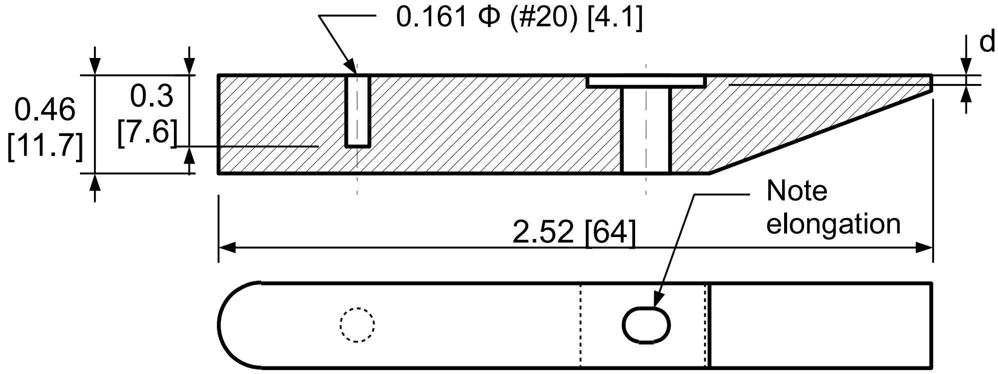
This piece can be made by cutting with a hacksaw and filing to shape.



Starrett rounds the ends of their clamps as shown; this looks nice and means fewer sharp corners to bump against. I typically just file the burrs off and leave the ends flat. The 20° angle is not critical -- make it an angle that pleases your eye (the last clamps I made used 30°).

Part D: jaw with pocket

Make length, width, height, shape and the hole locations the same as part C.



The through hole is elongated a bit (in the direction of the long axis) to allow clearance so the clamp jaw can tilt with respect to the screw's axis to allow clamping of slightly-tapered surfaces. The Starrett clamp can tilt up to about 10°. You'll have to either file this out by hand or use a sufficiently long milling cutter (or just use a larger drill). Another method is to drill two small pilot holes side by side, drill them each out with a larger drill, then file to finish.

> But this is easier to say than to do, especially in steel. If you only have a drill press, see if you can get a milling cutter that is just slightly larger than the outside diameter of the threads. Then drill two holes close together (clamp the vise to the table tightly). Finally, drill exactly between the two holes. File to finish things up.

The depth *d* for the clearance of the E-clip depends on the thickness of the clip. This slot is milled if you have a milling machine, but it is filed if you don't. You'll probably want *d* to be 0.03 to 0.05 inches or so.

E-clip alternatives

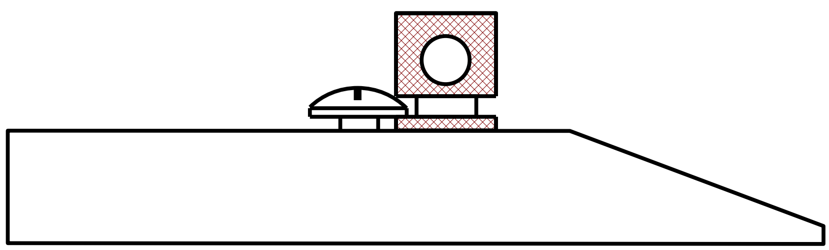
I originally wrote down that making a C-clip from some piano wire could be an alternative to an E-clip. Then I tried it with my Starrett 161B clamp that's missing its E-clip and found that it's harder than it looks. The reason is because the hole in the jaw is elongated and it wasn't easy to make a clip that was both easy to install and didn't get caught in the elongated hole (or maybe I just don't have enough practice at it). A washer could fix this problem, but it would require deepening the clearance slot on the jaw and this isn't straightforward in case-hardened clamps. I was using 29 mil stainless steel spring wire.

I finally quit trying and installed another E-clip, although I expect it to fall off with a bit of use, as a number of others have. The most likely fix would be to find a suitable retaining ring, but this will require a trip to a hardware store. Instead, I might try to solder, braze, or weld a small wire across the open end of the E-clip so that it can no longer fall off.

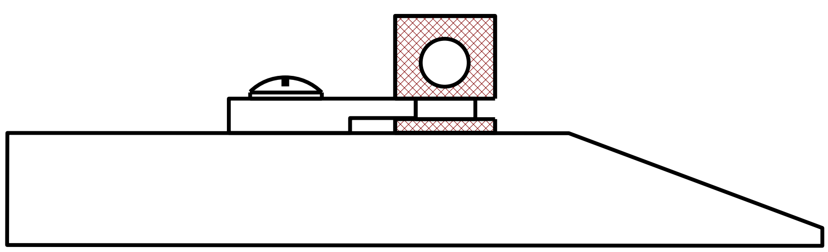
You may also see something like the following design:

This clamp uses a small metal retainer to hold the size-adjusting screw in place. The retainer can be made by bending in the vise and filing to shape.

Harold Hall's [*hh*] sketch 2 shows a practical use of a binding or pan head screw to secure the adjusting screw (use a spacer washer under the screw):

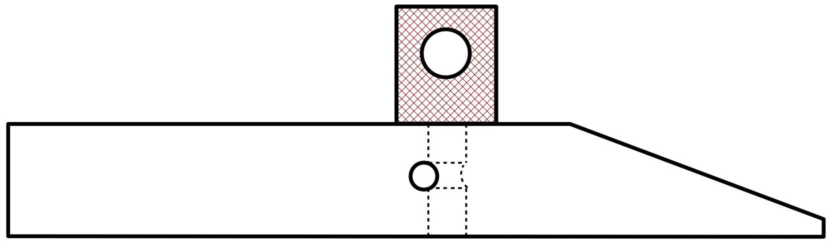


Guy Lautard's design [*tmbr*] uses a machined clip:



> Frankly, I've not used a clamp with the above designs, but I don't care for these screwed-on clips. I feel it would be likely that I would be turning the adjusting screw with my fingers and I'd accidentally ding my fingernail on the exposed clip or screw. One improvement would be to use an end mill to machine a pocket for the clip so it is flush with the top of the jaw. But if you're going to go to that much trouble, why not use an E-clip or retaining ring?

Another finger-friendly design uses a small pin:



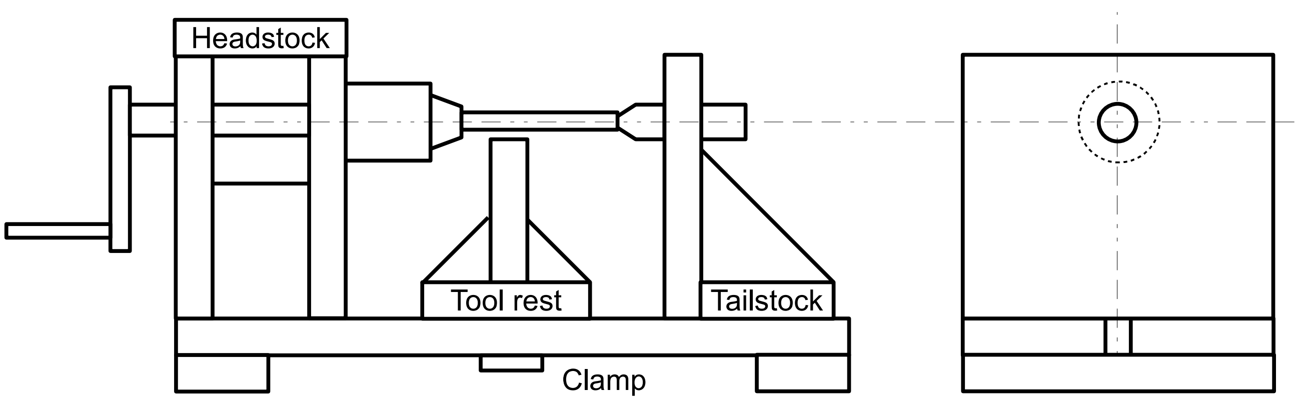
This will require a lathe to cut the needed groove. The cross hole weakens the clamp, but a small hole will probably be innocuous. A 1/16" diameter spring pin would work well in this application. If you can cut a groove, it's probably best to use an E-clip or retaining ring.

A small dog-point set screw could be used instead; Loctite it in place before it clamps the screw but so it retains it in the jaw. Another method is to drill a small cross hole in the set screw and press in a piece of nylon fishing line, causing the set screw to hold its position by friction in the hole. You'd cut a groove with a diameter of the thread's minor diameter and the dog point would sit in this groove without touching the screw. The screw turns freely, but is captured until you want to remove it.

If you make bigger clamps, you might want to machine a hex or flat on the end of the screw besides providing the cross-hole and knurling. This allows you to use a wrench or socket to tighten the clamp.

For these methods that use clips, you'll need a lathe to cut a groove in the head of the clamp screw. If you don't have a lathe, you may be able to cobble something together using your hand-held electric drill or drill press. You can file the needed groove with a file while the electrical appliance turns the threaded rod. You can file the thread in a vise with a needle file, but this will take time and skill.

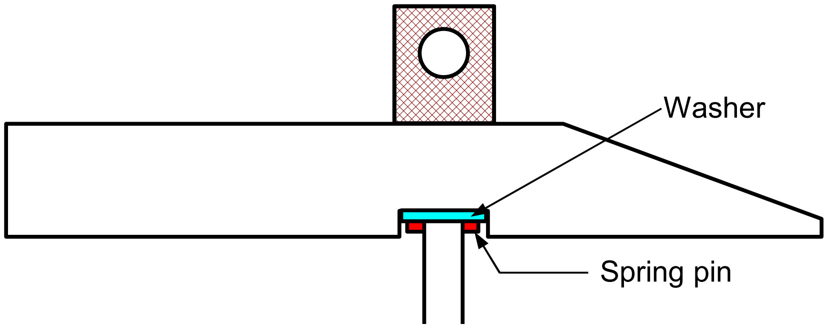
Although I've not tried it, you could try to make a primitive lathe from some 2x4s:



The gap between the 2x4's is used to clamp the tailstock and tool rest in place.

A helper could turn the crank while you file the groove or you could use a hand-held electrical drill for power. Yes, it would be slow, but it would do the job -- and probably better than most people can hand file, as the filed groove would be concentric with the rod's axis.

A method that only involves drilling a hole in the screw is putting in a small spring pin (shown in red):



If you use this method, I'd also recommend that you include a washer for the pin to rub against (rather than rubbing against the jaw's metal). This takes a deeper slot in the jaw. An advantage is that the pin takes no significant load, so it can be a small diameter. A taper pin would also work well, but they have virtually disappeared from common use because of the need for a special reamer.

A detail is that the E-clip or spring pin as shown above requires a slot or counterbore for clearance; otherwise, you can't close the clamp all the way. However, if you make some soft jaws for your clamp, they can provide the needed clearance and take away the need for the slot/counterbore.

