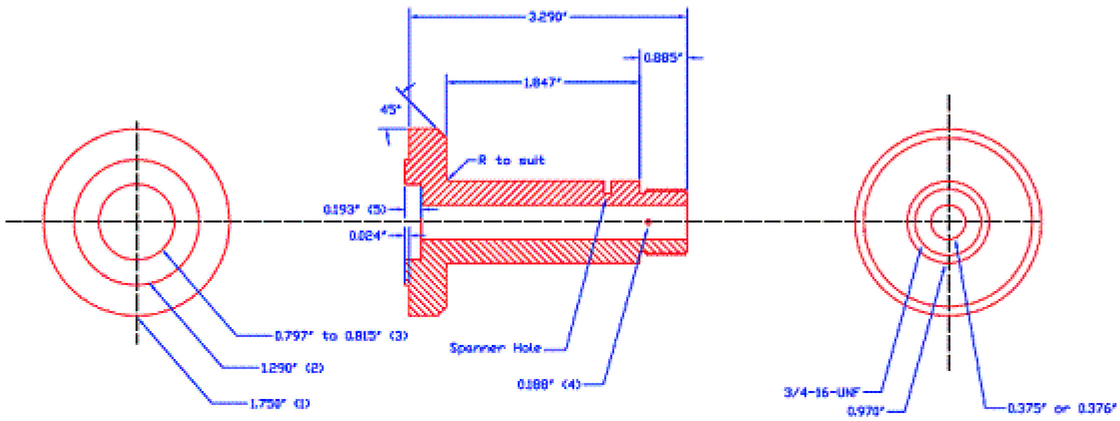
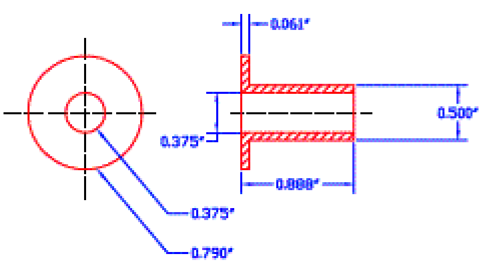
INTRODUCTION

My 9-inch South Bend lathe is a 1934 Workshop Model 405 Standard Change Gear lathe.
The Workshop Standard Change Gear lathe without power cross feed, after late 1938, was called a Model C.
In 1934 the Workshop versions, A, B and C, did not exist yet, only the original model called the Number 5 or 405 as we call it today was available. The 405's have the smallest dials of all the workshop lathes, only 7/8 inch in diameter. I have always had difficulty reading them and as I age my sight has not improved. I felt it was time to do something about it. Ed Godwin has provided an excellent documentation on adding a large dial to the Model A/B lathes. In general I have followed his dimensions except where noted in the text. It is required that, before you start this project, you first read Ed's project. http://www.wswells.com/projects/ed_godwin/crossfeed.pdf
Here I will attempt to do two things:
Show how the 405 cross feed dial is converted to a large dial, this be should extendable to the 415 and later model C's.
Point out the little eccentricities in the 405 that make it so different. Note that the items to be machined remain essentially the same as in Ed's write-up. They consist of:
The cross feed mount extension sleeve:



1) Match OD of the dial you intend to use.
2) Optional raised face.
3) Slightly larger than the needle thrust bearing being employed - 0.796"
4) Drill 0.188" through one side only to match oiling hole in saddle.
5) Bearing used in this design is 0.143" thick.

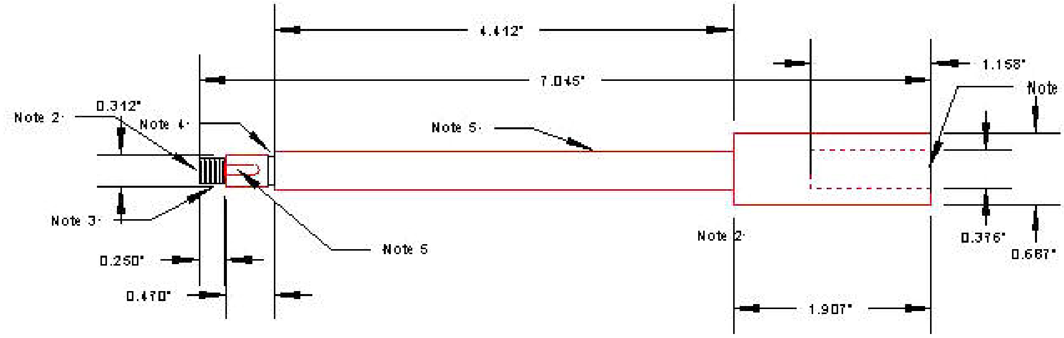
The inner dial sleeve:



