Building a Single Tooth Dog Clutch for the 9 X 20 Lathe

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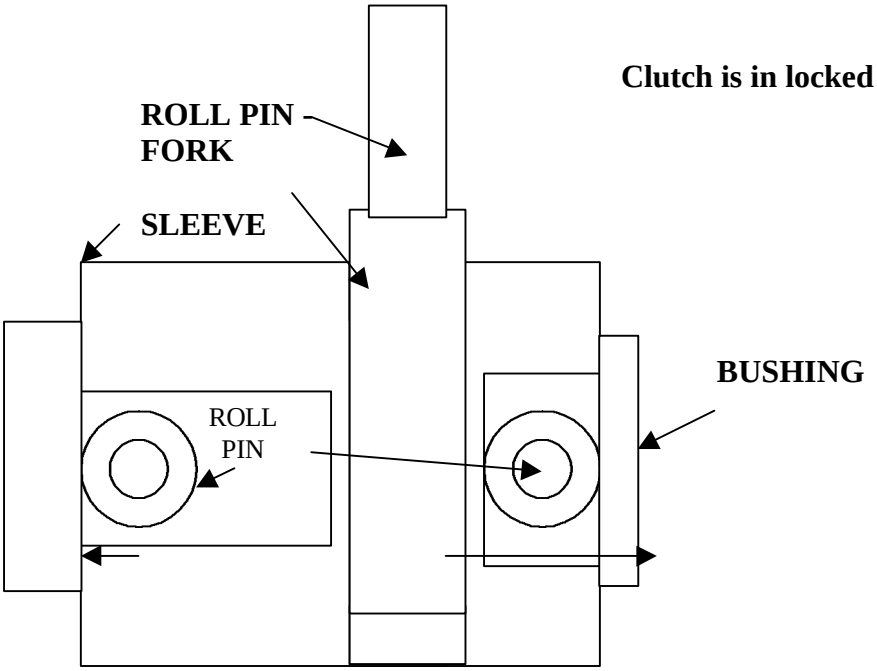
These are very basic instructions, meant for people who are less knowledgeable than you are… so please be patient when you are reading this.

NOT TO SCALE



Clutch is in locked or driving position

The Concept:
Build a single tooth, dog clutch with the least amount of modification to the Lathe. Make it as simple possible.
The dog clutch should be small enough to keep from interfering with the carriage as the carriage travels towards its maximum travel limit against the lathe headstock and quick-change gearbox.
Not much room left to build this puppy is there! (Should be about 1 1/2 inches in total length more or less.)

Examining your lathe - How and where and why.

You need to take the lead screw off; this involves driving the shear pin out. Driving the shear pin out requires a punch; I used a 5/32 Dia. Punch for my removal.

If you don't have a 5/32 punch you can make one by drilling a 5/32 hole in a small scrap bar then cut the shank end off the drill bit, leave enough shank sticking out to act as the punch.

The existing shear pin is probably aluminum or some other soft metal. That's why it's called a shear pin.

Remove the two hex socket head screws holding the right hand steady bearing for the lead screw.

Pull the steady bearing support out a little to make sure there is no alignment pin in it.

Your lead screw should now come out of the GEAR SHAFT SOCKET by gently moving the carriage towards the tailstock carrying the lead screw with it.

Once you have the lead screw out you will notice that the original hole for the shear pin is very near the end of the lead screw.
THIS DISTANCE IS VERY IMPORTANT TO KNOW.

WHY?
Because the driving dog tooth (roll pin) must MISS/CLEAR the end of the lead screw shaft when it is drilled in the socket of the gear shaft. You don't want a dog tooth pin acting as another shear pin for the lead screw. (More about that Later).

You will notice that the lead screw threads taper off a bit near the end of the shaft. This is Good. It gives you a chance to make a bushing which will give a nice tight slip fit over some of that portion of the faded or faintly cut threads.

WHAT KIND OF BUSHING GOES ON THE LEAD SCREW?

The bushing is a plain bushing made out of CRS. Nothing fancy, just a bushing that makes the gear shaft socket look like it's longer than it really is.
This bushing is turned to the same Dia. on the outside as the outside Dia. of the GEAR SHAFT SOCKET.
The inside Dia. of the bushing is a snug fit over the lead screw shaft.

The bush is held in position on the lead screw by a dog tooth (roll pin). (More about the bush length and how to make it and position the dog tooth (roll pin) on it later).

WHAT'S A ROLL PIN
A roll pin ,commonly known as a "split roll pin" is a pin that can act as a shear pin or have other uses…in this case it is used as the dog tooth and to hold the bushing in place.

If you have gotten this far and agree with the observations you can lay the lead screw down some where and start to build the Dog Clutch. You don't need a lead screw to make the clutch just use your rack on the lathe.

Okay let's make this thing.