Screws on same side

Here's a slightly different clamp design that puts the screws on the same side:

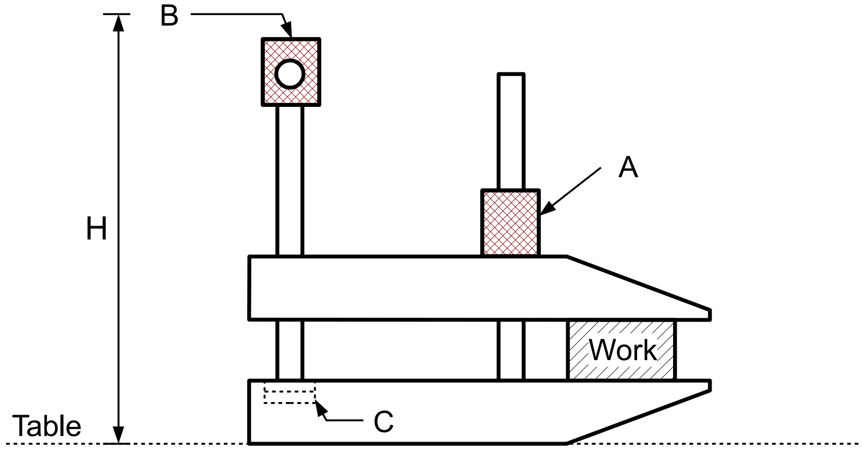
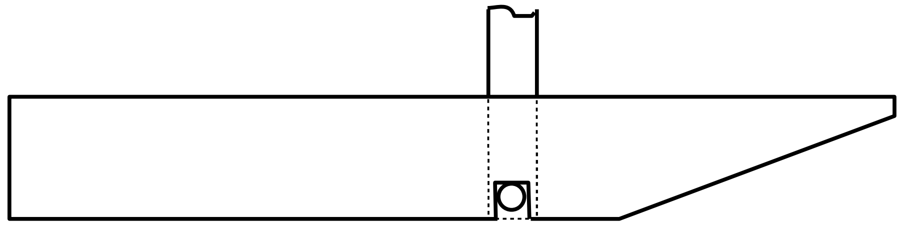


Figure 4

Since a cross hole can't be put through the nut A for a tommy bar, it might seem like a problem. However, since part A is used to adjust the clamp to size and the clamping force is provided by the other screw, this isn't a hardship. Or, use a hex nut that can be tightened with a wrench.

The advantage of this design is that you can clamp work and hold things steady on a flat surface, as hinted at in the drawing. With two of these clamps and some jaws with grooves, bar stock can be held safely in the drill press (clamp the machinist clamps to the drill press table with some C-clamps). Vee blocks are more suitable tools for this task, but these machinist clamps have other uses, making them a bit more versatile.

A modification to the bottom jaw lets you utilize different clamp screw lengths (now it's a clearance hole instead of being threaded):



A pin holds the screw against rotation but allows it to be replaced with a screw of a different length. You could also make the tapped hole for the clamp screw a standard size and then use different lengths of hex-head bolts as clamp screws. Having different pinned threaded rod and bolt lengths then allows you to minimize the height H in Figure 4, which e.g. allows a chuck to get closer to the work.

If you have a milling machine with a set of tee nuts and studs tooling for the table slots, then you already have the hardware needed to make these low-clearance machinist clamps. You might want to put a replaceable brass insert at C, as it will get chewed up by the threads on the bolts or studs. You may want to add a set of hex-head bolts that are threaded full length to be used as the clamp screws, as the longer clamping studs are not threaded full-length. Another option is to remove the clamp screw, insert a spacer or step block, and use the size-adjusting screw to do the clamping. This low-profile clamp will find use on a milling machine, as it's easy to clamp in the milling vise and e.g. tilt to cut various angles. And it lets you grab small parts that aren't as easily held in the vise.

> If you do make such a clamp that uses milling machine tooling, note that you'll want to use e.g. grade 8 hardened and tempered washers against the mild steel jaws if you want high clamping forces -- regular low carbon steel washers will deform and gall under significant clamping forces.

Another suggestion is to put a set screw or bolt at B in Figure 4 and clamp a tommy bar in place for convenient tightening. Then it can be removed when you want to lay the clamp on its side.

Here's a design from [*cstk:60*]:

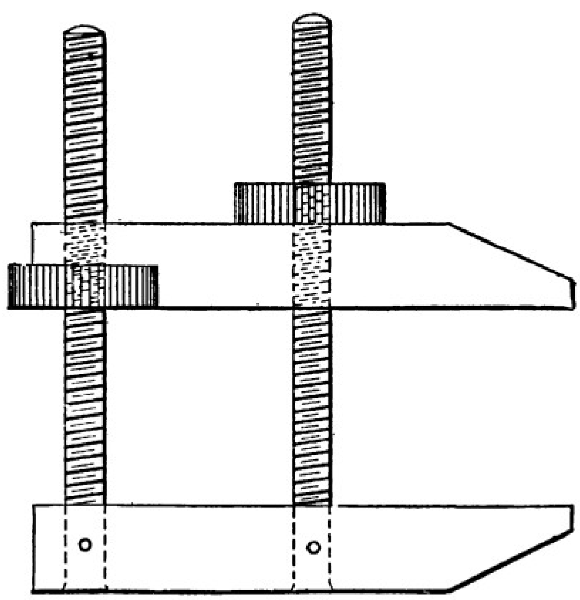
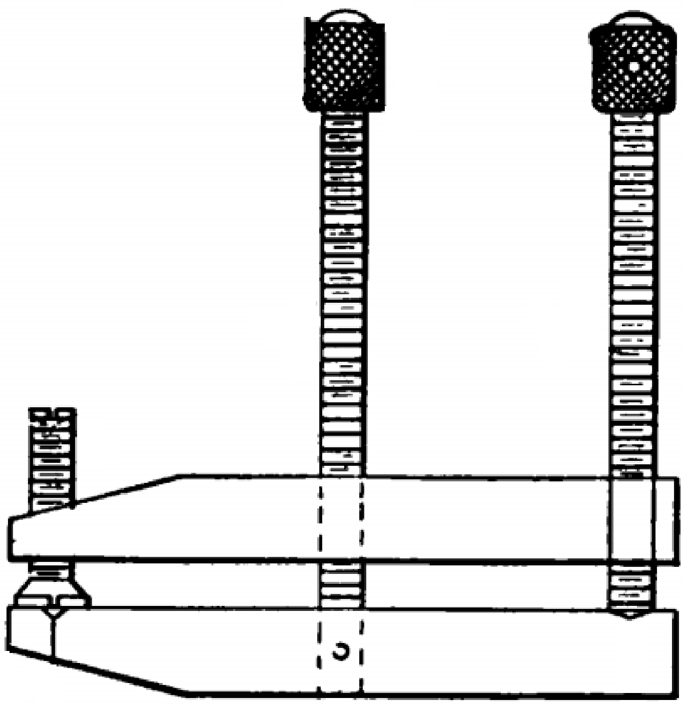
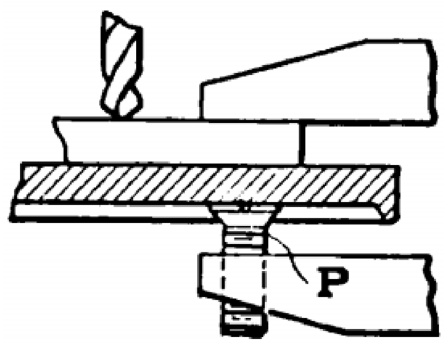


Figure 5



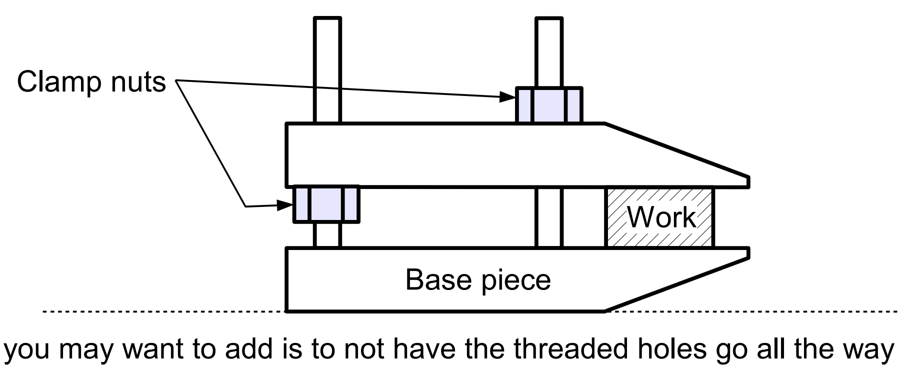
Note the small vee groove below the clamping pad. Also note the use of a flat-head screw, which can be used to clear an obstruction:



As this recessed-need is common on cast iron drill press tables, you might want to make a pair of these clamps for use on your drill press.

The authors recommended that the clamp's jaws be made from 3/4" to 1" square stock and the center-to-center distance of the screws to be 2.6 inches.

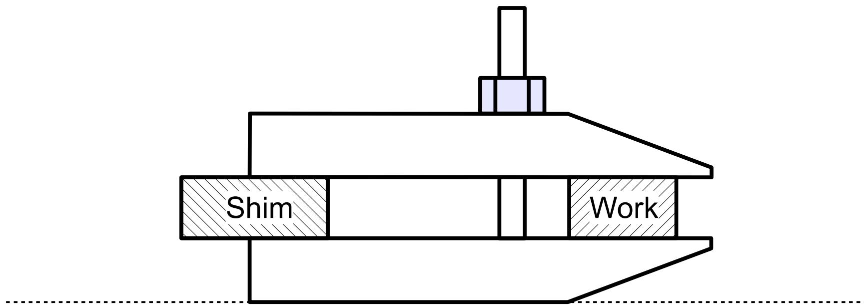
Here's a design that utilizes the clamping studs and nuts from a milling machine clamp set (it's the same as Figure 5 above, but it uses hex nuts instead of knurled/coined nuts; hex nuts let it lay flat if desired):



A design detail you may want to add is to not have the threaded holes go all the way through the base piece (e.g., the same as the typical tee nuts) so that the studs don't turn when tightening (i.e., you only need one wrench) and don't extend beyond the base, dinging up the surface the clamp is sitting on. Another approach is to thread these holes all the way through, then insert a short set screw or spring pin to block a stud from going all the way through when desired. If you use a blind hole, the stud may bottom out tightly and could require a stud remover to remove; the set screw design gets around this problem.

If you can mill some angular relief slots in the nuts, then you can have quick-adjust nuts on this clamp. I haven't done this, but I suspect such nuts would be for lighter-duty use. See the *Quick-adjust design* section for details.

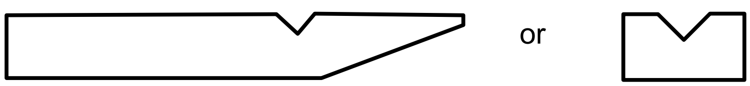
Or, leave out the clamp nut for tightening and use a shim or step block (this is basically a milling machine strap clamp):



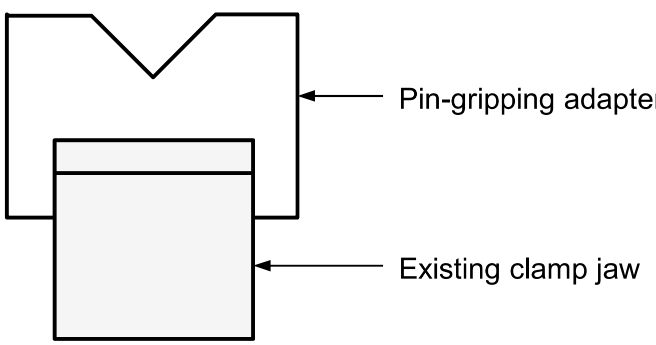
You won't be able to get the desired parallel clamping forces unless the shim is the same thickness as the work.