Index Dial Bushing

1) The length of this bushing is critical. It should be one of the last things machined and it's length should extend about 0.002" past the end of the dial and also slightly past the handle-mounting shoulder on the shaft. When you tighten the handle nut on the shaft, the handle will bear on the narrow end of this bushing and press the bushing's flange against the thrust needle bearing. The 0.002" clearance gives enough spave for the dial to rotate freely on the OD of this small bushing.

A new screw:



Note 1 Drill ream 0.376"
Note 2 Center drill and c'sink 1/8 by 1/8".
Note 3 12-24 thread by 1/4" relieve threads.
Note 4 Relieve 0.312 Diameter 0.010 deep. Trim at assembly for fit on inner sleeve
Note 5 3/32 ball end endmill, 0.047 deep

PART I, MAKING THE EXTENSION SLEEVE.

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Because of the potential interference between the cross slide and the compound handles the cross slide must be moved back. This requires an extension, screwing into the cross slide and a longer cross slide screw. Several years ago I had obtained a new cross slide nut from Miller Machine. (The nut on the 405 is a bit different than the 415 and later models). I did not, at that time, replace the cross slide screw. While I could have used the old threaded portion, which was not that worn, I thought it best to replace it with a new 7/16-10 LH Acme section which I obtained from Steve Wells. When Ed made his sleeve he hogged it out of a large bar of 2-¼ inch diameter steel. I decided to fabricate mine as a brazement. I had some 2-¾ inch diameter steel and I cut a slice ¾ inch thick and bored it to a 0.875 diameter.

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Figure 1: Boring 0.875 for the 1" rod.

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I then turned a 1-inch piece of drill rod to have a ¾ inch long step 0.870 diameter. (I left a bit of room for the braze to flow) This is shown in Figure 2. The step on the rod makes the two pieces self-jigging. The rod was held and the large end heated to braze the two parts together the only difficult thing about this fabrication process was the combination of heavy oxidation and baked on flux. I initially tried to just wire brush off the crud, without success.
I quickly put together a small electrolytic cleaning tank using TSP and cooked the parts for several hours and that did the job. The brazing material I used was Harris 45 and I used the Harris black flux. The white flux is easier to clean but I wanted a good braze and I have been having better results with the more active black flux.

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Figure 2: Turning 1" drill rod.
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Now the assembly could be faced and turned. (see Figure 3)
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Figure 3: Facing rear of mount bushing.
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I had mentioned to Dennis Turk that I was starting the project and he sent me some drawings for a special 2" large dial and extension mount bushing. The extension sleeves for these, at least the later ones have bronze inserts acting as radial bushings and only the first and last ½" of the sleeve are actually in contact with the screw assembly. This both lowers the rotating friction and provides a well for oil to accumulate to keep the screw lubricated. I decided to incorporate this improvement into my extension sleeve. Besides I had a piece of bronze. The sleeve assembly first needed to have an axial through hole somewhat bigger than 3/8 of an inch. I was very antsy about drilling a deep hole that would remain concentric with the OD so I decided to leave the OD oversize and turn the part true to the ID (If needed). I center drilled and then drilled through with 5/16 drill and then bored the ID to just over 3/8". (Figure 4)
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Figure 4: Boring ID to insure concentricity.
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This was not so much to size the hole as to insure that it was true to the OD. Note that I am holding the brazement in a 1" collet in my 10L. (Figure 5)

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Figure 5:

