TAPER TURNING GAUGE

Device for setting precise taper angle on the top slide of a lathe.

GENERAL

There are various ways to turn tapers on a lathe.

It is not the aim of this short paper to expound on all the possible methods with their virtues and failings.

If the machine is large enough, the taper may be cut using the top slide swivelled around to the appropriate angle.

Precise setting of the angle to turn accurate tapers is very much harder than it appears.

If there is an accurate pattern to copy, such as a Morse taper setting bar, it may be set up between centres and a dial gauge traversed its edge.

By trial and error, the angle may be adjusted so no variation in the dial gauge reading occurs during a traverse of the taper edge.

Adjusting and checking the angle is not as quick as it sounds because angular adjustments upset

previous readings, and the traverse must be started again.

The device to be described was evolved so quick and repeatable settings can be made. It works very well,

even in the absence of an accurate pattern. I would not be without it.

BACKGROUND

Recently, when cleaning out a drawer, I came upon 8 drawings I made about 15 years ago. Some were incomplete. They were the result of an article I had begun to write for a magazine on machining and model making about a device I made in 1979. It is different from every other device I have ever seen described, and, in my opinion, quite superior in operation.

After some correspondence with the editor, I became dissatisfied with their policy. I saw no reason why my work should end up with them owning the copyright to the material, so simply switched off. Maybe it was arrogance on my part, but I simply did not like their attitude.

Here is a short version of what I would have originally written, but with the benefit of many more years of testing and hindsight.

Sometimes more than a year passes without my using the device. But, whenever it is used, I never cease to be amazed at just how well it works, and how such a simple device tames the setting of taper angles in a lathe. Many other contrivances I designed were consigned to the scrap heap years ago. Some are better left unmentioned. This one, however, seems more valuable every time it is used, and, with hindsight and experience, cannot be improved in any significant way.

The turning of tapers using the top slide may not be so useful with very small lathes because of limited travel. This device was originally made for a large lathe with sufficient top slide travel to turn a No 4 Morse taper. Taper turning from the top slide of very small hobbyist lathes will be more limited, but I still think owners of such a lathe may find the device invaluable.

This could be exactly what many machinists are looking for.

If you are interested, build the device and pass on this web information to other interested parties.

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PRINCIPLE

Graduated, angular scales on machine tools usually are an order of magnitude less accurate than the

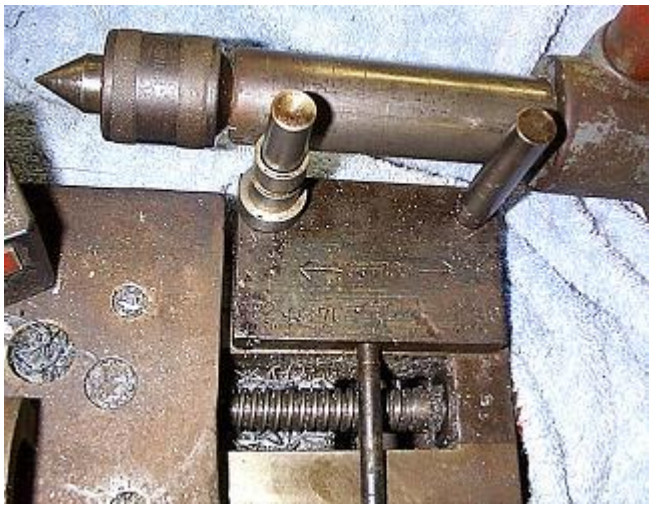
sine bar principle. Anyone who has done much precision

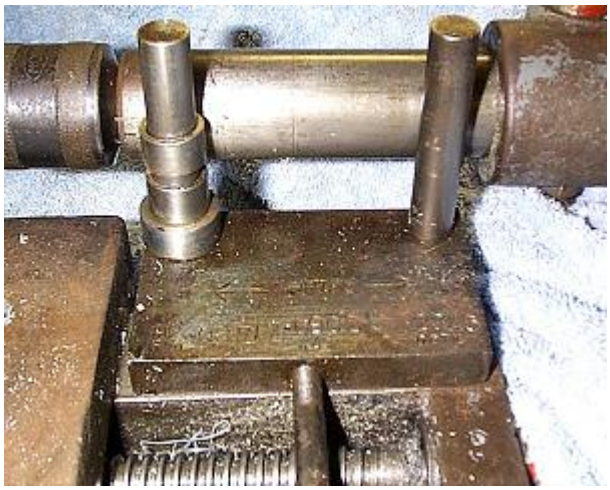
taper turning will be painfully aware of this.