First thing to make is the bushing for the lead screw that butts up against the gear shaft socket.
Get some CRS material at least 1 inch in Dia. about 2 inches long, chuck it up and drill a ½ in hole in it about 1 ¼ inch deep.
Gently bore it out until the lead screw will fit in it snugly.

Then turn it down on the outside of the bush until the bushing is the same Dia. as the gear shaft socket.
Cut off the bushing at about 1-inch in length.

This is too long but you can easily trim later and there is a reason for it being left long.

Trimming later means the hole will be where you want it relative to the end of the bush.

The next step is to drill the hole for the roll pin used as a dog tooth in the bushing.

This requires two different drill sizes the 5/32 drill bit for the roll pin and a smaller drill bit. How small ? at least one drill size smaller than 5/32.
WHY THE SMALLER BIT?
Because the hole it makes will be used as a knock out hole for removing the dog tooth pin.
The 5/32 hole DOES NOT go completely through the bushing. The smaller drill bit hole does.

HOW TO DRILL THE BUSHING HOLE
Using Vee blocks center drill with the smaller drill bit, a hole in/or NEAR the middle of the bushing completely through both sides of the bushing, next chase the hole with the larger 5/32 drill bit stopping short of going completely through.
This should make the pin use both walls of the bush as a function for the pin to act against. Yet not let the pin drop or push it's way through the bush and you can still drive out the pin at some later date should it break off by punching through the smaller hole.

THE TRICKY STUFF

At this point you have a bushing which is too long but has a nice hole for the roll pin which will act as the dog tooth on the lead screw.
We could go ahead and put it on the lead screw, then figure out where and drill the lead screw but that will come later.

At this point we should start to make the SLEEVE - which is the main part of the dog clutch.
The sleeve is nothing more that a tube with notches at each end and a groove around it for a shifting fork to ride in.
Find a piece of CRS material 2 inches in Dia. and about 2 to 3 inches long, Chuck it up and drill a hole in it at least 2 inches long and just undersize for the Dia. of the gear shaft socket a ½ inch to 3/4 inch drill bit is fine for starting your bore.
Finish this hole with a boring bar to size so it will slip on your bushing and the gear shaft socket.
Being a tad over size on the hole will just make it slide more easily on both the bush and the gear shaft socket. So it's not that critical of a fit but try and keep it reasonable.
4 to 6 thousands larger than the bush and gear shaft socket is nice.
You don't want too precise a fit because it may bind during the release and engagement operations of the clutch as it slides over the bush and socket portion.

Next step is to turn the outside Dia. down to 1.69 or 1.68. for at least 1 and 1/2 inches on your work piece. Cut it off at the 1 and ½ inch point and save the other piece to build the SHIFTING FORK later.

WHY IS THE OUTSIDE SO FAT (1.69 TO 1.68) AND SO LONG
At this point you have a sleeve that is a bit too long but it slides nicely on the socket and the bush at the same time. The sleeve seems fat but you need the thick walls to grab the dog tooth pins and to take the control SHIFTING FORK groove which comes later AND THE ADDITIONAL HEIGTH helps bring the fork control rod closer to the underside edge of the bed way. All this will be clear later when we get to that part.
We will cut the notches for the dog teeth on the sleeve later.

THE REALLY SCARY PART

You have to drill two holes in your machine, and yes I know it almost borders on sacrilege to do that. But you can't have a working dog clutch with out doing it.

<u>WHICH HOLE FIRST AND WHERE?</u>
The first hole should probably be drilled in the gear shaft socket. As far from the face of the gearbox as you can without drilling into the end of the lead screw and yet still leave a little clearance for the lead screw when it is reinstalled in the gear shaft socket. In my case that was <u>.440 from the side of the gearbox and I didn.t hit the end of lead screw. If you can get more than .440 then I would take it</u>
<u>WHY?</u>
The reason for trying to get a little extra room from the side of the gear box is that during release you don't want the sleeve butting up tight against the gearbox wall.

Having a little room left over means that you can move your carriage by hand when it stops and get a little clean up on the work piece without readjusting your stop bar on the lathe bed way. A small consideration but an important one.

<u>WHAT KIND OF HOLE</u> ? A similar hole to the one you made in the bushing using a small drill bit chased by a 5/32 bit. The idea is that the roll pin must pass through one wall of the socket and not completely through the other wall on the opposite side. There must be a smaller hole to insert a punch to drive out broken pins when they occur. The use of VEE blocks to center drill this shaft is recommended. So that means taking the gear shaft out from the quick change gearbox.

Question: should the hole be on the same alignment as the existing hole that the shear pin used or at 90 degrees to that hole or some other angle to the old hole in the socket. ANS: I doubt if it makes a difference.

If you have completed the hole you can reinstall the gearbox shaft and drive in your first dog tooth (roll pin).
With any luck it should be 0.440 +- inches from the face of the gearbox housing to the center of the pin. A little more distance from the gear box housing is probably better than a little less. You can now see the maximum travel that the sleeve can take for engagement towards the carriage. Not much travel distance is there.