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You could use a 4-Jaw chuck and dial in the part. This allowed me to do some things more easily. The boring bar (Figure 4) is 5/16 in diameter and I ground the tool and cut it so it just protrudes. Boring this close requires small bites, continually clearing the hole, or the swarf will bind up and ruin the part. The Large dial conversion also adds ball/roller thrust bearings to the cross feed. These remove any axial play, not associated with the screw/nut. The bearing nearest the dial is a roller bearing and it sits in a counter bore. This step is machined at this point. (Figure 5). Note that I have also turned the OD of the large diameter. This will carry the reference mark for the large dial. I also bored a larger diameter (0.406), 1" deep for the bronze bushings. These were machined with the ID of the hole a bit undersize and the OD of the bearing a light press fit into extension sleeve. I pressed them in on the lathe; leaving them a little proud of the ends of the sleeve and machined them flush with the sleeve. (See Figure 6) The bore was then reamed 0.001 oversize (0.376).

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Figure 6

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I next needed to thread the end of the sleeve ¾-16 RH. I planned on holding the large diameter in the 4 Jaw chuck and indicating the 1" rod. I wanted to support the end with the center and to insure that the center was on center I realigned the tailstock just to be sure. Next came the thread, repositioned in the chuck, I turned the ¾ step, cut a thread relief and single pointed the ¾ thread (Figure 7)

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Figure 7
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Before finishing the small end of the sleeve I needed to put a radius where the large diameter blends on to the 1" barrel and a 45 degree chamfer on the large diameter. I have ground tools for doing this (Figure 8, Figure 9)
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Figure 8
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Figure 9
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I had left a little extension on the shaft for tool clearance on the live center. This needed to be removed and the ID bored for the bronze bearing. Then the bearing needed to be pressed in and finished flush with the extension sleeve. I used a steady rest to insure the part was supported. This setup is shown in Figure 10. That finished the extension sleeve except for making the zero mark line, inserting the zero and drilling the oil and spanner holes.
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Figure 10 Stub removed, bushing pressed, faced, and reamed.
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Although I had been using a strap wrench to be sure that the extension was thoroughly bottomed against the saddle, I wanted to add a hole in the bottom for a spanner, just to be sure. The drilling of the two holes is an ideal application for the Cross Drilling Adapter. Mine is shop made and mounts on a QCTP holder. This is shown in Figure 11. Here I have previously screwed the extension sleeve into the saddle and marked the hole through so that it will line up with the existing hole. Ed, in his instructions wanted this done. The original sleeve on the 405 never had this nicety and the sleeve oil hole was about 90 degrees off the saddle oil hole. The oil always seemed to find its way onto the shaft, but I suppose Ed's is a better approach.
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Figure 11
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The cross drilling fixture was then moved, the work rotated 180 degrees and a 5/16 hole was drilled into the 0.960 bore about ¾" from the threads and ¼" deep. (For ease in removal). This matched with the original hole on the 405. At this point the extension needed to be marked. I locked the sleeve into place on the saddle and set up a strait edge on the saddle to mark for the zero. My saddle has two lines scribed onto it for setting the compound. I aligned the strait edge to these lines and clamped them using the existing threaded holes in the saddle and then lightly scribed the zero line. The conventional way to make these lines is to scribe them in the lathe using a scribing tool. I have not been a fan of this approach. The dials I have never seemed to be scribed deep enough to hold colored fill. Any fill I put in to accent the lines never seem to stay. I thought that I would try to make a deeper clearer mark. I used a 0.010 wide saw blade to cut the lines on my Mill. Now if you don't have a mill scribing is fine, but since I have one I used it. Figure 12 shows how I marked the zero line. Removing the compound I found two scribed lines on the saddle. These are used to set the compound and are in the middle of the cross-slide. I lined the right edge of a piece of ¼" ground stock up with theses lines, clamped the stock to the cross slide and then clamped a second piece of stock to the face of the first. This second piece just touched the large diameter of the dial. I blued (actually I use red dye) the dial and scribed a light mark on the dial. (See Figure 12)
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Figure 12 Lining up the Zero Mark
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Figure 13 shows the extension sleeve after I have milled the Zero line. This was just over 0.010 deep. Even though the saw is curved you don't seem to notice it in the line. I next needed to stamp the number Zero.
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Figure 13 Marking the zero reference line
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Ed had noted that you need a fixture to accurately position the number dies. I made one from a scrap piece of round and a piece of ½" square. The square was turned round on the end and a ¼" hole was drilled into the round. The OD of the round was cleaned up and then two 1/4" slots were cut at right angles into the round. One on center and one offset by 2/3 of number width. I never used the offset slot. The fixture is held in a tool holder on the QCTP. This allows for accurate positioning and alignment and getting the punch on center. Figure 14 shows how the number die is held. The hardest thing is getting the right and consistent force. It would be better if I took the time to make a cover and machined the holder so that the cover just cleared the dies. There was a tendency for the die to wiggle left and right which affects both uniformity of depth and positioning of the marks.
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Figure 14 Stamping the Zero Mark
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Finally Figure 15 Shows the finished Sleeve with the zero mark. If your eyes are sharp, you will also note that a flat has appeared on the top of the 0.920 diameter section. It seems that this is a 405 eccentricity. The top slide hits the 0.920 diameter that Ed specified in his drawings. I had a choice of turning the OD a bit or adding the flat. If I had only a lathe I would turn, but with the little Burk mill it was easier to just mill a flat on the body.