The sine bar has for years become one of the preferred ways to set accurate angles. It is normally used by machinists in conjunction with the table of a milling or some similar machine, but there is no reason it has to be with respect to a plane, horizontal, table. The device to be described simply uses a modification of the sine bar in a vertical plane, using the tailstock barrel as the reference direction [1].

Examine the photographs below. This is a very old lathe having an exposed dovetail topslide. Although considerable wear is evident on this machine, the topslide dovetails have been reground and are very accurate. The rest of the machine, despite wear, can be coaxed to produce quite accurate work, when one understands the errors present. I now have a more modern lathe, but, because this machine can swing 24 inches, and I have made many attachments for it, this machine tool has been retained, and is still used.

The photographs show a device clamped to the dovetail topslide, with two identical vertical setting posts. These are placed in contact with the tailstock barrel. By means of a precision spacer, the topslide may be set accurately to any angle.





The Gauge, which is held on, or clamps to, the top slide, is shown in more detail below.

If there is no dovetail to clamp around, the bottom bar may be omitted. Then the two identical vertical bars simply project below its base and contact on the side of the body of the topslide.

This particular device was made from a piece of plate steel accurately machined with two flat parallel surfaces.

In this implementation, the rods were chromed steel from some old shock absorbers. Chromed rod is ideal as it

is both rust and wear resistant. The brown gunk is an added rust preventative measure to beat tropical corrosion.

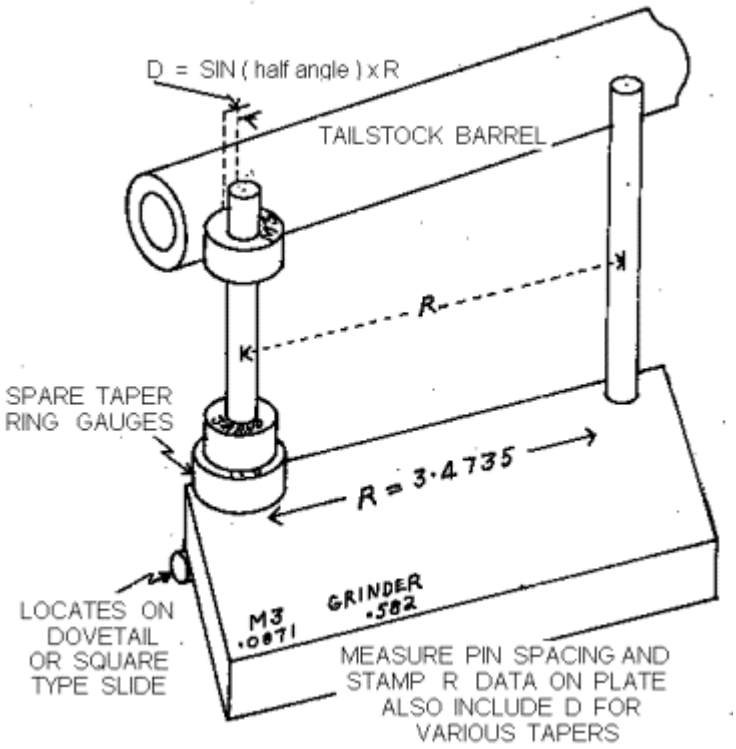
For each common taper, a setting ring is made. These shown above are for Morse 3 and Morse 4, and another quick release taper I use

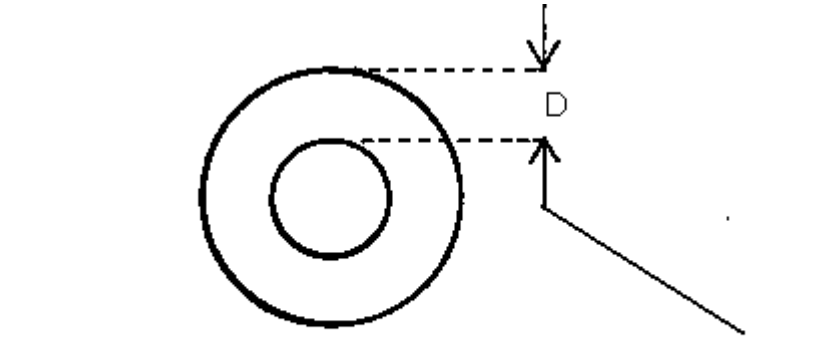
to hold grinding wheels in a tool and cutter grinder. I do not know exactly what it is, but having the ring gauge, it is instantly repeatable.