NOW WE TRIM THE BUSHING
WE have to trim the bushing and reinstall the lead screw as you normally would but with the bushing on it, FIRST trim the bushing on one end and when the distance from the CENTER OF THE PIN ON THE gear shaft socket AND the CENTER OF THE PIN ON THE BUSH are about 0.854 apart when the bush is against the gear shaft socket ..stop. This distance 0.854 is not written in stone so you can change it to a larger number if you want a longer sleeve. You have to make a decision about how long you want the sleeve. 0.854 is the minimum distance I would recommend, 0.900 is nice or 0.954 is good. The factors involved are distance that will be lost in carriage travel and sleeve stability…remember I had no plans when I built mine.
I will wait while you decide. If you can't decide, then go for 0.954. at least that will make the groove easier to place in the sleeve.
That end of the bush will be called the SOCKET END trim the other end until the over all length of the bushings is about 0.500 or 0.600 if you went with the 0.954 measurement.
Slip the bush on the lead screw with the SOCKET END facing the gear shaft socket and reinstall the lead screw as per normal, Tighten all the bolts and put in a temporary shear pin in the old shear pin hole for the lead screw. Run the lathe a few turns to make sure the lead screw settles in. Stop the machine.

Push the Bush up tight against the gear shaft and hold it there then using a hand held drill with a 5/32 bit insert it in to the bush hole and lightly drill a shallow hole/mark for reference later when you center drill the lead screw.

Now take the whole thing apart again and using some VEE Blocks drill a hole through the lead screw using the shallow hole or mark as a guide. If you have done every thing right the holes on the bush and lead screw will match up. You can in stall the roll pin and bushing on the lead screw and reassemble the lead screw for a trial run watching for any slop or strain on re-assembly. Use plenty of lube on the lead screw end that goes in the gear shaft socket. The socket is now functioning as a bearing for the lead screw so it needs lots of oil.

FINISHING THE SLEEVE

The sleeve is much too long at this point and it requires two notches to accept the dog teeth (roll pins).

HOW WIDE SHOULD I MAKE THE NOTCHES IN THE SLEEVE?

The width if the notches is not important, they should be wide enough for the pins and the wider the better; especially for the notch that accepts the bushing roll pin as this will make engagement and release easier when the lead screw is turning faster. Too narrow a notch on the sleeve and the pin will have a harder time on engagement to the bushing pin. For starters you could make the notch for the bushing pin ½ inch wide.

HOW FAR IN FROM THE FACE OF THE SLEEVE SHOULD THE NOTCH FOR THE BUSHING PIN BE ?

This notch should be only as deep as the roll pin is wide and a little tiny bit more. WHY? Because the contact point is on a round pin and more depth is just wasted travel distance, something we don't have a lot of is room for.. remember we will be moving towards the gear box housing on the release so extra travel could be a problem.

How do I make my notches?

First drill a ¼ inch hole as near the edge of the sleeve as you can through one wall of the sleeve only, then rotate the sleeve enough to drill another ¼ inch hole beside it.

Using a file or Dremel tool remove the metal in between the holes and square up the notch with a file. Remember to slant the notch faces towards the center of the sleeve so that the pin will rest against the notch face fully.. Re-chuck the sleeve and trim it until the depth of the notch is nearly the same width as the roll pin. Perhaps a little wider than the pin is but not much more.

At this point you now have one notch a little wider than ½ inch and about the same depth as the roll pin DIA. used as the dog tooth on the bushing.

How do I make the second notch?
The second notch can be narrower…say ¼ inch wide or wider if you like and it will start at 0.240 (or 0.340 if you used 0.954 for your pin distance) from the bottom of your
First notch.. That is where the second notch for the driving dog tooth on the gear shaft socket starts and the slot continues to the other end of the sleeve.

IF YOU ARE USING A ¼ INCH DRILL THEN THE HOLE WILL BE 0.365 AWAY FROM THE FIRST NOTCH 0.240 + .125 (1/2 OF THE WIDTH FOR A ¼ INCH DRILL BIT)
I used a series of ¼ inch drill holes and a file for this step. It's quicker than using my mill.

DO THESE NOTCHES HAVE BE IN LINE WITH EACH OTHER?
ANS: No they don't; the placement or alignment of the notches in relation to each other is not critical. They could be 180 degrees to each other and there even may advantages to having them at 180 degrees to each other, who knows who cares.
We may get a mechanical engineer to advise us on this issue at a later date.

The next step is to trim the sleeve to a final length. This final length should allow disengagement and a little more travel to make sure that there is true disengagement.
Remember what I said about extra travel room for cleanup with out adjusting the stop rod on the release.

A TRIAL FIT IS IN ORDER AT THIS TIME.
This means re-assembling with the sleeve on and checking for movement and engagement and disengagement. You will probably be tempted to fire up your machine and flip the sleeve back and forth with a screwdriver. If you do and I'm too far away to stop you - at least make sure you are running at a slow speed and be careful. That's how accidents happen.