Jaws with grooves

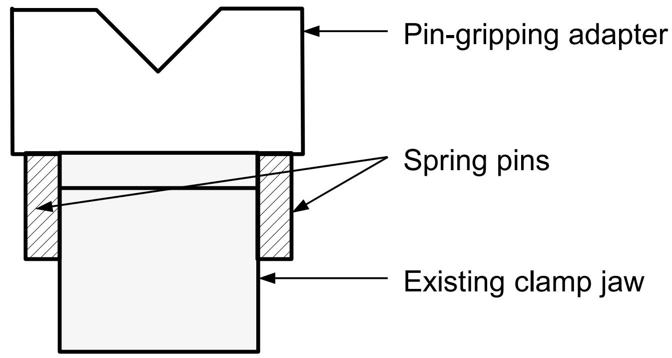
Since jaws are easy to make, here are some vee-groove modifications that can hold pins or round stock:



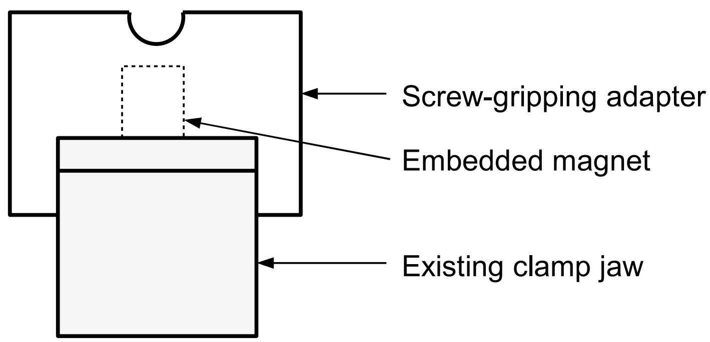
You don't have to make special jaws with grooves -- instead, you could also make an adapter that fits an existing clamp (looking end-on):



If you don't have a milling machine to cut the vee-groove, you'll have to file or chip it (few people have such skills today). Instead of using a bottom groove to mate with the clamp jaw, you could drive in some spring pins:



As grabbing little pins and screws is a common task in the shop to e.g. file on the part, you could make some dedicated circular form adapters by drilling them with a thread's clearance hole (clamp two together and drill at the interface; tap the holes for a better grip):



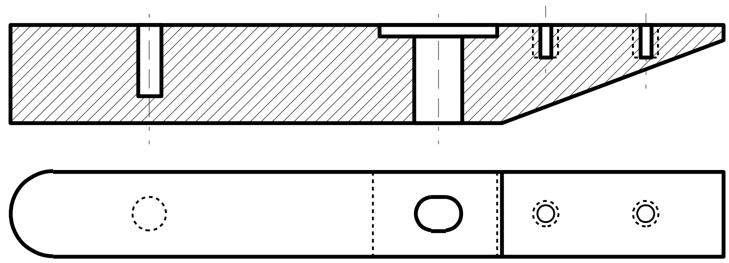
Embedding a small magnet with epoxy could help hold the gripping adapter on the clamp jaw. You could peen in a chunk of bent piano wire (see how the jaws of a tap wrench are held together) to keep the pair of adapters together (offset the wire so it doesn't hit the clamp's screw).

While the most common vee is cut with a 90° angle because this is easy to do with a milling cutter, you can also cut other angles such as 120° to e.g. hold hex stock. The easiest way to do this in a milling vise is to set the work parallel to the vise jaws, then use a 15° angle block to rotate the work off the normal to the left, cut a 90° groove, then turn the 15° angle block around and rotate the work off the normal to the right and make the second cut. Clamp a parallel clamp to the stock to make it easier to measure the tilt angle with a protractor.

Probably the easiest way to supply such vee grooves if you don't want to machine the jaws themselves is to make some soft jaws (see the next section).

Soft jaws

For holding delicate work, you may want to make some soft jaws for your clamps if they are made from steel. One way to add them would be to include two small tapped holes in the jaws:



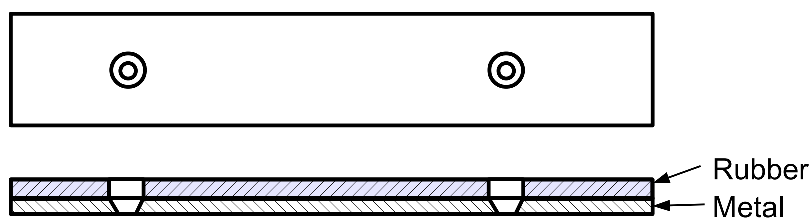
These would allow some flat-head screws to attach a strip of soft material to the jaws. Countersink the screws below the surface of the strip so they don't contact the object you're clamping. Some material ideas are:

- ♦ Copper, brass, aluminum, lead
- ♦ Nylon, Delrin, PVC, UHMW polyethylene, etc.
- ♦ Urethane plastic
- ♦ Rubber
- ♦ Masonite
- ♦ Cardboard
- ♦ Cork
- ♦ Hard felt
- ♦ Linoleum

A more temporary method is to bend some brass or copper sheet and hold it in place with some rubber bands. Of, if you want it to be semi-permanent, include some small tabs that you bend around the clamp jaw behind the adjusting screw after positioning.

You can slit a chunk of copper tubing lengthwise with a hacksaw and turn it into some useful copper sheet by hammering/bending. Since copper work-hardens, heat it a dull red color and plunge it into water to anneal it.

Here's how I made some rubber soft jaws. I glued some strips of inner tube rubber to a chunk of 1/8" aluminum sheet metal:

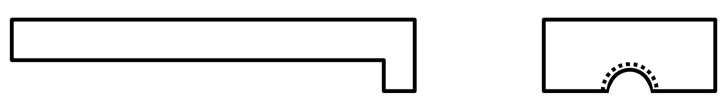


The rubber was glued with some silicone RTV sealant. I squirted two thin smears down the length of the rubber and aluminum, then spread it out to a uniform thin layer with a Popsicle stick. A chunk of flat steel bar was put over the strips, a weight was placed on that, and the assembly was allowed to dry.

Then the holes were drilled and a single-flute countersink was used to cut the embedded countersinks. Flat-head screws were used to hold the soft jaw to the clamp jaw.

Some advantages of making and using soft jaws in your machinist clamp are 1) it can simplify the fabrication, 2) increase the versatility, and 3) do away with the need for a counterbore for an E-clip. See the *Aluminum clamps* section below for more details.

You can also make soft jaws for special applications. For example, here's a jaw that could be used to tightly hold a short screw for finish operations:

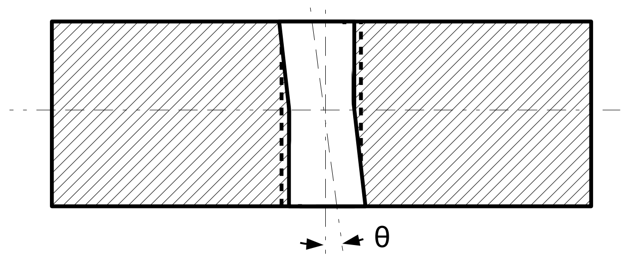


To make a pair of these, clamp two rectangular pieces together with a piece of card stock separating them. Drill and tap the end hole(s), then mill the clearance behind the holes. These jaws will tightly clamp a thread when mounted on the machinist's clamp. Instead of tapping the hole, you can just drill it at the screw's major diameter.

Some suitable angle iron could be cut to size and kept on-hand for making special soft jaws that would allow clamping around obstructions. You'd hacksaw them and file them to size as needed.

Quick-adjust design

An old method for a quick-adjust design for a thread through a tapped hole is to run an end mill through the hole at an angle:



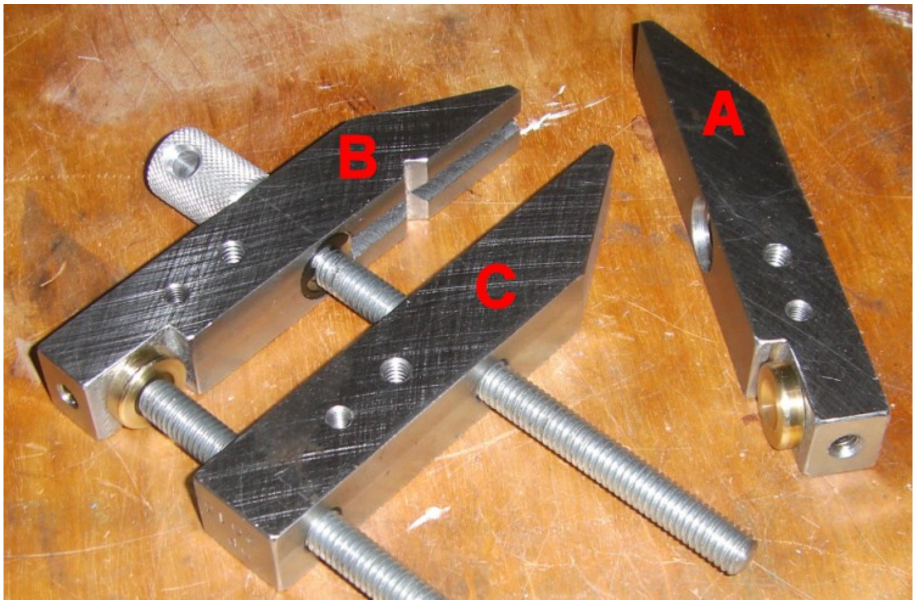
You'll need an end mill slightly larger than the major diameter of the thread (or use a boring bar in an adjustable boring head). It needs to be tilted at an angle θ to remove enough of the material to allow the threaded rod to be tipped enough in the hole to disengage the threads to allow you to slide the rod through the hole. Tilt the rod back to perpendicular to the jaw's edge to re-engage the thread.

I've done a quick experiment with a 3/8-16 UNC thread and a tilt angle of $\theta = 10°$, using a 3/8 inch diameter end-cutting end mill to drill the hole in some 1 inch thick material. It worked well, although I would prefer thicker material to have more threads remaining. Ideally, you'd use an end mill about 0.02 inches larger in diameter than the thread's major diameter (or using a boring tool). Otherwise, you'll find there's a slight bit of interference, causing the male thread to need to be pressed to "pop" into position. This could probably be removed by removing the tilt and doing a little judicious milling with the end mill.

Carr-Lane sells some knurled quick-adjust nuts that utilize this construction (for example, part number CL-4-QKK for a 3/8-16 thread). The angle of tilt is $\theta = 12°$ and the end mill used is 1/32 of an inch larger than the thread's major diameter. The length of the nut is about twice the major diameter of the thread. For making a few of these, it would be handy to use a boring head on a mill rather than acquiring a special-size end mill.