By the way, different Morse tapers do not use the same angle. I suspect this is a direct result of

errors when originally derived. For exact taper angles, you should look up machinist's handbooks.

The diagrams below may be more informative.





CRITICAL DIMENSION IS WALL THICKNESS D
BORE DOMENSION IS IMMATERIAL WITHIN REASON
SUGGEST ABOUT 10 THOU BORE CLEARANCE

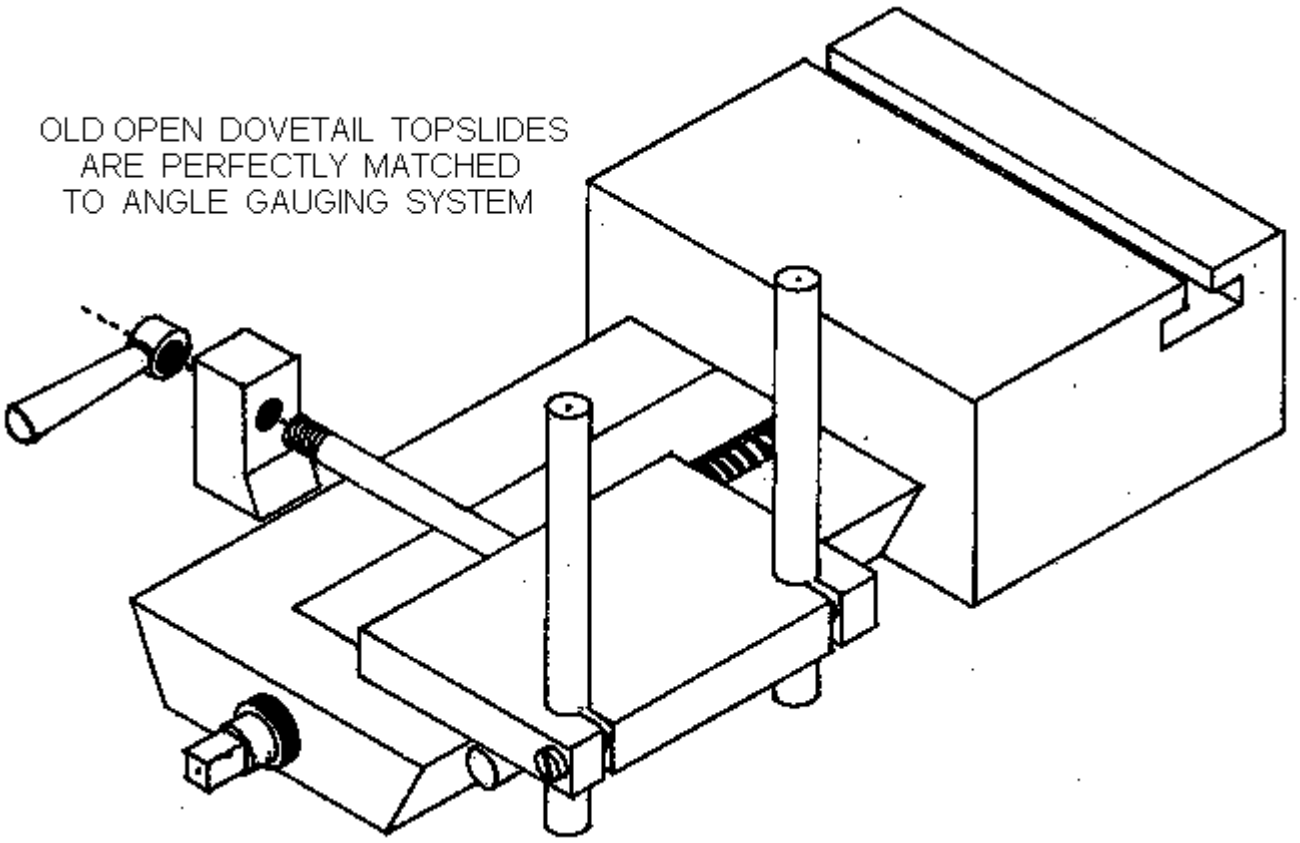
Recently one of these devices was made for another lathe in which the rods were set in place with locktite. The plate was bored in a mill. There is no need to have a specific rod spacing as long as it is accurately measured after assembly. The perpendicularity and parallelism (most important) of the rods should be checked.