If you are satisfied that the sleeve moves freely and engages the roll pin dog teeth and disengages from the tooth in the bushing with a little clearance so nothing can inadvertently rub or engage. Then you are ready to make the SHIFTING FORK and the SHIFTING FORK groove on the Sleeve.

The First thing to make is the SHIFTING FORK groove on the sleeve.
Why? Because it's easier to make a groove and fit a piece to it then it is to make a piece and cut a groove for it to fit in…I'll get plenty of arguments on that statement.

How wide is the SHIFTING FORK Groove?
It has to be wide enough to take the pin that will act as the SHIFTING FORK PIN and a little wider to allow for some thickness on either side of the pin.

The pin is 5/32 (0.156) so allowing for 0.040 on each side of the pin makes it 0.236+-

Where does this 0.236 in groove go on the sleeve.
Center this groove in between the two edges of the slots.
There is not much room between each slot unless you used a 0.954 pin distance

How deep is the groove to be?

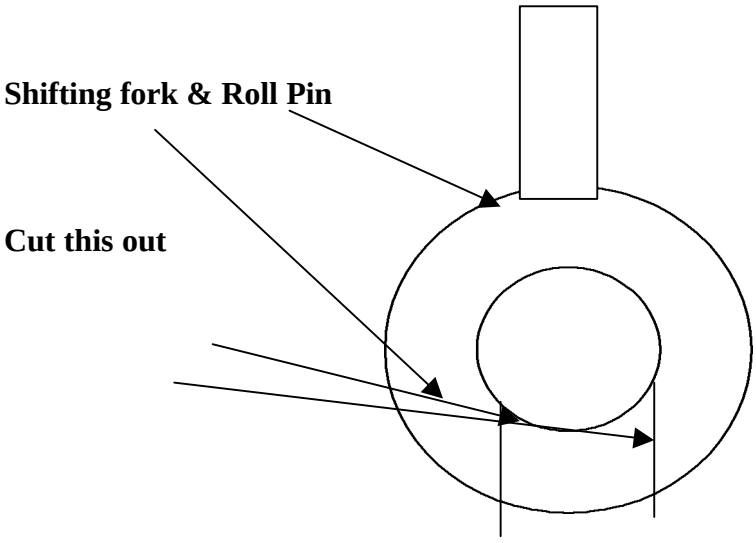
A 0.236inch groove should be at least the same in depth. 0.250 to 0.300 is fine for the depth.

How do I make the groove?

ANS: Use a parting tool

If you have completed the groove, you are ready for the SHIFTING FORK.

THE SHIFTING FORK



To make the SHIFTING FORK you need to remember that left over piece from the making of the sleeve.
Chuck that piece up and open the hole up to the same DIA. as your groove DIA. in your sleeve. (the bored hole should be about 1/2 wide so you can cut it off later).
Next step turn down the outside of the piece until it is .200 bigger in dia. than your sleeve outside dia. (fork O.D. should be 1.88 +)
BEFORE YOU PART IT OFF. Take it out of the chuck and:
Drill your pin hole in using a Vee Block,,,the same type of hole you did for the bush
Drill the hole well in from the edge….THEN CHUCK IT UP AND FACE TOWARDS THE HOLE UNTIL YOU HAVE THE 40 THOUS. ON THE SIDE OF THE HOLE.
It's a lot easier than trying to drill down the exact center of a thin ring later..

Use a parting tool and cut off a ring at ¼ of an inch wide or better. Then face this side until if just fits in the groove and there should be about 40 thous on that side of the pin hole as well.
This ring or I should say part of the ring is your Shifting Fork.

Note. Having the ring a little narrower than the groove is normal for a running fit, Having too tight a fit on the SHIFTING FORK in the groove means that something else will have to move when the sleeve rotates and wobbles. WE DON'T WANT THE DOG TEETH TO DISENGAGE so let the fork do all the movement.

Cutting a portion out of the ring to make the SHIFTING FORK fit and look like a shifting fork. That can be done with a hack saw, band saw or bench grinder take your pick.

Once you have opened the fork to fit on the sleeve you must install the pin,

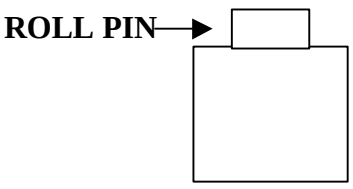
Drive in the pin and you have your fork completed.