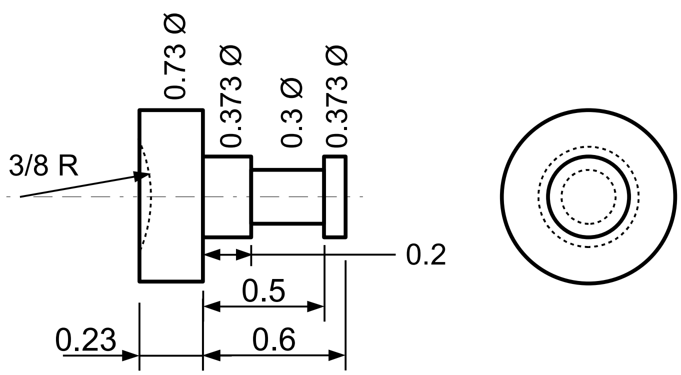
Convertible design

I had three pieces of 3/4 inch Blanchard-ground steel plate that were 0.9 by 5 inches long. I decided to turn these into three parallel clamp jaws and used the screws-on-one-side design. I also get conventional machinist clamp behavior by making some screws with knurled handles and providing a clamping pad in jaws A and B with the through holes (jaw C has two through holes with 3/8-16 UNC threads):

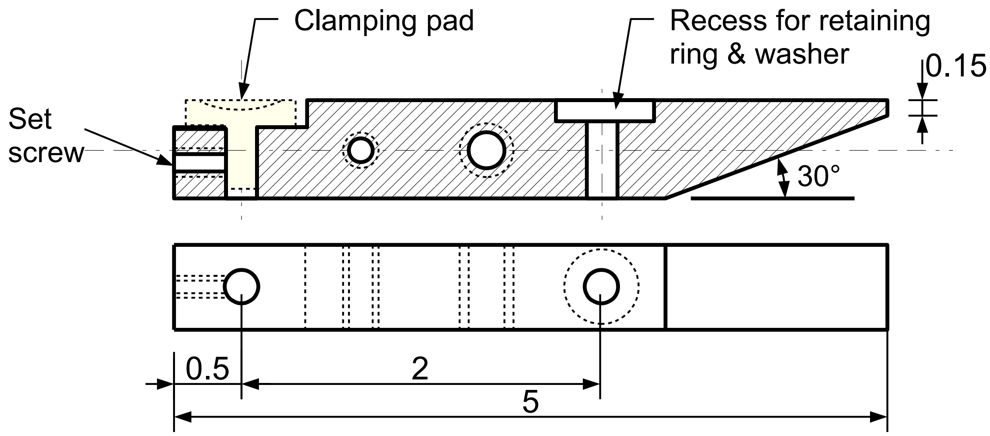


Jaw A has two 3/8 diameter holes in it, as does jaw B (both were widened longitudinally with a milling cutter to allow the jaws to tilt). Jaw B also has two grooves in it for clamping round work. When used in the screws-on-one-side configuration, some set screws are put into the bottom of jaw C so that the clamp screws don't go all the way through. On jaw B, you can see the clamping pad to the left and the brass washer and retaining ring used to hold the size-adjusting screw in place. A 1/4-20 set screw holds the clamping pads in position.

The two clamping pads were made from some scrap brass bar stock:



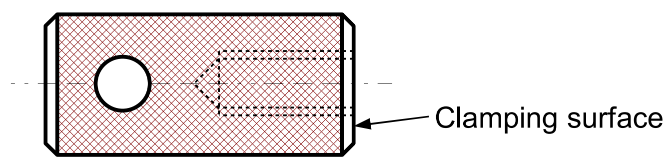
The 3/8 radius dimple was cut with a 3/4 inch diameter ball end mill. The depth is not critical; I made it about 0.1 inch. A matching radius was filed on the end of the threaded rods to accommodate the ±5° tilts the jaws are capable of. The clamping pad is held in place by a 1/4-20 set screw in the jaw's end:



The two holes through the side were tapped 10-32 and 1/4-20 for various tooling needs. For example, these holes allow me to attach a post holding a test indicator; then the clamp can be attached to a machine tool for indicating something. The set screw in the end for holding the clamping pad was 1/4-20.

The recess for the retaining ring and washer was bored to 0.68 inches in diameter. The hole for the size-adjusting screw was widened by 0.05" on either side of the nominal center by a 3/8" end mill and a pocket was milled to allow the jaws to tilt about 6° off parallel either way.

A knurled handle was turned from some 3/4" aluminum bar stock to an OD of 0.71 inches (this is a diameter that gives an integral number of knurls and also provides a bit of clearance so the 3/4" thick jaws will lay flat on a table):



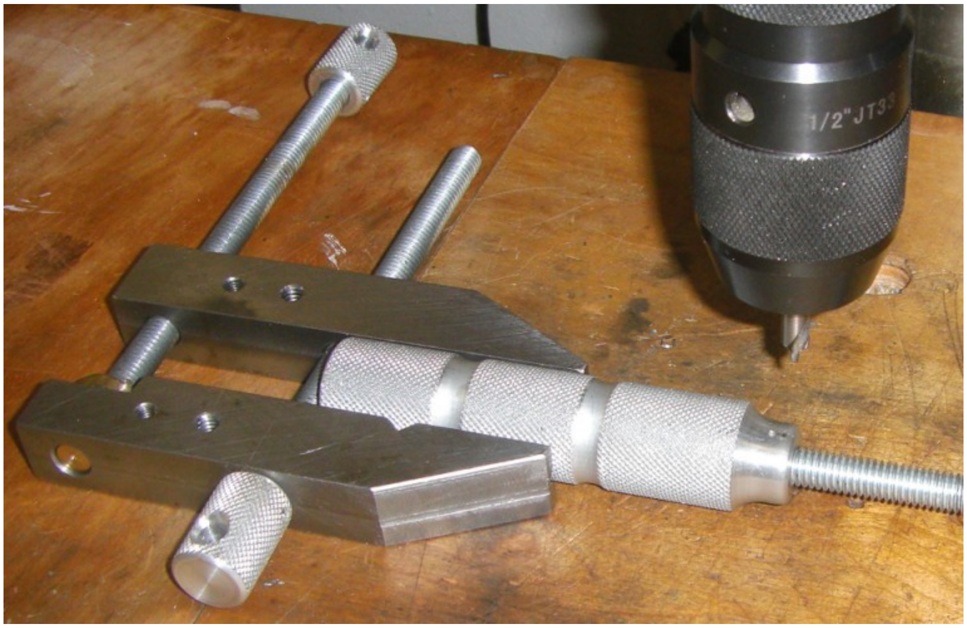
These knurled handles were held on by a 1/8 inch diameter spring pin that was 1/2 inch long. If I had to do things over again, I'd have made the left-hand side longer and tapped it for a 3/8 inch set screw. This would provide a storage location for the set screws used in the bottom of jaw C as well as let you clamp a tommy bar in the knurled handle when desired.

The spare jaw can be used as a strap clamp in the mill. The edge hole sits on a nut/washer held by a stud and tee nut and allows continuous adjustment, unlike a step block.

For significant non-parallel clamping, you'd want to use e.g. a spherical washer set under the size adjusting screw's knurled portion. You can find such things from tooling supply places like Carr-Lane.

The threaded rod used for the screws came from two scrap pieces I happened to have; I used them unchanged. They are a bit long; this clamp opens up to over 4 inches when needed.

Here's a picture of the clamp being used to hold a 1 inch handle being drilled for a spring pin to hold the threaded rod in place:



One of the advantages of this clamp with the longitudinal vee groove is it lets me hold smaller diameter round stock for drilling and there's no vee block clamp to get in the way.

Here's the clamp holding a scriber, having just made a scribe mark on an aluminum workpiece held in a vee block (thus, acting like a surface gauge):

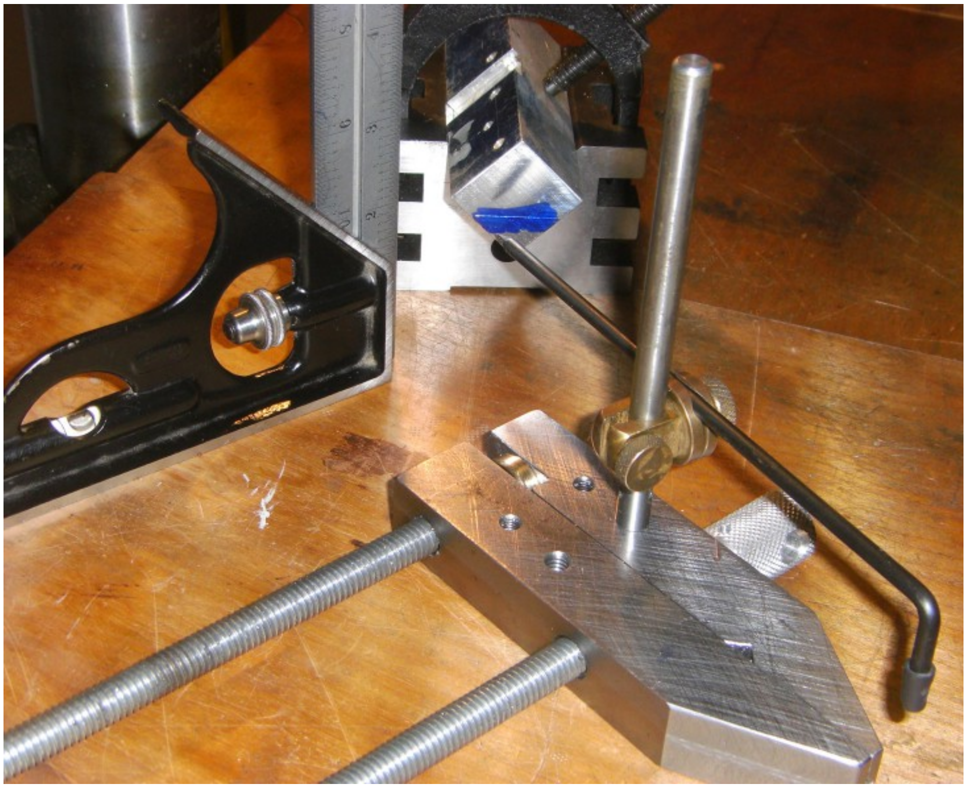


Figure 6

Comments:

After a few years of use, I've found that I use this clamp a lot, more than I thought I would. It has replaced my drill press vises for many small clamping jobs and the longitudinal vee grooves are quite useful for holding round stock. I don't really care for the brass clamp pad and would have preferred to have a hole with a simple recessed pin in it to clamp against (I recently bored it out to a bit over 5/16" diameter and turned a mating diameter on the threaded rod). The main reason is that the recessed hole helps constrain the clamping screw when you're adjusting the clamp to size.

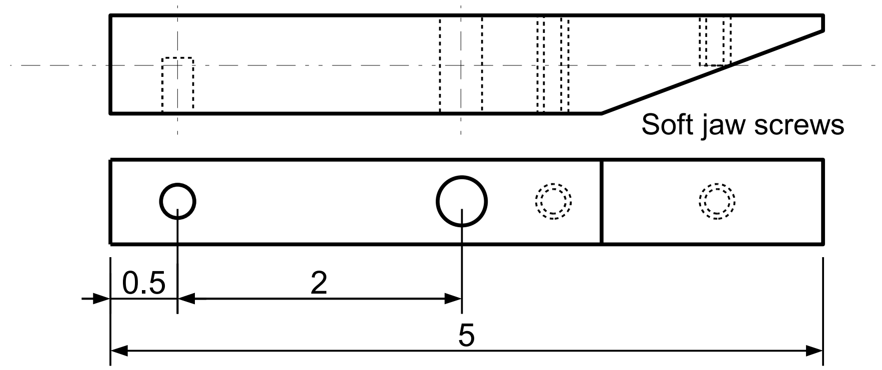
Though it is a convertible design allowing the use of the clamping screws on one side, I haven't needed this feature yet.