After final measurement, stamp the center to center rod spacing on the top of the base. The best way to measure center to center distance is to average the ID and OD measurements. For the one above, this is 3.4735 inch, which has been stamped on the base. This is just visible in the photographs. Obviously, the longer the baseline, the more accurate will be the setting, but you will be limited by length of tailstock barrel and topslide body. It would be convenient to use 5 or 10 inch or 100 mm but, with the convenience of hand calculators, it does not matter very much.

More details are shown below. If you have a topslide with square corners, you may leave off the bottom rod.

The example photographed above had the bottom rod held in a vise while very small dobs of weld were applied to hold it in place.

Since welding ALWAYS distorts the object, these MUST be extremely small or else some other method used.



Although this shows the perpendicular rods held in place with clamp screws, I have simply pressed or locktited them in place.

METHOD OF USE

1 Calculate the distance D.

You will need to look up the angle of the taper. Now perform the required calculation using

D = SIN (half angle) x R

Where D is the setting to be applied to the sine bar and

R is the radius of sine bar – in this case the distance between the centres of two vertical bars.

Be very careful that you have the HALF ANGLE, and beware that the angle MUST be halved before finding it's sine.

You must never find sine of the entire angle then halve this value.

I recently did a quick calculation for a taper and double checked the result. It was obvious there was an error. Investigation revealed the calculator had been inadvertently set to Grads instead of Degrees. Don't

make a similar error. In my opinion, such options as Grads and Radians have no place on a hand held calculator unless there are interlocks to prevent errors like this. Anyway, I am perfectly capable of dividing by 180/pi or 10/9 if I want these other angular measures. The screen display is usually so small that any mode setting like this is almost invisible to see in practice. Double check things like this, so there is no waste of materials and effort. **All this is more reason to make specific setting rings for each taper – the risk of errors diminishes enormously.**

2 Make a setting ring with **this wall thickness** which easily drops over the posts. The only critical thing is the wall thickness and it is best made a loose fit.

There are of course other setting methods possible, but the ring is most convenient for long term use, quick repetition, and less prone to error. See later for alternatives.

3 Adjust the topslide angle. Mount the device on the topslide, loosen the angle adjusting bolts, and adjust the angle, until the post and ring are all in firm contact with the tailstock spindle. You might like to use paper between the contact points as an indicator.

If the topslide is free to rotate, as you gently use the cross slide to advance the posts into contact, the angle will set itself automatically. Alternatively, when the ring falls is a good indication of loss of contact. Finally, clamp up the topslide. It is firmly held to the correct angle while the bolts are tightened by the post contact. Now proceed to cut a perfect taper !. If the topslide has an angle scale, you will usually find it is quite inaccurate – certainly it was never intended for precision of this order.