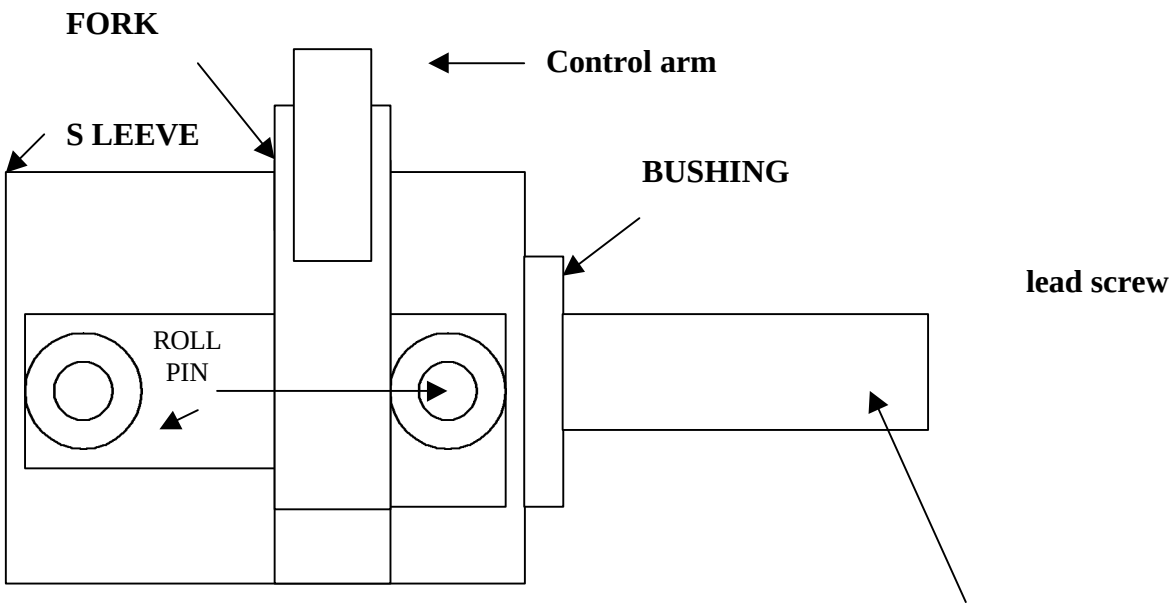
THE CONTROL ARM

The control arm is a piece of 3/8 square bar stock. The arm goes from a point just under the lathe bed way towards the front of the gear box. The hole in the control arm that takes the roll pin of the fork is slightly OVERSIZE, to permit the fork to wiggle.
If the hole is the same size as the pin the lever arm will wiggle when the machine is running.
Why does the control arm go all the way towards the lathe bed and end up under the bed way?
That is so the auto release can follow the bedway and trip the lever. (more about that later)

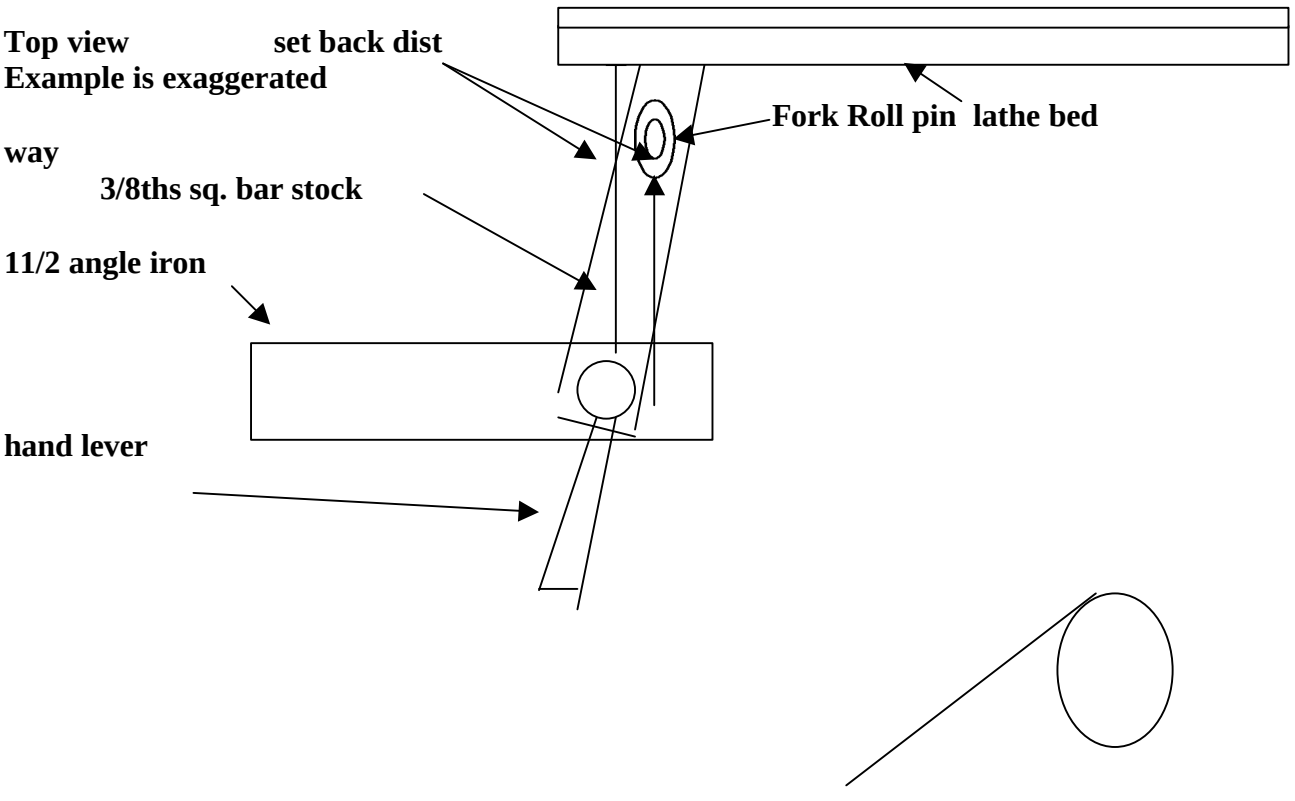
The DOG CLUTCH & BUSHING, Showing ROLL PINS & POSITION OF THE SHIFTING FORK