One of the key uses of this clamp is to hold material for filing and similar work. I naturally hold this clamp in my bench vise, which allows flexible positioning. One feature that you may want to consider when making such a clamp is to make the distance between the threaded rods larger than the width of the saddle in your vise jaw. This will allow you to position the clamp with the threaded portions either up or down. I didn't think of this when I laid out the clamp dimensions, but I got lucky and my clamp's screws just barely clear the saddle on my vise.

Aluminum clamps

After making the convertible clamp described above, I found it so useful in the shop that I made two more from some scrap 3/4" thick aluminum plate I had on hand (such plate is handy because it can be rough cut to shape with a wood-cutting bandsaw).

The design of these was about as simple as could be made (this is the clamp jaw with the clearance hole):

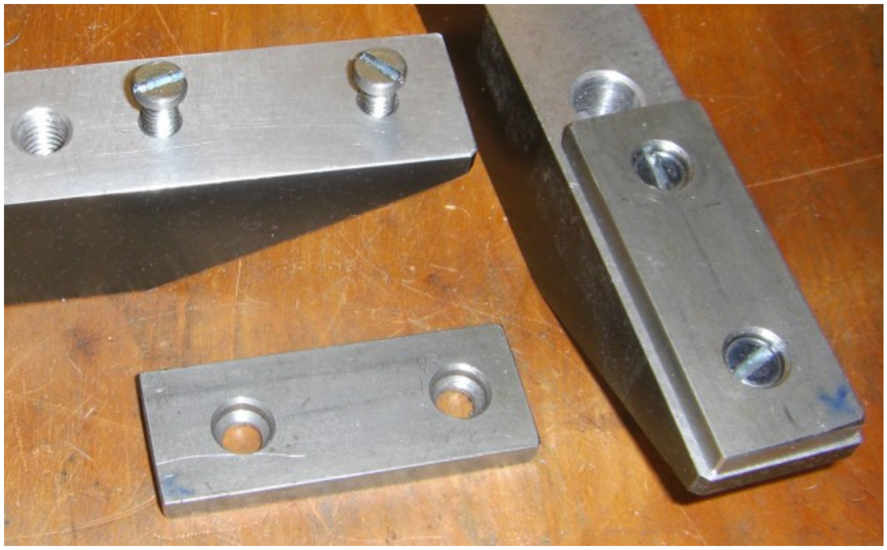


Here's a picture of one of the clamps (the jaws are 3/4 x 0.9 x 5 inches):

The knurled handles are turned to 0.71" diameter before knurling and the clamp screw's handle has a 0.27 inch diameter hole for a tommy bar. The handles are held onto the 3/8-16 threaded rod with 1/8" diameter spring pins. The threaded portions are 5 inches long, allowing the clamp to clamp something a bit over 3.5 inches thick.

I recommend making this size of clamp from aluminum for general shop use because you'll appreciate the reduction in weight over steel jaws. I use the steel clamp I made above almost exclusively on the drill press and milling machine for holding work; I appreciate the extra mass of the steel to help avoid a drill causing the held work to rotate. However, the aluminum clamp sees more general-purpose use in the shop.

These aluminum clamps are especially flexible work-holding devices if you make them with auxiliary jaws. Here's a follow-on clamp I made from some scrap 1-1/8 inch thick anodized aluminum plate I had:

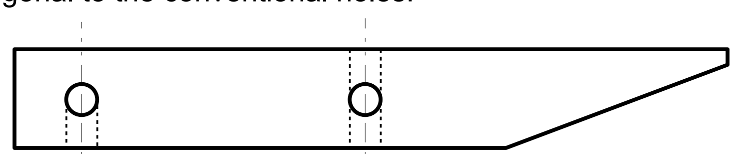


The jaws are held in place by flat head 1/4-20 screws. I turned the head's OD of the screw down to 0.37 inches in diameter to allow them to fit in a counterbored hole made by a 3/8" diameter single flute counterbore. You'll want to slow the drill press down to its slowest speed and use oil when using the counterbore. These steel jaws are made from 1/4x1 inch steel flat stock. I just cut the stock off with a hacksaw and filed it reasonably flat; no precision construction is needed. The holes were laid out with a rule and hermaphrodite calipers.

A better design for holding the jaws is probably to use some socket head cap screws from the back side. They only need to be small screws. However, unless you put in a deep counterbore in the longer hole, the screws need to be different lengths.

Orthogonal holes

A design change (I haven't tried this) to the conventional machinist's clamp is to include threaded holes that are orthogonal to the conventional holes:

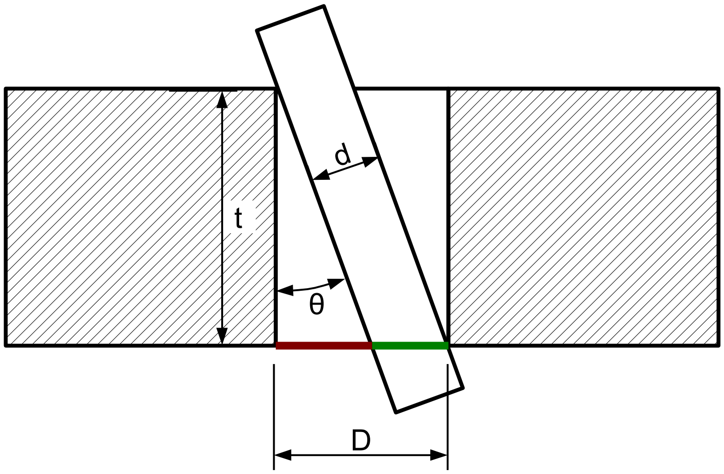


This allows you to change the clamp's configuration; for example, the tapered jaws result in a low-profile clamp that may prove useful in some situations. To accommodate these orthogonal holes, you'll want to ensure there's enough remaining jaw material to not significantly weaken the jaw. The E-clip or retaining ring might not let the jaws close fully, however, unless you counterbore them.

Hole clearances & tilt angle

How much can a threaded rod tilt in a drilled hole? This determines how much a machinist clamp's jaws can tilt to clamp non-parallel surfaces.

Suppose we have a hole diameter D with a rod of diameter d through a plate of thickness t. This allows for tilt angles as follows:



We have (the term's colors match the colored segments in the drawing)

$$D = t\ \tan\theta + \frac{d}{\cos\theta} \tag{1}$$

If you're designing a clamp, insert the outside diameter *d* of the threads, the thickness of the jaws *t*, and the desired tilt angle θ and you can calculate what hole diameter *D* to drill.

> ***Example:*** to get a 10° angle of tilt for a 3/8 diameter threaded rod in material 0.9 inches thick, the drilled hole diameter needs to be
>
> $$D = 0.9\ \tan 10° + \frac{0.375}{\cos 10°} = 0.54$$

Should you wish to solve for θ, assume the threaded rods' diameter *d* will be fairly close to *D*, meaning θ will be small. This lets us approximately solve for θ in equation (1) because the cosine will be nearly 1:

$$\theta \approx \tan^{-1}\frac{D-d}{t} \tag{2}$$

This should get you θ to within about 5% for angles up to 10° of tilt.

Equation (1) can be rewritten as

$$\frac{D}{t}\cos\theta - \sin\theta = \frac{d}{t}$$

which is an implicit equation for θ. This equation can be iterated to get θ to the desired precision.

> ***Example:*** Using some 0.9 inch thick material, I made some jaws with 3/8 inch threaded rod. How much angle of tilt can I get if I drill a 1/2 inch diameter clearance hole? From the previous example, we know θ will be less than 10°.
>
> We have $D/t = (1/2)/0.9 = 0.5556$ and $d/t = (3/8)/0.9 = 0.4167$. Thus, we need to solve
>
> $$0.5556\cos\theta - \sin\theta = 0.4167$$
>
> The above approximation (2) gives 7.9°. Plugging 7.9° into the left-hand side of this equation gives 0.4129. As the result is a bit low, we must reduce our estimate for θ; 7.8° gives 0.4147 and 7.7° gives 0.4166. This is close enough for our needs.

Note the jaws will tilt by angles of $\pm\theta$. From the clamps I've made and used, I'd suggest you'd want θ to be perhaps 5° and no more than about 10°. Larger tilt angles will give you clamping problems (plain steel washers and nuts will gall) unless you machine spherical ends and depressions or make or buy a set of spherical tooling washers (e.g., Carr-Lane sells hardened spherical washer sets).

If you want to clamp non-parallel work surfaces, you may not be able to clamp to a surface if θ is too large. We can estimate this angle as follows. Self-holding tapers work when the tangent of the taper angle with respect to the centerline is less than the coefficient of friction between the materials. Assuming steel on steel with no lubrication, *Machinery's Handbook* gives the coefficient of static friction as 0.8 for dry and 0.16 for lubricated. Let's use the value of 0.5, as typical shop work won't necessarily be clean and we're just looking for an estimate. Since

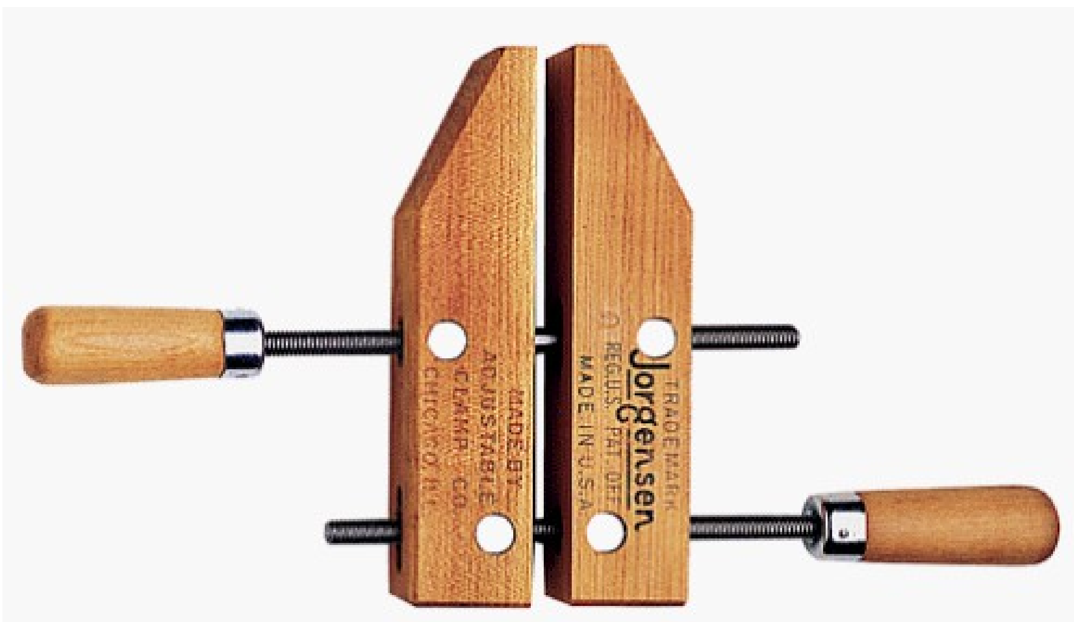
$$0.5 \tan^{-1}(0.5) = 13\,°$$

I'd guess that 10° is probably around a practical limit.

However, other jaws (e.g., rubber or urethane) might make this slippage angle substantially larger. If you make such a clamp, you'll need a spherical washer set and you'll want to mill a slot for the size adjustment screw to pivot in. You also may want the clamping screw to have a spherical surface and seat on a spherical surface (see what I did in the *Convertible design* section).