Alternate setting methods

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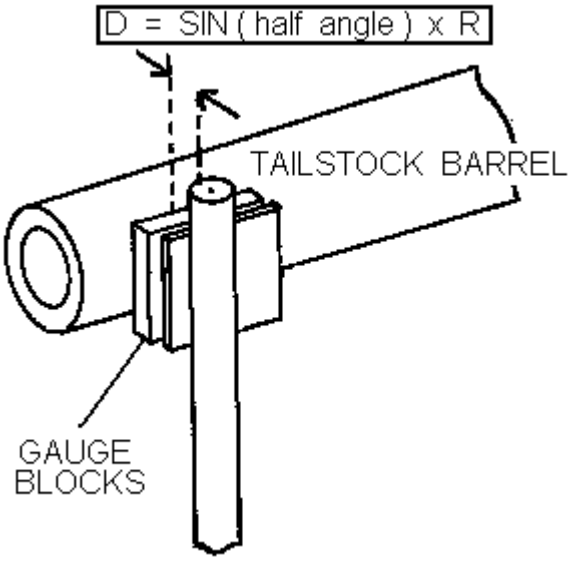
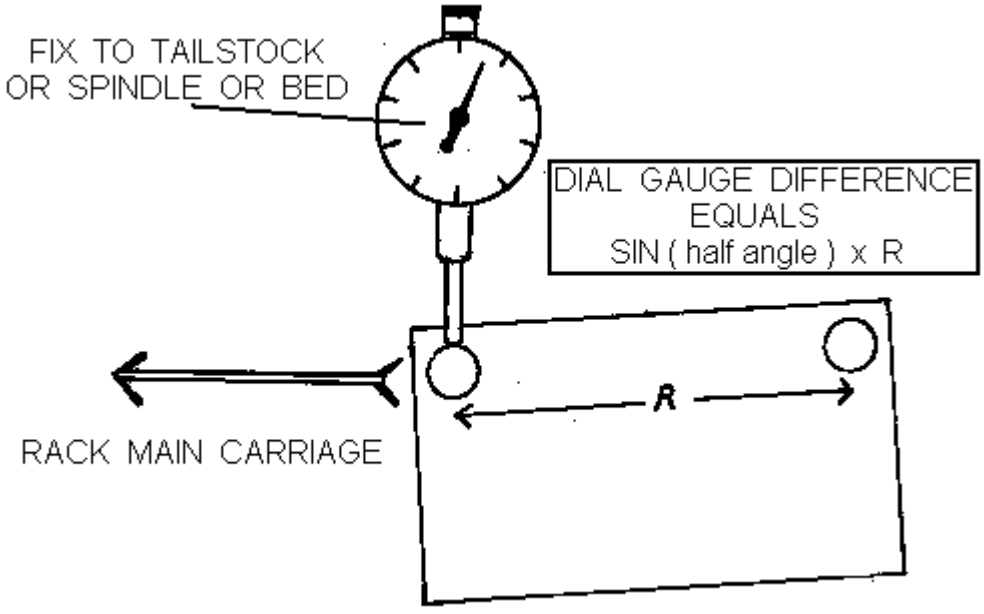
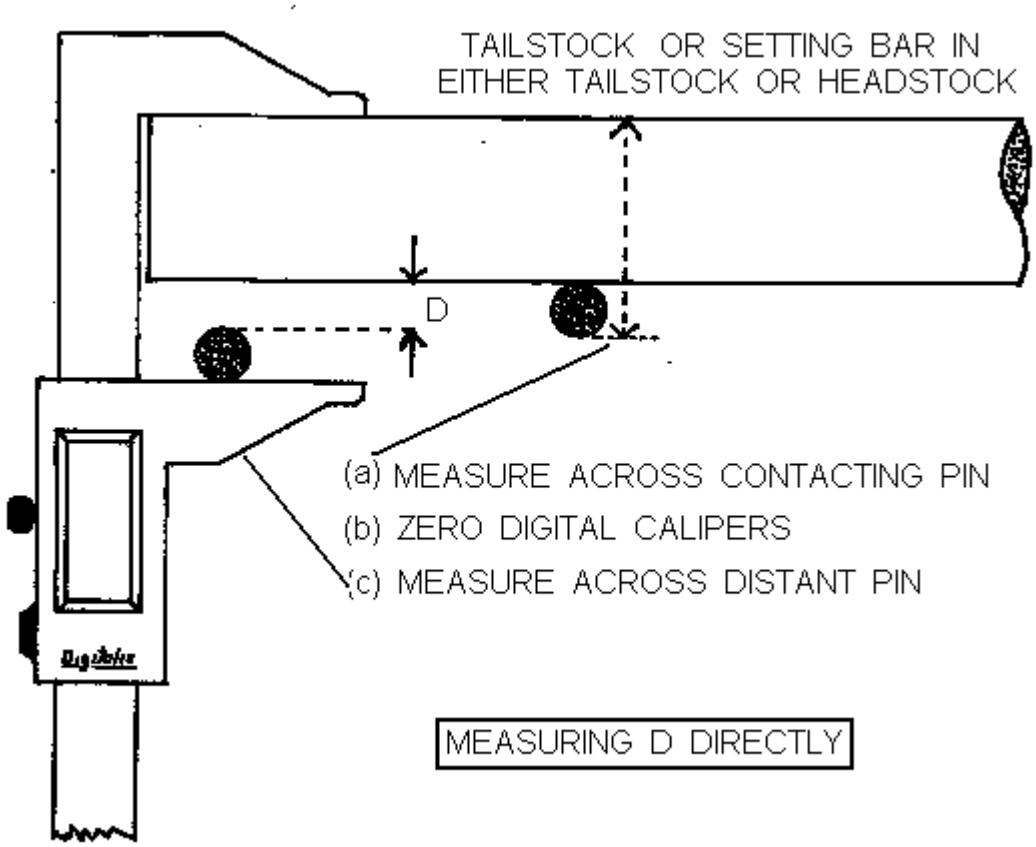
My own experience shows that the setting rings are much easier to use than any other system, but for infrequently met

tapers, it may not be worth making settings rings. The following are other methods that can be used.