<u>NOT TO SCALE</u>

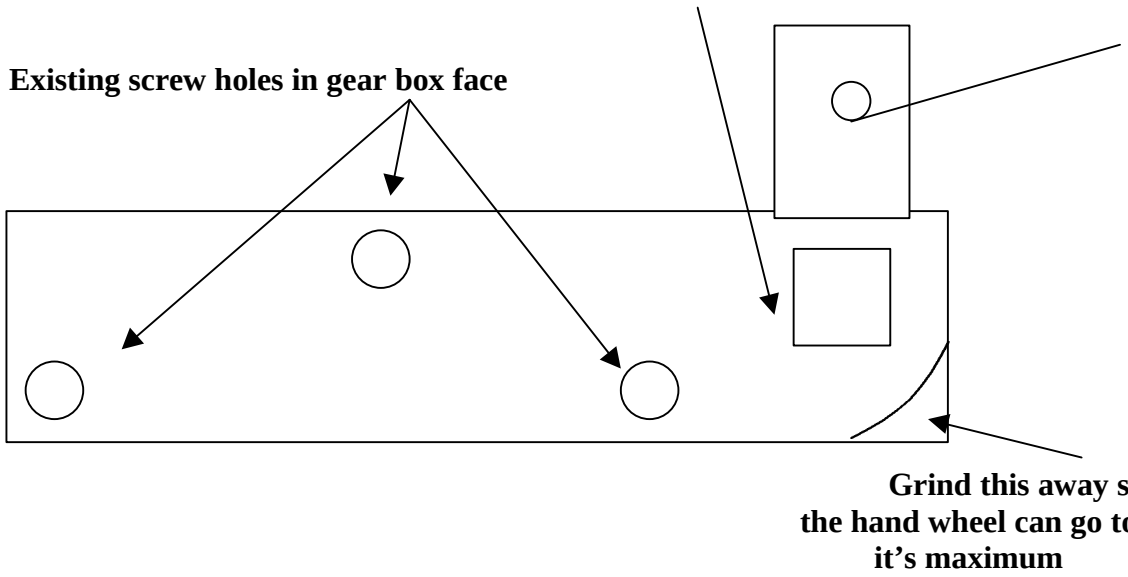




The Control arm front panel that attaches to the front of the gear box using the existing 3 bolt holes. Make this out of 1/1/2 inch angle iron 6 ½ inches long
Drill the holes using your front cover as a template, replace the cover along with the angle iron using some longer hex socket screws.
The hole in the angle iron for the lever to pivot on should be slightly back from a right angle. That is to say… closer to the gear box than the front of the lever where the fork pin is. This gives an OVERCENTER advantage to the linkage in the locked position