Woodworking clamp

A 6-inch Jorgensen woodworking clamp will cost you $20-$25 each:



You can make a clamp like this from wood, but which uses the machinist's clamp design rather than the commercial design (which requires a left hand tap and die). You'd buy some threaded rod, bar stock, copper tubing caps, and some brass welding rod. Cut off the bar stock to a bit less than the thickness of the wood and drill and tap a cross hole in it. Turn, file, or whittle the handles so that the copper cap fits snugly as a ferrule and then drill a hole for the threaded rod. Insert the threaded rod and drill a cross hole, then peen in a chunk of the brass welding rod to hold things together (10 or 12 AWG copper wire works well for pinning too).

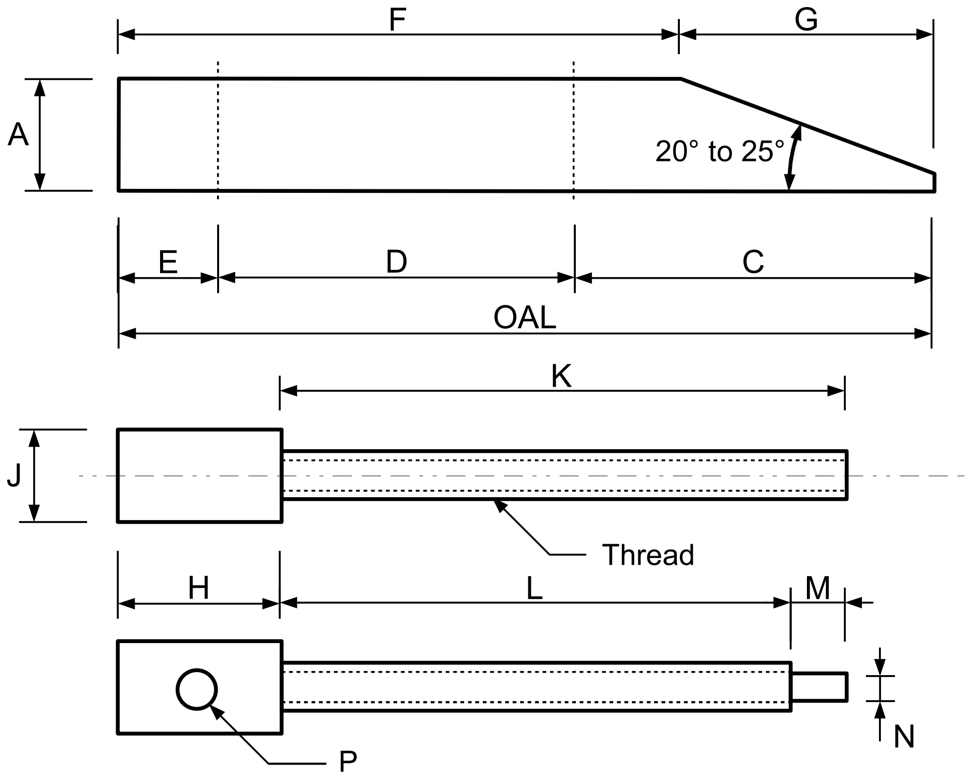
If you have a lathe or can hack one with your drill press, you can file a small groove for an E-clip and then have a bit more convenience.

You might want to make 5 or 10 clamps in one run, as it wouldn't be that much more work than making one. There are commercial outfits that make the hardware (you supply the wood).

If you do have a left-hand tap and die, you can make an exact copy of the Jorgensen clamp if you wish. Note the handle is pinned on after the clamp is assembled.

Range of sizes

Guy Lautard in *The Machinist's Bedside Reader* [tmbr] gives a table on page 151 describing a set of clamps that provide various sizes:



The dimensions are given in inches; I've rounded Lautard's fractions to the nearest 0.01 inch.

	OAL = overall length					
Dim	**1.6**	**2.1**	**2.6**	**3.1**	**4**	**5**
A	.31	.38	.44	.50	.62	.75
C	.69	.94	1.19	1.38	1.94	2.25
D	.69	.94	1.19	1.50	1.75	2.25
E	.25	.25	.25	.25	.31	.50
F	1.12	1.44	1.75	2.19	2.75	3.25
G	.50	.69	.88	.94	1.25	1.75
H	.38	.50	.50	.62	.75	1.00
J	.25	.31	.38	.44	.56	.62
K	1.62	2.25	2.75	3.50	4.00	5.00
L	1.31	1.88	2.25	3.00	3.50	4.50
M	.19	.25	.25	.25	.31	.38
N	.10	.13	.16	.18	.24	.33
P	.09	.12	.12	.16	.19	.25
Thread	8-32	10-32	1/4-28	1/4-28	5/16-24	7/16-20

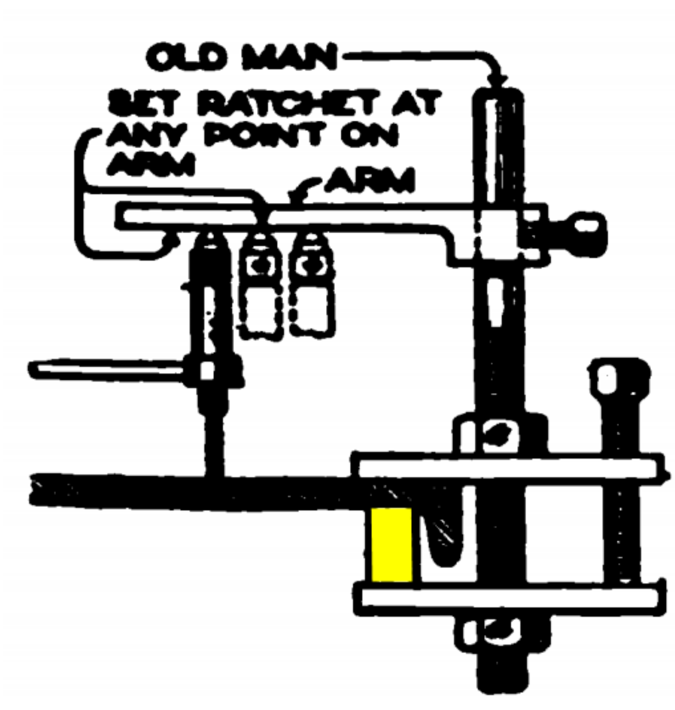
Here's the same data converted to the nearest 0.1 mm with a metric thread close to the given thread:

	OAL = overall length, mm					
Dim	**40**	**53**	**66**	**79**	**102**	**127**
A	7.9	9.7	11.2	12.7	15.7	19.1
C	17.5	23.8	30.2	35.1	49.2	57.2
D	17.5	23.8	30.2	38.1	44.5	57.2
E	6.4	6.4	6.4	6.4	7.9	12.7
F	28.4	36.6	44.5	55.6	69.9	82.6
G	12.7	17.5	22.4	23.8	31.8	44.5
H	9.7	12.7	12.7	15.7	19.1	25.4
J	6.4	7.9	9.7	11.2	14.3	15.7
K	41.1	57.2	69.9	88.9	101.6	127.0
L	33.3	47.8	57.2	76.2	88.9	114.3
M	4.8	6.4	6.4	6.4	7.9	9.7
N	2.5	3.3	4.1	4.4	6.1	8.4
P	2.4	3.0	3.0	4.0	4.8	6.4
Thread	M4-0.7	M4.5-0.75	M7-1	M7-1	M8-1.25	M12-1.75

The metric equivalents were chosen to be the metric coarse threads.

Combined with old man

Here's an interesting design based on the parallel clamp that uses an old man and a ratchet drill for drilling holes:



This is from the 1921 Popular Mechanics Shop Notes, page 3449. If you're unfamiliar with an old man and ratchet drills, they were extensively used in the 1800's and early-to-mid 1900's for manually drilling holes. The ratchet drill had a ratchet handle and the upper portion was a cylinder on a thread that would be turned while drilling, providing lots of drilling force[2]. They're slow, but they can drill holes where electricity is lacking and where there's not much clearance. Note it's not difficult to make a ratchet drill if you have a lathe and a ratcheting pipe threader of the Ridgid design; you just turn up a suitable chunk of steel to hold the drill in one of the pipe dies, pin in a chunk of threaded rod for the feed, then thread and knurl a piece of bar stock to fit on this rod.

2 Look up "Cole drill" on the web for an evolved (but overpriced) design.

Note the standoff (in yellow) used to get around the lip on the work.

A common size range for the bar used for the old man was 1 inch to 1.25 inch diameter (the old man I have uses a 1-1/8" diameter shaft).

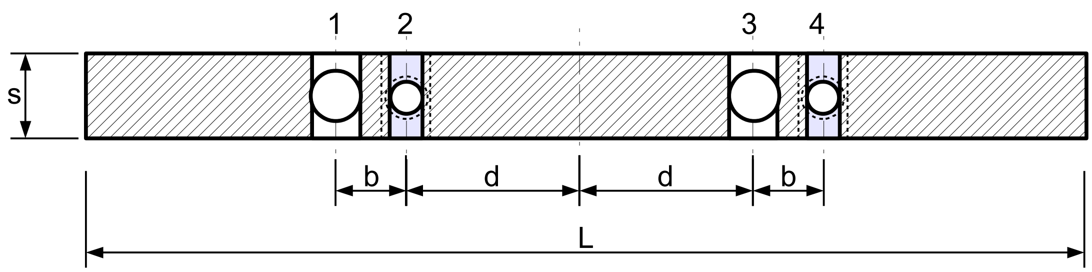
Drill press clamp

Because I have found that these 5 inch parallel clamps are quite useful around the drill press, I decided to design a similar clamp for drill press use. The key feature needed for such a clamp to be useful is to be quickly adjustable. Since I have a modern cordless impact driver, this is the tool I would use for this quick adjustment, as it keeps the design of the clamp simple.

I haven't made this clamp yet, so I don't know if it works well. My design goal is to find some 1.5 inch square stock and make all of the faces of the bar usable as clamping surfaces. They will be able to accommodate soft jaws and orthogonal holes will allow a variety of clamping surfaces to be used together.

These could be used with a 3/8 UNC thread, which allows the clamping accessories of the milling machine to be use, extending flexibility. But a better choice for heavier clamping might be a 1/2 UNC thread, as this lets me use 3/4" sockets/wrenches. A 3/4" clearance hole allows about 10° of tilt.

Here's the basic design (the blue holes are tapped and the material's cross section is a square of size *s*):



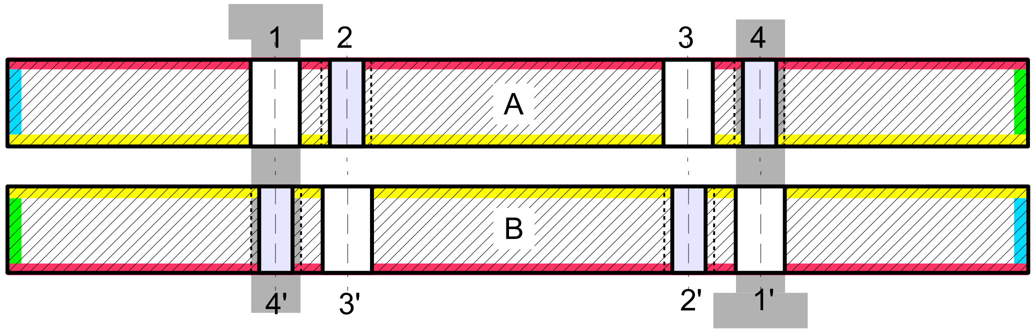
Note that the clearance and tapped holes exist in two orthogonal directions, which allows the bars to be used as clamps that utilize any of the sides.