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Figure 15 The finished extension sleeve with markings and flat.

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This completed the construction of the Extension Sleeve

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PART II, FABRICATING THE NEW SHAFT.

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I had obtained a length of precision 7/16-10 LH ACME threaded rod from Steve Wells. The use of the Extension Sleeve requires a longer and different shaft than the old one in the 405. This is a change gear lathe, equivalent to, what is now called, a Model C so there is no cross feed power and no pinion gear to get power to the shaft. That makes total fabrication a lot easier. There is a large section that is 11/16 diameter, with the ACME threaded rod on one end and a 3/8 shaft on the other. I could have fabricated this out of a long section of 11/16 but I decided to use another brazement. Partly because I hate to waist steel and partly because the 11/16 material I had was drill rod and hard to finish well. This would be a double brazement. First a 3/8 rod would be brazed into the 11/16 section, then the 7/16 acme rod would be turned to 3/8 and brazed into the other end. Since you need to allow room for braze press fits are out of the question. I started by cutting a piece of 11/16 material to approximate size, facing off one end and drilling 3/8.
I needed this to have clearance for braze to flow, so drilling is fine. However I wanted the very end 3/8 inch of the 3/8 shaft to be a press fit for alignment. I snuck-up on the 3/8 diameter by drilling undersize, 23/64 to Letter U to 3/8, this results in a hole which is a wring or light press fit. (If you are using good made in the USA drills). Figure 16

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Figure 16: Drilling for dial and handle shaft insert

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I then cleared out most of the hole with a Letter V drill to allow braze flow. I also cross drilled a hole to allow the flux and air to escape.

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Figure 17: Cross drilling weep hole
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The 3/8 portion was also constructed from water hardening drill rod. One end was chamfered, the other was center drilled. This was then pressed into the back portion of the 11/16 section using the lathe as a press. Doing it this way insured that the 3/8 shaft was concentric with the 11/16 portion. Remember the outer portion of the 11/16 shaft is drilled oversize to allow room for the braze.

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Figure 18: 3/8 rod aligned and pressed

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The assembly was then silver brazed. Unfortunately the flux from the brazing process proves to be difficult to remove. I use an electrolytic tank to expedite removal. I also use TSP (Trisodiumphosphate) in the tank. This is available at most paint stores and Home Depot. (Do not use TSP substitute. This is Oxalic acid). I usually just throw together a setup as needed. The one I use for this project is shown in Figure 19. It consists of a plastic bucket, some angle for the anodes and the electrolyte.