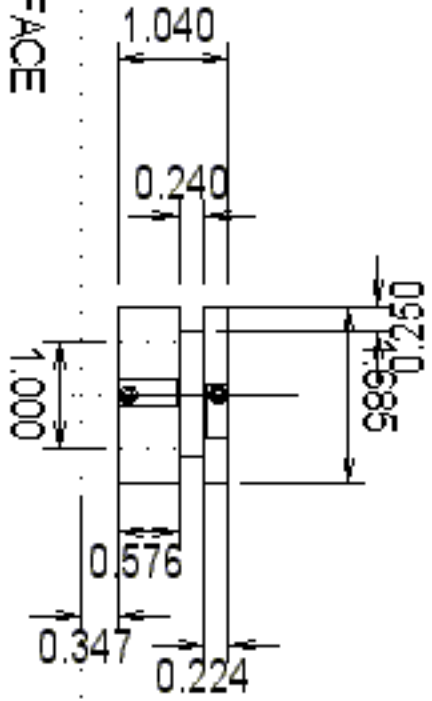


End view of control arm front panel showing lever & control arm



GEARBOX FACE

DOG CLUTCH SHOWN IN DRIVING POSITION



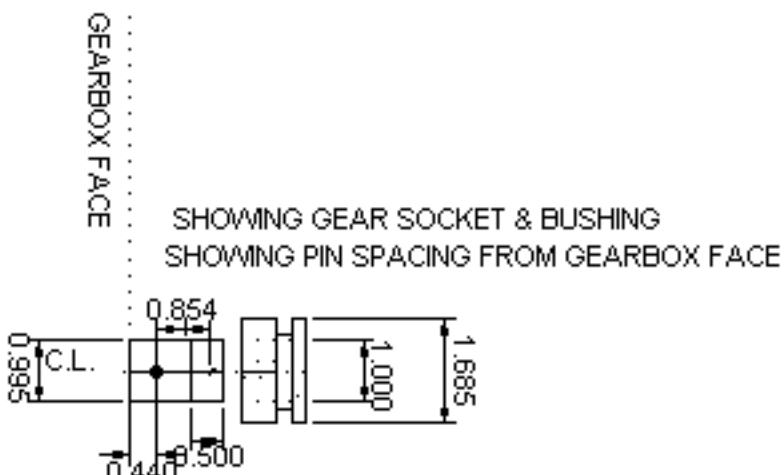
Sleeve length 1.040

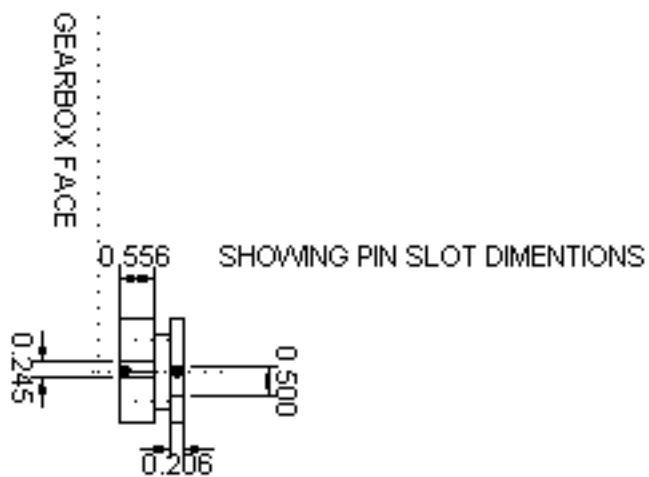
Sleeve Bore Dia. 1.000

Sleeve Outside DIA. 1.685

Sleeve Fork Groove Width 0.240

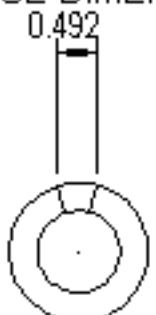
Roll Pins are Split type 5/32 DIA.


GEARBOX FACE
SHOWING GEAR SOCKET & BUSHING
SHOWING PIN SPACING FROM GEARBOX FACE
0.854
0.995
C.L.
1.000
1.685
0.440
0.500


GEARBOX FACE
0.556
SHOWING PIN SLOT DIMENTIONS
0.245
0.500
0.206

END VIEW OF SLEEVE

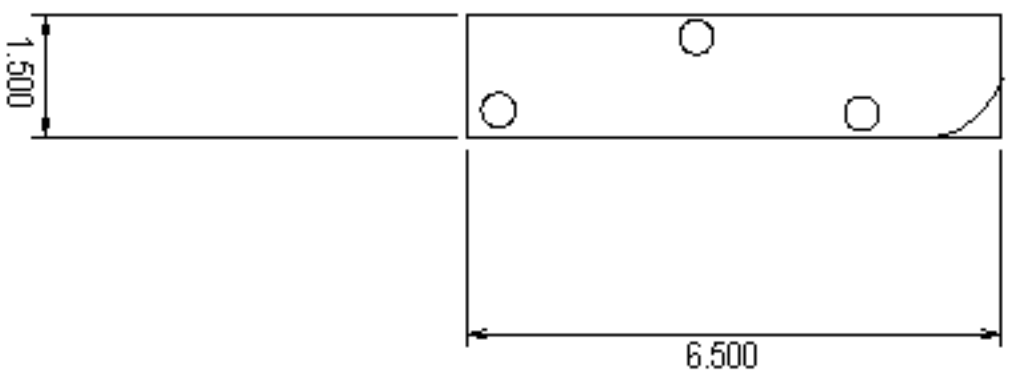
SHOWING APPROXIMATE SLOT WIDTH TO ACCEPT PIN ON THE BUSHING
AND WITH NEARLY THE PROPER ANGLE FOR THE PIN
THESE DIMENTIONS ARE NOT CRITCAL BUT THE ANGLE REQUIRES SOME FILING TO FIT RIGHT