The maximum usable bolt hex head size is given by $\sqrt{3}\,s/2 = 0.866\,s$ where s is the size of the square material:

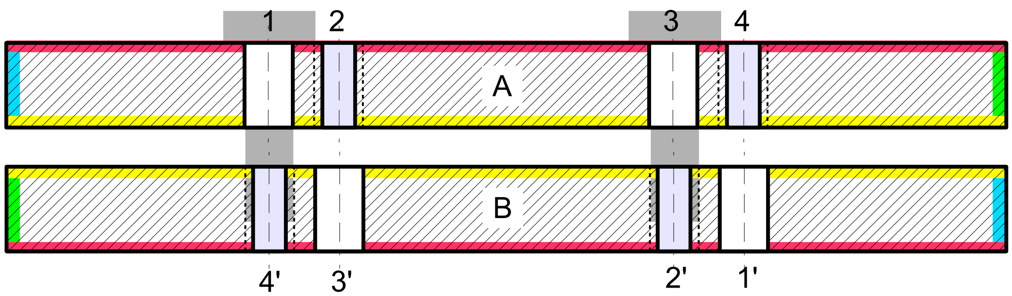
s	**Max hex**
0.75	0.65
1	0.87
1.25	1.08
1.5	1.30
1.75	1.52
2	1.73

Here are some ways the clamp could be used. The parts A and B are identical; the sides are colored to show how they are oriented.

Clamp screws on opposite sides: (like conventional toolmaker's clamp)



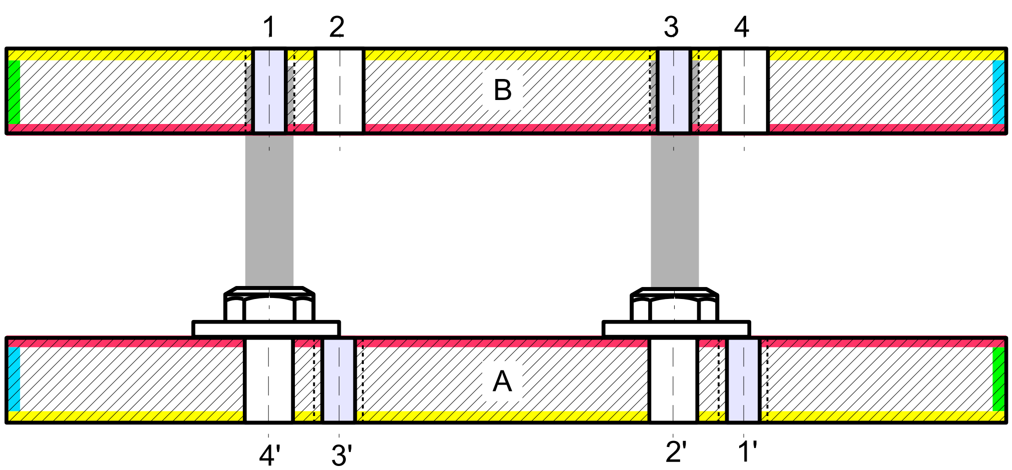
Clamp screws on the same side:



This lets you e.g. use the bars in a vertical plane and stand the clamp on the drill press table on the bottom red surface.

Note the non-tapped clearance holes allow the bars to move along the longitudinal axis, meaning the ends may not line up. With careful machining and a washer with an indexing lip on it, the ends could be made to line up accurately if desired.

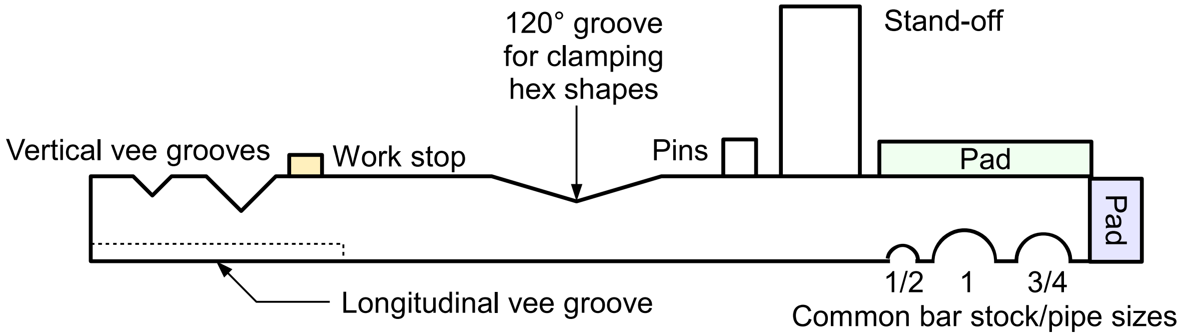
Spreader: The clamp can act as a spreader when used with some nuts, washers, and threaded rod:



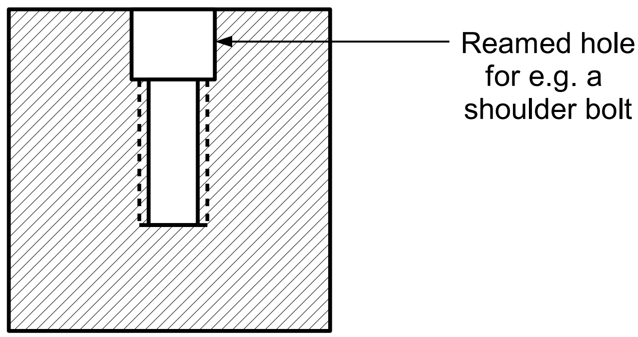
The spreader idea could be used with a clamping bolt as above to make a clamp that acts like a machinist's clamp. A retaining ring could be used on the clamping bolt if desired. This would give quite a bit of flexibility.

Because of the desire to have high clamping forces, class 8 washers and nuts should be used.

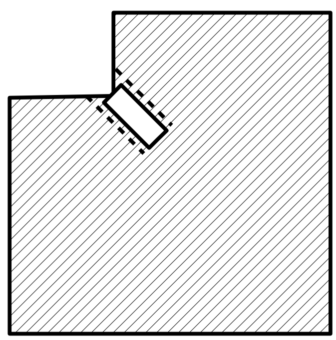
Jaw ideas: Many convenient features can be put on the bars to allow for specialized clamping tasks:



Various threaded holes can be included on the bar. These threaded holes can have the following construction to allow repeatable location of pins by a reamed hole:

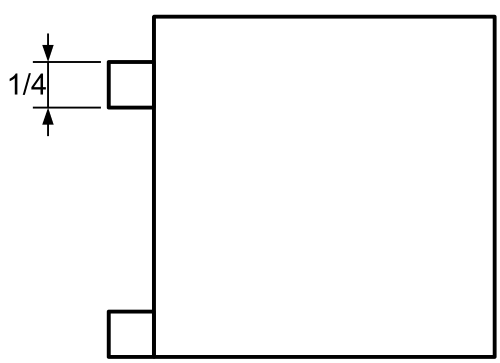


One side of the bars could have a recess cut in them to allow easy indexing of thin pieces:



This recess could be made larger and allow pieces of angle-shaped material to be screwed in, giving you custom groove depths as needed. This could be done using the indicated tapped holes and flat-head screws.

Another nice feature would be shelves that could be pinned and screwed to the sides. These would be in steps of 1/4" above the table surface, allowing for convenient clamping of drill press work and allowing you to support wide workpieces with standard-thickness parallels.



Two ends could have reamed 3/4" holes to allow for the construction of special tooling. Side set screws would hold the tooling in place against rotation. Of course, these holes could be hex or square too (I'd probably pick 3/4" square holes that would take standard key stock). An example of use would be to make a custom-sized spanner wrench. A round hole with a set screw that clamped in a relieved groove would be easy to adjust to an exact size and could have replaceable tips, allowing you to adapt to nearly anything. Use a tommy bar through the big holes for leverage.

The screws must be quickly adjustable. This can be accomplished in a few ways:

- ♦ Quick-adjust threads: use a tilted end mill to remove material to allow the thread to be tilted.
- ♦ Drill/impact driver: spin things with an electrical tool.
- ♦ Mechanism: have some embedded mechanism that operates like half nuts.

Though I would like something like embedded half nuts, it's hard to argue with the utility and ease of construction if an impact driver or drill is used.

Instead of using hex head bolts, it would be straightforward to use chunks of threaded rod with regular hex nuts and lock nuts. You'd use an impact driver with a deep socket and wrench to adjust. This would cut down on pieces of hardware, as you wouldn't need to stock a bunch of bolts.

A square or hex hole could be put in the end of each threaded rod to allow the use of a driver or ratchet for turning.

A very deep socket for turning a nut could be made by cutting a standard socket and welding a piece of tubing into the middle.

Another idea is to put 3/8 holes through the pieces to allow them to be used on the milling machine as a vise. You'd bolt some dowels to locate the device in the table slots like that used on the vise. This could be a versatile vise for general milling tasks. The width of the slots at the top are 0.57".

Precision locate reamed holes in the sides so that dowel pins can be inserted and used to ensure that the clamp's surfaces are parallel when desired (or see how much they're out).

Uses

Like woodworker clamps, one of the advantages of the machinist's clamp design is that slightly non-parallel surfaces can be clamped (as long as there's jaw clearance for the clamping screw hole). With a reasonably fine thread, they will also apply a lot of clamping force.

These are parallel clamps, meaning that they are most effective when the jaws' surfaces are parallel to the surfaces of the object(s) being clamped. If the jaws are not quite parallel to the surfaces being clamped, the contact changes from a plane to a line and the clamping becomes significantly less effective and allows the clamp to swing more easily. **Often, beginners don't get the clamping action correct and label the clamps as no good -- when, in fact, they're just not using the clamps correctly**.

Here's how to adjust the jaws for parallelism to the work. Adjust the size-adjusting screw so that the clamp's jaws are parallel to the surfaces to be clamped. Snug it down, then snug the tightening screw. If there's no side-to-side swinging when you push sideways on the clamp, you have it adjusted properly. Otherwise loosen the tightening screw, make a fine adjustment of the size-adjusting screw, and try again. Where the clamp pivots when swinging tells you in which direction the adjustment needs to be made. If it pivots at the tip of the jaws, the jaws are too far apart. If it pivots near the adjustment screw, the jaws are not far enough apart. When the jaws are parallel to the work and the tightening clamp is tightened with a tommy bar, you shouldn't be able to move the clamp when you push on it sideways -- it should be tighter than Dick's hatband[3].

I want to reiterate: if you get these clamps adjusted properly, they will clamp something tightly. But a small misalignment will cause a significantly poorer clamping action and is the reason many users think these clamps don't clamp very well. Spend the time to figure out how to get the proper

3 A lovely old phrase that has been traced in print back to the late 1700's.

clamping action and you will find you start using these clamps a lot more. As you use them more, you'll find you adjust both screws simultaneously, "feeling" for the correct clamping position. It's a bit hard to explain, but you make a dual adjustment, then assess how easy it is to push the clamp to one side. If you can push it, then it's not clamped properly. When you get it just right, then use a tommy bar to tighten the tightening screw, you shouldn't be able to push the clamp sideways, even on a smaller clamp. When I tighten my Starrett 161-B clamp on a chunk of metal, then tighten it with a 2 inch long rod, I am unable to push the clamp sideways -- I have to use a dead-blow hammer to get it to move. It's surprisingly tight.