D = SIN (half angle) x R
TAILSTOCK BARREL
GAUGE
BLOCKS

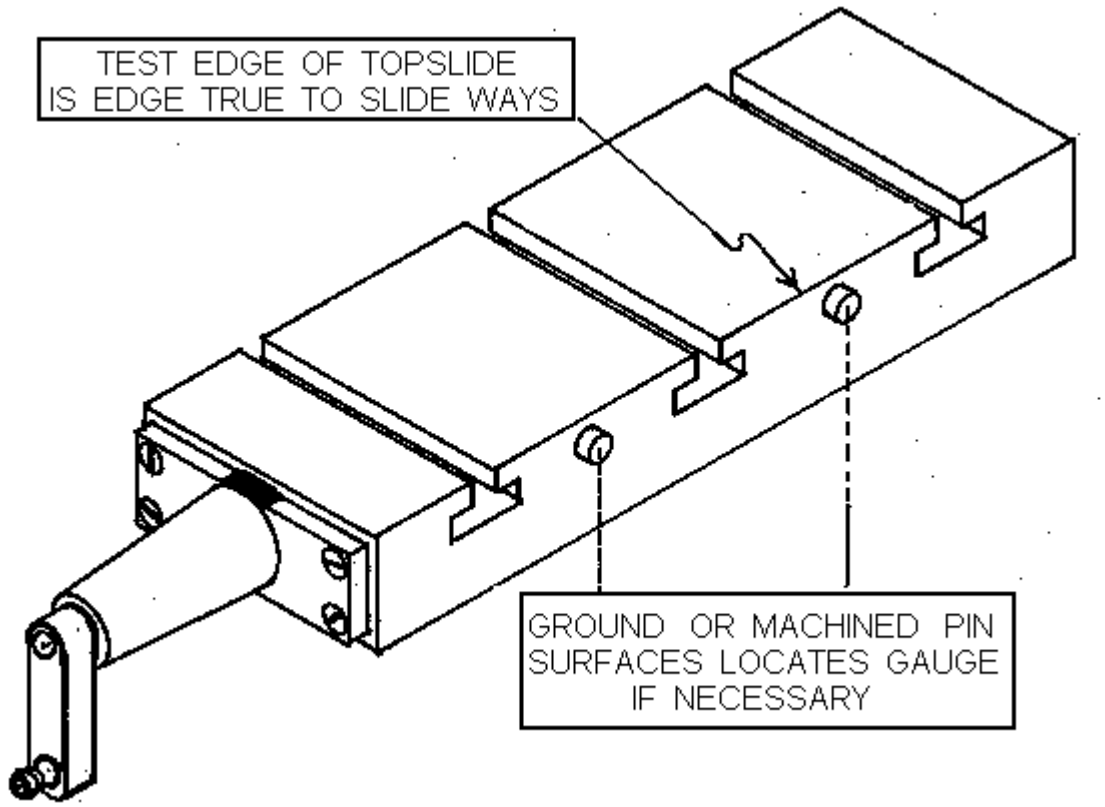

FIX TO TAILSTOCK
OR SPINDLE OR BED
DIAL GAUGE DIFFERENCE
EQUALS
SIN (half angle) x R
R
RACK MAIN CARRIAGE



Parallelism of enclosed top slides

One should not simply assume the edge of a topslide is exactly parallel to its direction of motion. Since the method of setting has the potential for extreme precision, this possible source of error should be tested. The critical factor is easily checked, by mounting a dial indicator so it runs against the edge of the slide, as the slide is traversed. The indicator should remain unchanged.

If the topslide edge is misaligned, or if the edge has been significantly damaged, it may be worth fixing two buttons on its edge, at the appropriate spacing, to contact the posts, as shown below. These could easily be machined, or ground in situ, as the slide is traversed.



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[1] There is no reason a setting bar in the headstock cannot be used – in fact this is fundamentally more accurate. The Tailstock barrel is convenient and quick. If it does not have sufficient length, it may be advisable to use a longer setting bar in the tailstock or headstock.