FRONT VIEW

ANGLE IRON FOR THE FRONT OF THE GEAR BOX

USE OLD HOLES IN FRONT OF GEAR BOX TO SECURE

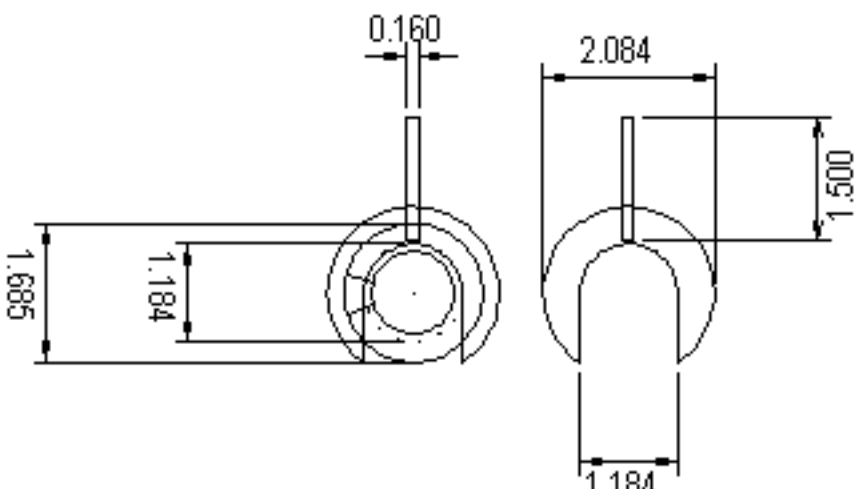


GRIND CORNER FOR HANDWHEEL

TO CLEAR

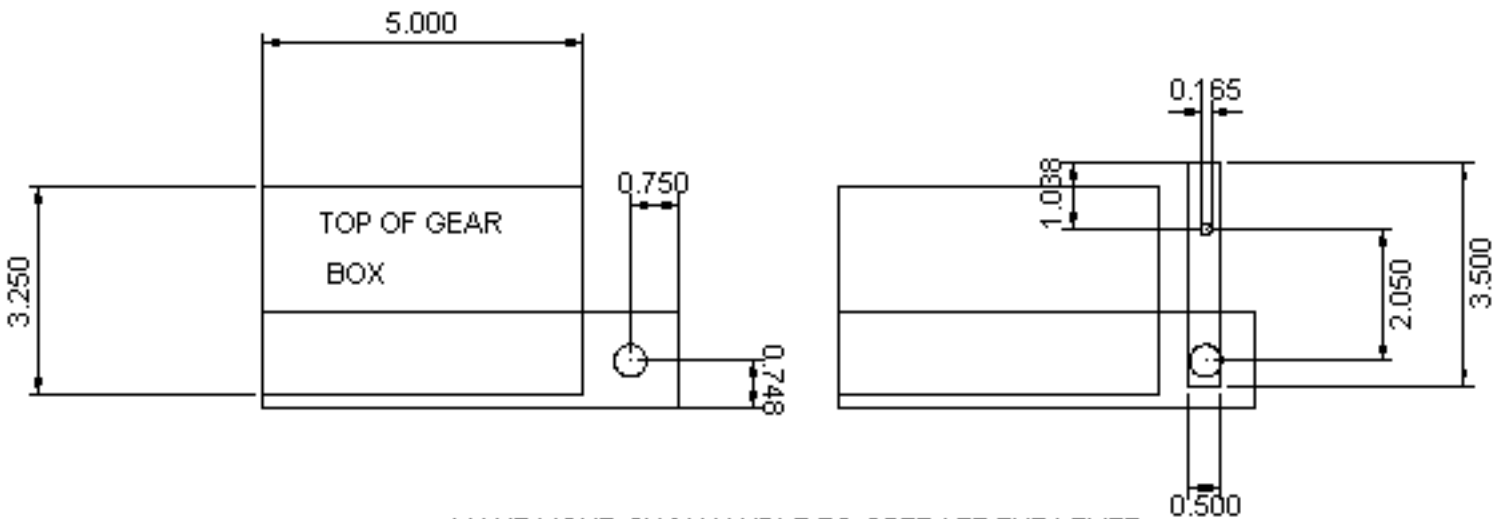
END VIEW OF SLEEVE

SHOWING FORK & PIN THAT IS TOO LONG, TRIM IT AFTER ASSEM



TOP VIEW OF ANGLE IRON FOR THE GEAR BOX

SHOWING POSITION OF HOLE FOR HANDLE



MAKE YOUR OWN HANDLE TO OPERATE THE LEVER

KEEP IN MIND THAT THE HANDLE NEEDS TO HAVE DOWNWARD PRESSURE
TO AVOID PREMATURE RELEASE, IT SHOULD CONSTANTLY DRAG TO A RELEASE

I'M STILL IMPROVISING ON MINE AND I WILL
LIKELY ADD A SPRING OR SET SCREW TO KEEP FRICTION
CONSTANT AT THE HANDLEVER CONNECTION TO THE LEVER THAT

WORKS THE FORK....BEST WISHES JACK HAMMOND