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Figure 19: Electrolytic tank

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The shaft was then cleaned up and the opposite end drilled 5/16. The precision 7/16-10 Acme rod from Steve Wells

was next cut to length and a section was turned to 0.307. This does not quite get to the root of the Acme thread; there is a small spiral left which is 0.005 or so deep. (See Figure 20)
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Figure 20: Acme screw turned to 0.307
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I had initially planed on, also, brazing the screw into the 11/16 section. However I could not find a way to jig it properly, so I opted to use Ed"s method of Loctite coupled with a taper pin. I jigged the assembly by inserting it into the cross slide and the acme nut. In Hindsight it would have been better to use the lathe with the 11/16 part in a collet and the screw center drilled and held by a center. The spiral groves formed air paths for the Loctite so the flat that Ed added was not used. The Loctite has a long cure time. Since I had made the parts with about 0.004 clearance two days were needed for the adhesive reach full strength. After allowing the material to cure, the assembly was then cross-drilled 0.093 and a taper pin reamer was used to allow for the insertion of a 02 taper pin. I chose this size since it balanced the diameter of the pin with the remaining diameter of the screw. I was able to obtain 02 taper pins at the local hardware store, without the need to purchase 100 pieces. They were, of course, too long. I fitted the taper hole to the pin so the pin was about 1/32 shy of the end of the 11/16-diameter boss. I marked the desired length of the pin by bluing it and putting a scribe mark on the pin. I then made a fixture, a ½ diameter rod with an axial through tapered hole. I put the fixture in the lathe and parted off the taper pin 1/32 short of the scribe mark and rounded the edge. This left room to both set the pin and to insure that it did not protrude.
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Figure 21: Drill, ream and install taper pin
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The 3/8-shaft end was turned to 0.312 and then a 0.215 step and relief was added for the 12-24 thread. I had a 12-24 hex die so the thread was not chased. The entire assembly was then mounted on the Burke mill and using a ball end mill half of the required 3/32 slot for the retaining key was made. (Figure 22). I had to buy the end mill since I seldom use ball end mills. In fact I have only one other ball end mill.
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Figure 22: Milling the Round bottom Key slot
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While that finished the screw, eventually the length of the step will need to be modified to insure that the clearance of the direct reading dial is proper.
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Part III: Turning the Inner or Spacer sleeve:
Here I started with a ¾ piece of water hardening drill rod. Held in a 5C collet on the 10L. Cut a bit over length. I drilled through in steps, starting with a center drill then going to a 5/16-screw machine drill, clearing out the swarf every turn of the tailstock (0.1). I snuck up to the 3/8 drill as before and finished up with a 0.376 reamer.
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Figure 23: With a 3/8" rod as support, Diameters turned.
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I next supper glued a piece of 3/8 drill rod in the reamed hole as an arbor. This is a process I use quite often. The Super Glue holds quite well for turning but a sharp blow will release the arbor for removal. This will insure that the OD is concentric with the ID. I then turned the body to 0.500 using my standard carbide indexable tooling for a length of 0.875. Note the use of the way mounted dial indicator to set the length. My tooling inserts have a 1/32 radius. The sleeve needs to have a sharp step or a slight groove so as not to hold off the dial. I ground a tool with a sharp point and reversed the part using collets. I then parted the flange off and faced it to size.
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Part IV Finished Parts, Trimming and Assembly
Figure 24 shows all the parts before final assembly. As previously noted, only the new screw, the extension sleeve and the inner sleeve were fabricated.. The bearings were obtained from MSC, The large direct reading dial came from Steve Wells and the knob was the original from the 405 as was the 0.093 Key.
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Figure 24: All the parts before assembly

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There is a bit of fitting which needs to be done. First the flange on the inner sleeve was left a bit oversize in thickness. (Better than undersize.) If the gap between the direct reading dial and the extension sleeve is too large this would need to be faced off a bit. This gap can be measured with feeler gages a then the sleeve is faced off to make the resulting gap 0.001 to 0.003. The knob needs to bear down on the inner sleeve tight or the direct reading dial will turn when the thumbscrew is locked. However you do not want it to be proud of the step on the screw more than, perhaps 0.002. Since this preloads the bearings. This is tuned by either facing off the end of the small diameter or facing the step on the screw, between the 12-24 thread on the 0.312 diameter. On first assembly mine slipped a bit so I removed just a bit from the screw. Figure 25 shows the final finished assembly.

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Figure 25

Jim Benjamin
Verona, NJ
eeengineer@verizon.net

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