You can open a conventional machinist's clamp (Figure 3) quickly by holding one screw and rapidly rotating the other screw about the first screw's axis (but this can't easily be done with the alternative design with the screws on the same side). To use the same method to close the clamp, turn the screws in the opposite direction. This is similar to opening and closing C-clamps quickly: grab the screw in your hand and cause the frame to rotate rapidly around the screw by shaking at the right rate.

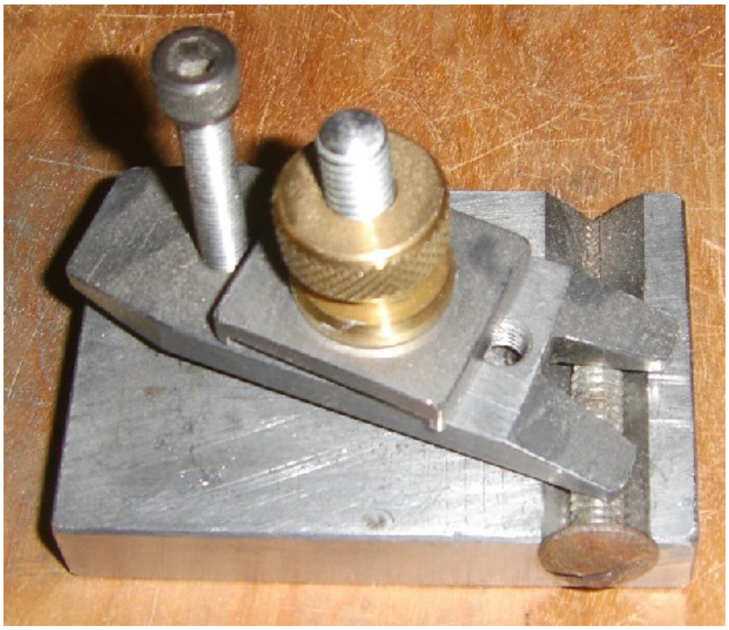
Other miscellaneous uses/thoughts:

- These clamps make a handy drill press vise for drilling a number of small parts that are all the same size.
- Hold parts for soldering, brazing, or welding.
- Grabbing a small part securely for filing or drilling; then clamp the machinist clamp in a bench vise (use soft jaws to avoid dinging up a machinist clamp that isn't hardened).
- A quickly-set-up stop for a repetitive cut when using a fence, milling vise, etc.
- Grab something unstable to allow it to stand on a thin edge. For example, the blade from a combination square can be held on a table with the thin edge touching the table top.
- A dial indicator can be clamped to a machine in odd places, especially when a magnetic holder can't be used. If you have the means of mounting your dial indicator to a rod, you can tap a hole in the clamp's jaw to accept this rod. See Figure 6 above.
- Clamp a stack of feeler gauges together to make them act as a single unit.
- Crushing soft metals (e.g., solder or lead). For example, my Starrett 161B clamp crushed a 1/16" diameter piece of solder quickly to half its thickness. This method can be used to make some custom shims, as long as the force clamping the two pieces together isn't enough to crush the shim more.
- If you provide a small protrusion in your toolbox, these clamps can grab it and be stored safely and securely out of the way -- they'll stay put until you want them. I clamp my machinist's clamps to the open lid of my machinist's chest.
- Small sizes of these clamps are often made using socket head cap screws -- this makes for fast construction.
- Don't feel you're constrained to making clamps from steel -- rectangular aluminum bar stock is easy to fabricate. However, the elastic modulus is about 3 times lower than steel, so they'll bend more easily -- and they'll support smaller stresses than steel. Thus, consider aluminum clamps as appropriate for more light-duty clamping tasks.
- I have some small plastic vials that need to be filled with a liquid I definitely don't want to spill (it's expensive and makes a mess). A machinist's clamp can be snugged up on the base of the vial and helps the vial sit on a counter without getting knocked over.
- When gluing up a woodworking project, there are never enough clamps. If the machinist's clamp will fit, then it could be a good choice.
- If you need heavy clamping forces, use some 1 to 1.5 inch square steel bar stock to make some machinists clamps and some fine thread screws with hex heads on the screws.

For some more ideas about using clamps, see Harold Hall's pages at http://www.homews.co.uk/page262.html. He has some good information about the safe use of clamps, some of which I've repeated here.

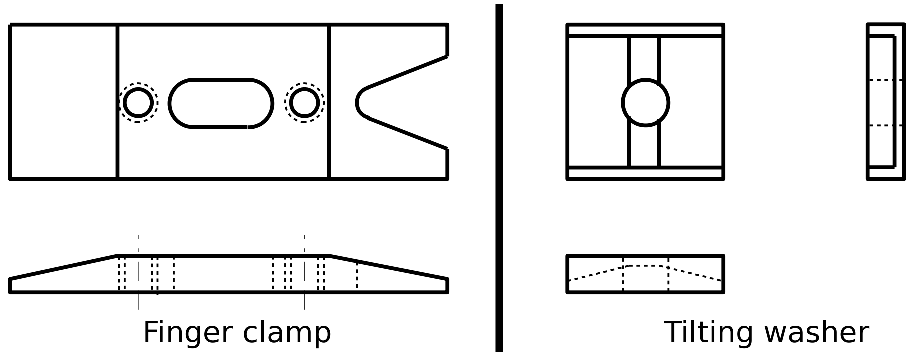
Finger plate

For a useful tool that can do things you'll find hard to do other ways, see the article in Lautard's books [*tmbr*] (Vol 1, pg. 88-89, Vol 3, pg 79) on a finger plate (they're topologically equivalent to the clamp shown in Figure 4). Here's one holding a screw about to be drilled:



Here's a view of the pieces:

The socket head clamp screw is 1/4-28 and is 1.5 inches long, with a brass tip pressed into a hole to avoid dinging up the plate. The brass washer is 3/4 inch diameter and 0.15 inches thick. The stud is 5/16-18 and is 1.65 inches above the top of the plate (it is held in place with Loctite adhesive). The plate is steel rectangular bar stock 2 inches wide by 0.5 inches thick and is 3 inches long; its vee groove is about 0.5 inches wide at the top and a 0.05" wide slot is cut into the bottom for burr clearance. The finger clamp and angled washer were made from some 1/4 inch thick steel stock 1 inch wide; here are their shapes:

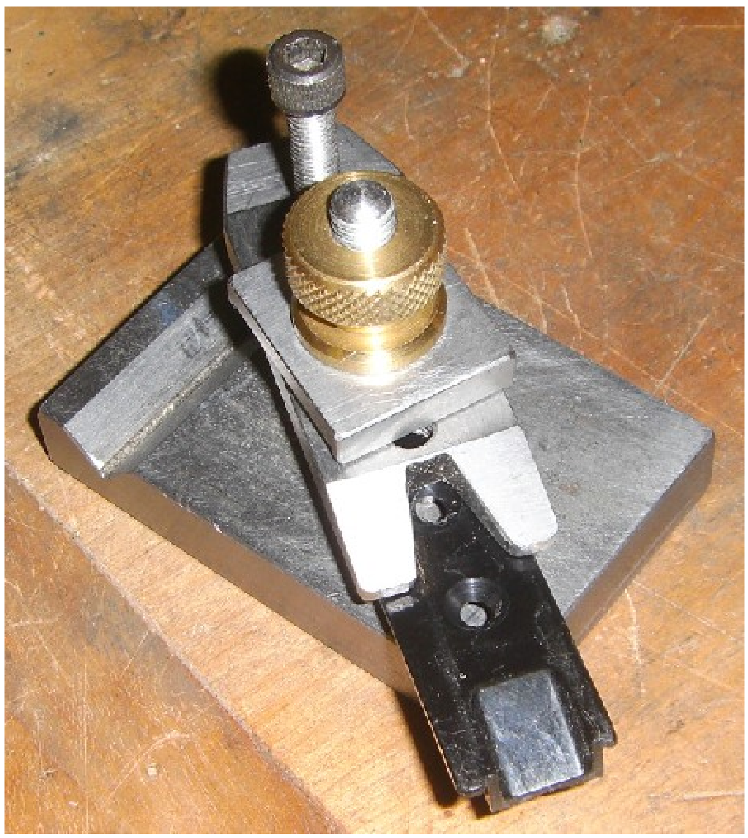


The tilting washer had its angled surfaces filed by hand and they're not perfectly even. But the clamp still works fine. I also filed the tapers on the finger clamp.

The dimensions of mine are such that it will hold a 3/4" thick chunk of flat stock and a 1 inch diameter chunk of round stock in the groove. I've never used it to hold anything that big, but it's nice to have the capability should I need it some day.

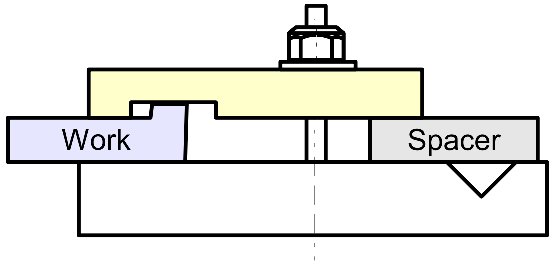
If you don't have one of these and you have access to a milling machine, I strongly suggest you make one -- you'll probably find you use it more than you thought you would.

Here's the finger plate holding a plastic part to a tape measure that needed repair. The shape of the part meant it couldn't easily be clamped in a vise, but the finger plate held it securely for the drilling and countersinking of the two holes for some flat head cap screws:



This plastic piece had an inconvenient angle on the bottom and would have been difficult to clamp securely with a regular vise or clamp. In this repair, I also used the finger plate to hold this plastic piece while filing a slot with a pillar file on the opposite side.

If a special clamping situation comes up, you can make a chunk of aluminum flat stock, a chunk of something as a spacer, and put a 5/16" nut on the central threaded rod to clamp things. I've not needed to do this, but it's a nice feature to have in your back pocket:



If you have a milling machine and a set of clamping paraphernalia for the T-slots, you may want to make the finger plate with the central tapped hole the same thread size as your mill's clamping stuff. Then you can use that tooling (e.g., studs, nuts, strap clamps, and step blocks) on your finger plate.

References

The old books can be found on Google books.

[*hh*] Harold Hall's web pages (http://www.homews.co.uk/). Sketch 2 is http://www.homews.co.uk/TMCLMAKE_M1.pdf and shows a drawing of some different clamp sizes. Note his alternate thread suggestions in inches are rather fine threads -- you may want to experiment first to find a thread you like (and if you want to make your clamps from purchased threaded rod, you'll have to make do with the rod material you can purchase -- in the US, this is typically UN coarse and fine threads).

[*tmbr*] Guy Lautard, *The Machinist's Bedside Reader*, volume 1, written and published by Guy Lautard, 1986. There are also volumes 2 and 3.

[*cs*] F. Colvin and F. Stanley, *Machine Shop Primer*, McGraw-Hill, 1910.

[*csdp*] F. Colvin and F. Stanley, *Drill Press Kinks*, McGraw-Hill, 1908.

[*cstk*] F. Colvin and F. Stanley, *Toolmaker's Kinks*, McGraw-Hill, 1908.